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Private Copying and Fair Compensation: A comparative study of copyright levies in Europe[2]

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ABSTRACT

Following the Information Society Directive of 2001 (introducing the concept of "fair compensation" for private copying into EU Law), total collection from levies on copying media and equipment in the EU tripled, from about €170m to more than €500m per annum. Levy schemes exist now in 22 out of 27 Member States (with only the UK, Ireland, Malta, Cyprus and Luxembourg remaining outside). Despite their wide adoption, levy systems are little understood, both in respect of their rationale and their economic consequences. Tariffs are increasingly contested in court, leading to a large gap between claimed and collected revenues. The European Commission has announced "comprehensive legislative action" for 2012.

This report offers the first independent empirical assessment of the European levy system as a whole. The research consolidates the evidence on levy setting, collection and distribution; reviews the scope of consumer permissions associated with levy payments; and reports the results of three product level studies (printer/scanners, portable music/video/game devices, and tablet computers), analysing the relationship between VAT, levy tariffs and retail prices in 20 levy and non-levy countries.

Key findings:

- There are dramatic differences between countries in the methodology used for identifying leviable devices, setting tariffs, and allocating beneficiaries of the levy. There are levies on blank media in 22 EU countries, on MP3 players in 18 countries, on printers in 12 countries, on personal computers in 4 countries. Revenues collected per capita vary between €0.02 (Romania) and €2.6 (France). The distribution of levy revenues to recording artists is less than €0.01 per album.
- These variations cannot be explained by an underlying concept of economic harm to rightholders from private copying.
- The scope of consumer permissions under the statutory exceptions for private copying within the EU vary, and generally do not match with what consumers ordinarily understand as private activities.
- In levy countries, the costs of levies as an indirect tax are not always passed on to the consumer. In competitive markets, such as those for printers, manufacturers of levied goods appear to absorb the levy. There appears to be a pan-European retail price range for many consumer devices regardless of levy schemes (with the exception of Scandinavia).
- In non-levy countries, such as the UK, a certain amount of private copying is already priced into retail purchases. For example, right holders have either explicitly permitted acts of format shifting, or decided not to enforce their exclusive rights. Commercial practice will not change as a result of introducing a narrowly conceived private copying exception.
- A more widely conceived exception that would cover private activities that take place in digital networks (such as downloading for personal use, or non-commercial adaptation and distribution within networks of friends) may be best understood not as an exception but as a statutory licence. Such a licence could include state regulated payments with levy characteristics as part of a wider overhaul of the copyright system, facilitating the growth of new digital services.

*This short report explains key findings of the research in policy relevant language. Three underlying studies were performed: Study I entitled "**Legal and policy context**" reviews the implementation of levy systems in the EU; Study II entitled "**Empirical effects of copyright levy schemes**" reports data on the relationship between VAT, levy tariffs and retail prices for three products in 20 levy and non-levy countries; Study III entitled "**Framework for analysis**" reviews possible rationales for state regulated levy systems. These supporting documents are made available as separate files:*

http://www.cippm.org.uk/publications/comparative-study-of-copyright-levies-in-europe.html

1. Legal basis

In EU copyright law, private copying has been given a specific meaning relating only to the reproduction right (i.e. not: communication to the public, distribution to the public, public performance or adaptation). Private copying is included among the closed list of exceptions permitted under Article 5 of the 2001 Information Society Directive. Article 5(2)(b) reads: [Member States may provide for exceptions or limitations to the reproduction right] "in respect of reproductions on any medium made by a natural person for private use and for ends that are neither directly or indirectly commercial, on condition that the rightholders receive fair compensation which takes account of the application or non-application of technological measures [referred to in Article 6]."[3]

[3] Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the harmonisation of certain aspects of copyright and related rights in the information society. See Study I: Legal and Policy Context.

2. Blurring between private copying and communication to the public

The narrow focus of the reproduction right does not map well onto typical copying behaviour in digital networks. Users may consider activities under the following headings to be private:

(i) Making back-up copies / archiving / time shifting / format shifting

(ii) Passing copies to family / friends

(iii) Downloading for personal use

(iv) Participation in file sharing networks / sharing digital storage facilities

(v) Online publication, performance and distribution within networks of friends

(vi) User generated content / mixing / mash-up (private activities made public)

In the analogue world, the private copying exception was aimed to permit discrete copies for non-commercial use in categories (i) and (ii). In digital networks, the distinction between private and public spheres has become blurred. Regularly, new services are invented that challenge earlier divisions (P2P, social networks, cloud lockers).

3. Implementation of the private use exception in EU countries

Under the Information Society Directive, only activities (i), (ii) and (iii) can possibly fall only under the reproduction right (and therefore be eligible for a compensatable exception as private copying). Even within these groups of activities, the scope and legal construction of private copying differs considerably between countries. In some countries, sources need to be lawful, in others not; in some countries, there are a set number of permitted copies specified, in others there are definitions of private circles; in some countries, the levy is constructed as a statutory licence, in others as a debt; in some countries compensation is only due for private copying of music, in others for printed matter (reprographics) and audio-visual works.

As a mechanism for "fair compensation", 22 out of 27 European Union members have chosen to meet the requirement through a levy system. The exceptions are the UK and Ireland (only time-shifting of broadcasts is permitted), Malta, Cyprus and Luxembourg (private copying treated as *de minimis*). Within the 22 countries that provide for a compensated private copying exception, levy schemes vary widely in the following respects:

- levies apply to different media or equipment that can be used to make copies (e.g. recordable carriers, hard disks, MP3 players, printers, PCs);
- levies differ in tariffs for the same media or equipment, and apply different methods of calculation (e.g. memory capacity, percentage of price);
- levies differ in whether they are imposed on the manufacturers, importers or distributors of media or equipment, or consumers;
- levies differ in beneficiaries (music, audio-visual, reprographic rightholders; wider cultural or social purposes);[4]
- regulatory structures differ (processes for setting tariffs and distribution, contestability of tariffs, governance and supervision of agencies).

The system as a whole is deeply irrational, with levies for the same devices sold in different EU countries varying arbitrarily. The following three figures illustrate the variable scope and density of levy schemes, and track the evolution of total revenues raised from copyright levies in the EU. The underlying data can be found in Study I.

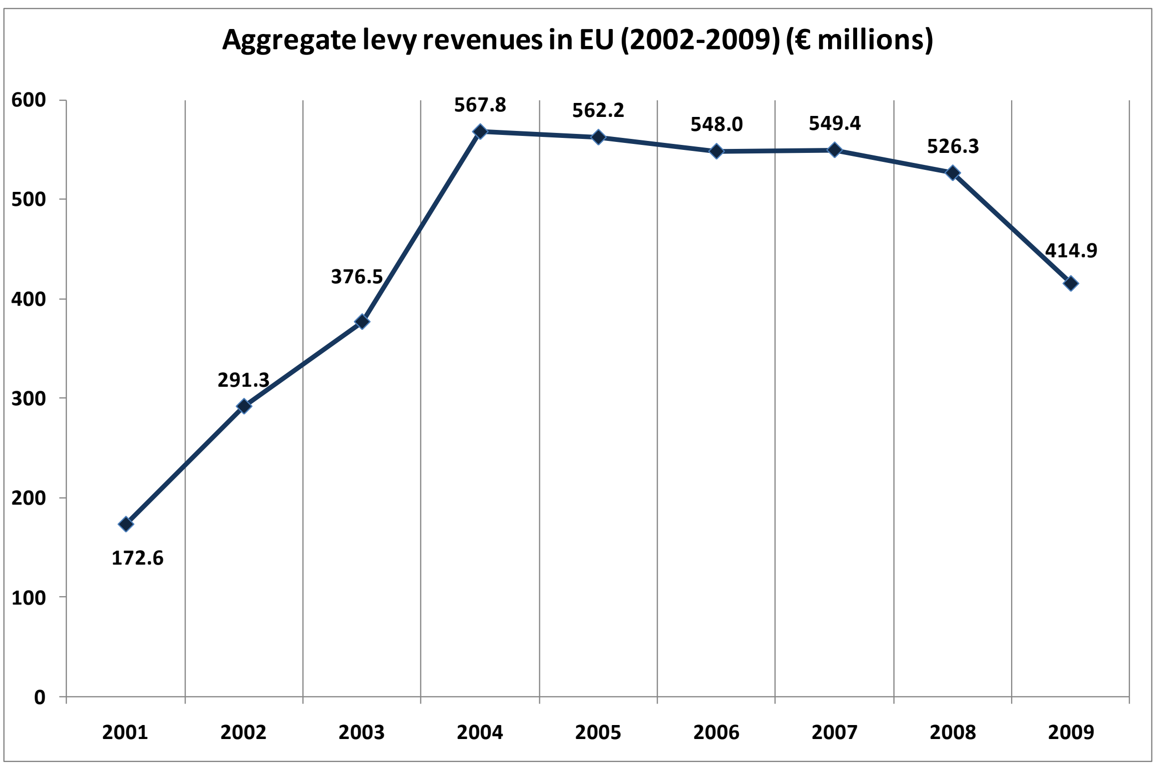
[4] For example, the distribution of levy revenues to recording artists is less than €0.01 per album; use of levy income for socio-cultural purposes differs between 0% and 33% of collected revenues. Variations have been catalogued in Study I.

4. Aggregate revenues, levy scope and levy density

The 2001 Information Society Directive introduced the requirement of "fair compensation" for statutory "private copying" exception into EU copyright law. This initiated a rapid rise in collection under levy systems from €172 million in 2001 to €567 million in 2004. Collection plateaued around the €500 million mark between 2004 and 2008, and is now beginning to fall as blank tapes, CDs and DVDs are disappearing from the market, and levies on new products are increasingly contested.

Figure 1 Aggregate levy revenues in EU (2002-2009)

Source: European Commission; de Thuiskopie; Business Software Alliance

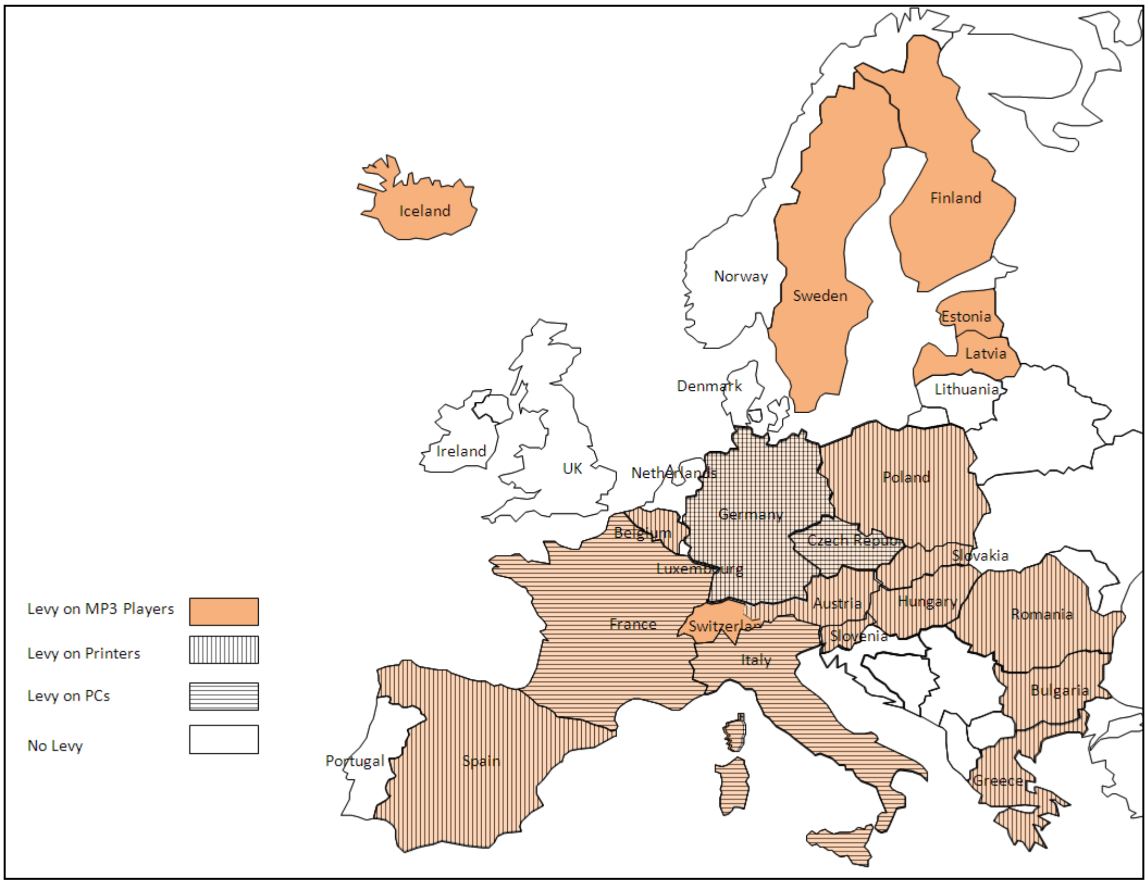


Collected fees need to be understood in a volatile context of claimed (but unpaid) and paid (but contested) tariffs. Recent examples of changes in tariffs and scope include:

- 1 January 2008: Amendment to German copyright law (UrhG 2. Korb): Tariffs in law replaced by negotiated tariffs between manufacturers and collecting agency ZPÜ; about €20m of claimed fees contested, and withheld by manufacturers.
- 24 February 2009: Decision by highest Austrian court (OGH, 4 Ob 225/08d); levy on personal computers cancelled; compensation can only be due on equipment that is designed for copying.
- 21 October 2010: Padawan SL v Sociedad General de Autores y Editores de España (SGAE), Case C-467/08, European Court of Justice (ECJ): Business media and equipment not leviable; Spanish collecting societies may have to return certain fees collected under Art. 25 of the *Ley de Propiedad Intelectual*.
- 11 April 2011: Dutch State Secretary for Public Safety and Justice Fred Teeven announces phasing out of levies (levies on recordable CDs will not be replaced by schemes on new media or equipment).

Across Europe, there are great variations in the products subject to copyright levies. There are levies on blank media in 22 EU countries, on MP3 players in 18 countries, on printers in 12 countries, on personal computers in 4 countries. In addition, there are currently nine countries where levies for mobile phones are claimed but contested, amounting to about €192 million in 2010 which may or may not become payable. The following map illustrates these differences for MP3 players, printers and personal computers (“no levy” here means “no levy on these three devices”).

Figure 2 Levies applicable to MP3 Players, Printers and PCs in Europe (2009)*



* *Source*: Annual reports of collecting agencies; de Thuiskopie, *International Survey on Private Copying Law & Practice* (21st revision 2010). Iceland, Norway and Switzerland are not members of the EU. They are added for illustrative purposes because their copyright legislation is EU compliant.

For the purposes of the next map, levy density is measured by revenues raised per capita of the population, ranging from €2.6 in France to €0 in non-levy countries, such as the UK and Ireland. Bulgaria has a levy scheme by statute but no reported collection.

Figure 3 Levy revenues per capita in Europe (2009)

France	€ 2.60
Switzerland	€ 2.10
Spain	€ 1.70
Finland	€ 1.60
Germany	€ 1.50
Austria	€ 1.40
Belgium	€ 1.20
Sweden	€ 1.10
Hungary	€ 0.90
Netherlands	€ 0.90
Norway	€ 0.90
Czech Republic	€ 0.70
Denmark	€ 0.70
Italy	€ 0.70
Iceland	€ 0.60
Slovenia	€ 0.50
Portugal	€ 0.30
Lithuania	€ 0.20
Latvia	€ 0.16
Greece	€ 0.13
Estonia	€ 0.10
Slovakia	€ 0.10
Poland	€ 0.07
Romania	€ 0.02
Bulgaria	€ 0.00
Cyprus	€ 0.00
Ireland	€ 0.00
Luxembourg	€ 0.00
Malta	€ 0.00
United Kingdom	€ 0.00

* *Source*: Annual reports of collecting agencies; de Thuiskopie, *International Survey on Private Copying Law & Practice* (21st revision 2010). Iceland, Norway and Switzerland are not members of the EU. They are added for illustrative purposes because their copyright legislation is EU compliant. Bulgaria

5. Empirical effects of levies on retail prices

Are levied products more expensive in levy countries than in countries that do not apply a copyright levy? In Study II, the following products were investigated for an analysis of the relationship between copyright levies and retail prices:

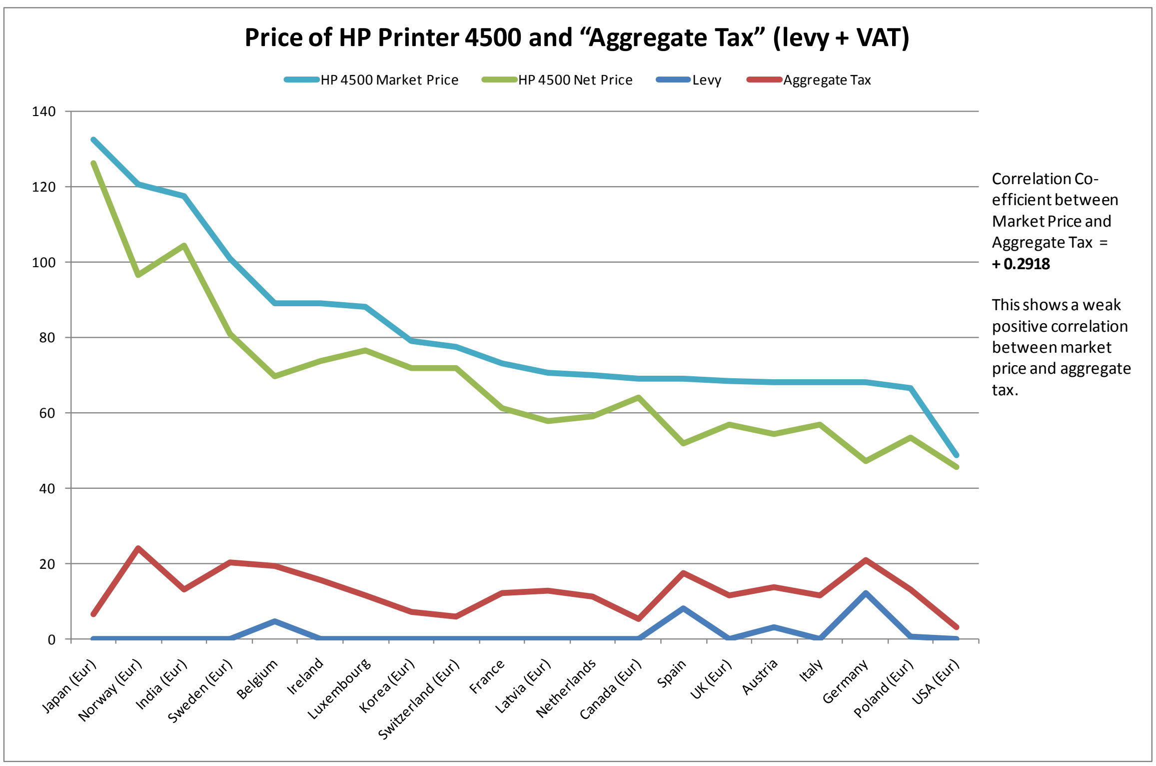
(1) printer/scanners: levies are applied in 14 out of 27 Member States ranging between €0.72 and €56 per unit for an HP 4500 Officejet printer;
(2) portable music/video/game devices: levies surveyed in 9 Member States ranged between €1.42 and €19.40 for Apple's iPod Touch 64GB;
(3) tablet computers: may be classified as a personal computer in 4 Member States (carrying a possible levy per unit of €12.15 in Germany, €8.00 in France and €1.90 in Italy).

The empirical analysis, plotting retail prices in 20 countries against levy and VAT rates, indicates that markets for printer/scanners are highly competitive. Manufacturers find it difficult to pass on higher indirect taxes to the consumer. In some high levy countries (such as Germany), the HP Officejet 4500 printer is retailing at a similar price as in non-levy countries (such as the UK), and there appears to be no systematic link between wholesale and retail pricing. For producers of premium products, such as the iPod Touch, there is a statistically significant correlation between total indirect taxation and the retail price, suggesting that manufacturers are able to pass on higher costs to the consumer.

Generally, there appears to be a pan-European retail price point for consumer devices, regardless of divergent levy schemes, with only Scandinavian consumers willing to pay more. Product launch decisions for innovative products (such as tablet computers) seem unaffected by the level of indirect taxation. Further details on launch dates for three tablet computers (iPad1, iPad2 and Samsung Galaxy) are given in Study II.

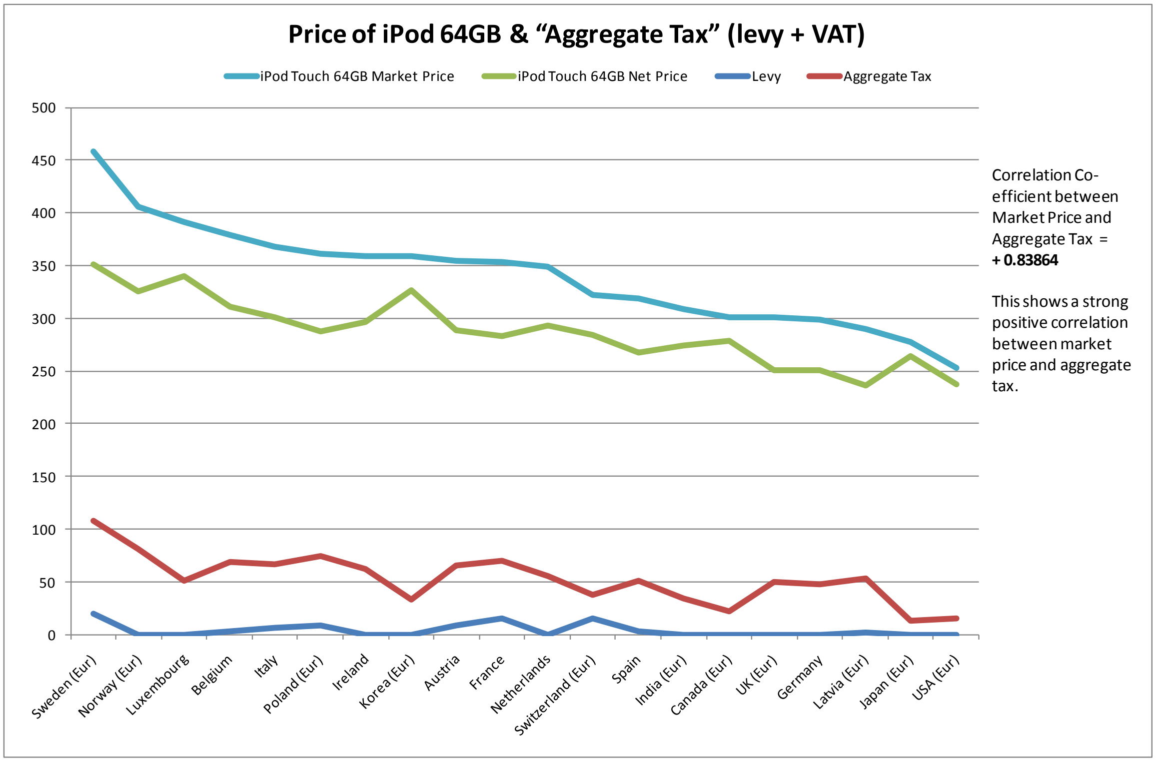
The following two figures illustrate the relationship between the total level of indirect taxation (copyright levy plus VAT) and retail prices for the Apple iPod Touch (64GB) and the Hewlett Packard Office Jet 4500 in a variety of countries, including the four countries that account for 75% of levy revenues in the EU: France, Germany, Spain and Italy; and countries neighbouring these large levy markets where cross border effects should be most prominent. In addition, non-levy countries, and the home markets of the products investigated were added. The countries are ordered from left to right by descending online retail price (April 2011, lowest price available, at Euro exchange rates of 15 April 2011).[5]

Figure 4 Relationship between price, levy and VAT (HP printer)



[5] The methodology for product and country selection, as well as the process of data collection is explained in detail in Study II.

Figure 5 Relationship between price, levy and VAT (Apple iPod Touch)



The two figures demonstrate that the price at which a product retails is dependent, not necessarily on the level of indirect taxation in a country but on market conditions and consumers' willingness to pay. The United States generally has the lowest prices; Germany's consumers seem to be getting a good deal despite quite high indirect taxes; Scandinavians appear to be willing to pay a premium.

The extent to which it is profit maximising for firms to pass on copyright levies to consumers (rather than absorb the costs) depends on a number of factors. These may vary across different markets. Relevant factors include the degree of competition, elasticity of demand, and if levies are applied uniformly to all manufacturers (firm-specific or industry-wide costs). It also matters that levies, as indirect taxes, are not fixed costs but depend on sales. Unless added explicitly on the retail price (as prescribed only in Belgium), the extent of pass-on is difficult to establish.

Making the levy explicit on consumer retail advertising and receipts may be explored as a policy solution, together with explicit consumer permissions "bought" with the levy.

6. The concept of harm

In the 2010 *Padawan* decision, the European Court of Justice held that the concept of "fair compensation" "must be regarded as an autonomous concept of European Union law to be interpreted uniformly throughout the European Union".[6] With reference to Recitals 35 and 38 of the Information Society Directive, the Court found (at 42) that "fair compensation must necessarily be calculated on the basis of the criterion of the harm caused to authors of protected works by the introduction of the private copying exception".

The concept of harm is problematic, and has failed to acquire a coherent meaning. From the jurisprudence on awarding damages, harm in law is likely to be interpreted as a lost licensing opportunity, i.e. a fee that could have been charged.[7] However, there is a circularity here: if there is a copyright exception, there is no infringement, and no licence could have been issued. Thus by definition there is no harm in law from a permitted activity.

In economics, harm is a lost sale, i.e. if copying replaces a purchase that otherwise would have been made. Evidence on the extent of private copying presented to the Copyright Board in Canada shows that in 2006-2007, portable music players (such as iPods) contained on average 497 tracks of music, of which 96% were copied.[8] In total, 1.63

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[6] *Padawan SL v Sociedad General de Autores y Editores de España (SGAE),* Case C-467/08, 21 October 2010. The intellectual origins of the concept of "fair compensation" can be traced to a decision of the German federal court in 1964 (BGH, NJW 1964, 2157; GRUR 1965, 104 – *Personalausweise*), and the copyright law of 1965 (UrhG). See Supporting Study I.

[7] Under the common law concept, damages shall put the claimant in as good a position as if no wrong had occurred: *Robinson v Harman* (1848); *Livingstone v Rawyards Coal Co* (1880).

[8] Exibit CPCC-3: *Étude de marché sur la copie privée d'enregistrements musicaux au Canada 2006-2007* (11 January 2008); 695pp report prepared by Réseau Circum for Société canadienne de perception de la copie privée (CPCC). The methodology is based on monthly telephone surveys of about 1,000 Canadians

billion copies of tracks were being made in Canada from July 2006 to June 2007. Of these, about half (808 million) were copied on digital recorders; of these 808 million, about 345 million (42%) came from the Internet. Only 20% of these tracks were authorised downloads (e.g. from iTunes). Thus, from July 2006 to June 2007, there were 646 million copies being made from unauthorised Internet sources that found their way on the typical portable music player.

How many of these downloads have been listened to, rather than stored? How many have replaced purchases? How many have led to purchases? These questions (illustrated here by reliable Canadian data) are hotly contested in the academic literature, and empirical studies have come to opposite conclusions.

Hal Varian shows (developing Liebowitz' concept of "indirect appropriability")[9] that we need to distinguish the number of works produced and the number of works consumed. If sharing is permitted, or takes place, the producer is likely to sell fewer units of the work, but since the consumer derives greater value from each unit, the producer's profit may even increase (if pricing is right). However, if the availability of free copies pushes the retail price to marginal cost, the original seller will find it hard to raise the price to a level where he can recover the cost of production. The basic idea remains the same: "if the willingness-to-pay for the right to copy exceeds the reduction in sales, the seller will increase profit by allowing that right."[10]

(above the age of 12), a sample representative of all Canadians. The data in the report are based on 12,011 "entrevues" between July 2006 and June 2007.

[9] Hal A.Varian (2005), "Copying and Copyright", *Journal of Economic Perspectives* 19(2): 121-138; Stan Liebowitz (1985), "Copying and Indirect Appropriability: Photocopying of Journals", *Journal of Political Economy* 93(5): 945-57.

[10] Varian, ibid. p. 130.

7. Distinction between "priced into purchase" and "statutory licence"

Reconsider the consumer activities listed in section two above. For (i) [Making back-up copies / archiving / time shifting / format shifting]; and (ii) [Passing copies to family / friends], a certain amount of copying appears to be already priced into the purchase (Varian's argument). For example, right holders have either explicitly permitted format shifting, or decided not to enforce their exclusive rights. There is no lost sale, and the European criterion of harm may be treated *de minimis*, i.e. no compensation is due. Commercial practice will not change as a result of introducing such a narrowly conceived private copying exception.

A more widely conceived exception that would cover private activities that take place in digital networks [activities (iii) to (vi)] might be better understood as a statutory licence. Possible rationales for issuing such a licence include: making the copyright system more permissive for consumer led innovation, as well as non-economic arguments (such as influencing the bargaining position of creators versus producers, or preserving fundamental rights of privacy). The EU concept of "compensatable harm" contributes little towards assessing an appropriate scope and tariff for such a licence. There is no case for copyright levies unless the payment of levies is linked to clear consumer permissions, and an argument is made why scope and tariff of these permissions cannot be left to the market.[11]

[11] See Supporting Study III.

Postscript

In May 2011, the European Commission announced "comprehensive legislative action" regarding private copying levies for 2012: *A Single Market for Intellectual Property Rights: Boosting creativity and innovation to provide economic growth, high quality jobs and first class products and services in Europe*, Communication from the European Commission (COM(2011) 287 final). Section 3.3.4. reads: "The proper functioning of the internal market also requires conciliation of private copying levies with the free movements of goods to enable the smooth cross-border trade in goods that are subject to private copying levies. Efforts will be redoubled to kick-start a stakeholder agreement built on the achievements of a draft Memorandum of Understanding (MoU) brokered by the Commission in 2009. A high level independent mediator will be appointed in 2011 and tasked with exploring possible approaches with a view to harmonising the methodology used to impose levies, improve the administration of levies, specifically the type of equipment that is subject to levies, the setting of tariff rates, and the inter-operability of the various national systems in light of the cross-border effects that a disparate levy system has on the internal market. A concerted effort on all sides to resolve outstanding issues should lay the ground for comprehensive legislative action at EU level by 2012."

How do state regulated licences with levy characteristics compare to privately negotiated levies? On 6 June 2011, Apple announced that it will offer in the U.S. a service that scans computers for music files, and then give access to these on any device from Internet (cloud) servers for a fee of $24.99 per annum.[12] In effect, Apple's iCloud attempts to legalise private collections of music files, regardless of origin. The terms of Apple's agreement with right owners are not known. What is the share of royalties between publishers and labels; what is the split between major and independent labels; how much will be passed on to artists? These details matter greatly for an assessment of the intervention of intellectual property rights from a competition perspective. This is in urgent need of further empirical research prior to legislative action on copyright levies.

[12] Announcement at Apple Worldwide Developers Conference (WWDC, 6 June 2011).

Who are the stars? Evidence from a sample of UK academic inventors.

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Abstract

This paper explores the characteristics of persistent academic inventors and how they are influenced by the attributes of the researcher and of the first invention. Using a novel dataset on 550 UK academic inventors we find that the quality of the first invention is the best predictor for subsequent participation in the patenting process. Further, researchers that were trained at universities that had already established commercialisation units have a higher propensity to patent persistently. Researchers that gained first patenting experience in industry, however, are less likely to continue patenting once they entered academia.

Keywords: Academic inventors, University patents, Persistent innovation

JEL codes: L24; 031; 032; 034

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1. INTRODUCTION

The exploitation of university inventions has been one of the major concerns of policy makers in Europe and in the US over the past 30 years. The protection and exploitation of intellectual assets is considered as vital for sustainable competitive advantage and economic growth, and following the Bayh-Dole Act of 1980, governments across the world have implemented similar regulations enabling universities to exploit their inventions (OECD, 2003). Consequently, the number of patents, licenses, university spin-outs and science parks has increased dramatically (Siegel et al., 2007; Verspagen, 2006; HEFCE, 2009).

However, there is a great heterogeneity in the extent to which academics engage in commercialisation of their research. Recent papers have shown that their distribution is highly skewed and that the majority of academics never patent (Agrawal and Henderson, 2002; Azoulay et al. 2009; Goldfarb et al., 2009; Lissoni et al., 2008). Even amongst academic inventors, the majority file only one patent. Breschi et al. (2008) examining the patenting activity of Italian academic inventors find that 60.2% of professors in their sample signed one patent and only 8.6% more than five. Narin and Breitzman (1995) found a similarly skewed distribution for firm inventors. They showed that patenting follows a Lotka (1926) distribution and that the most prolific inventors are even more productive than Lotka's Law predicts.

There is empirical evidence that such productive individuals are very important for technological advancement (see Gay et al., 2008). Zucker, Darby and co-autors (1996, 1998, 2002), for instance, have repeatedly pointed out the role of star scientists for firm success. They showed that firms collaborating with academic stars produce more innovations and grow more rapidly than other firms. Also within a firm Rothwell (1992) identified certain key individuals that contribute most to a firm's success. The most productive inventors produce patents of greater value and thus contribute most to their firm's performance (Ernst et al., 2000; Gay et al., 2008).

Key performers additionally exert a positive effect on their peers. In a recent paper, Azoulay (2010) find strong evidence for a positive effect of academic stars on the publication records of their co-authors. Similarly, academic inventors can have a positive signalling effect for their colleagues. They may act as role models and thereby trigger more commercial activity (Bercovitz and Feldman, 2008; Goktepe-Hulten, 2008; Stuart and Ding, 2006).

In view of the continuous focus of policy makers on the successful appropriation of research and the importance of star scientists or key actors for the advancement of knowledge, this paper wants to identify those factors that lead to persistent academic invention activity. It aims to investigate the characteristics of single and persistent academic inventors and their patents and wants to establish whether attributes of the university, of the researcher, or of the first invention are important for a persistent participation in the patenting process. First evidence by Bercovitz and Feldman (2008) showed that for researchers at two medical schools in the US, single and persistent disclosers appear to respond to different stimuli. It did, however, not take into account whether a disclosure was successfully turned into a patent, or the characteristics of the invention. We aim to add to their analysis by including these factors and further, aim at investigating in more detail what we can learn from "star" inventors about necessary policies to encourage single inventors to patent more persistently.

We use a sample of 622 academic inventors in the UK from the CID-KEINS database. We classified academics based on the number of granted patents as *single, one-spell* or *persistent inventors*. Using cross-sectional ordinal logit models, we estimate a researcher's propensity to belong to one of these groups based on institutional, personal and invention-based characteristics.

We find that researchers, who undertook their PhD studies at a university that had already implemented mechanisms to support technology transfer at the time of the PhD, have a higher propensity to patent persistently throughout their career. This supports findings by Bercovitz and Feldman (2008), who showed that social imprinting at PhD level, is more important than local peer effects. We find, however, no evidence for a positive effect of socialisation in industry on inventorship. Researchers that first appeared as inventors on a patent while working for industry are less likely to become persistent inventors than their peers from academia. This may reflect their choice to return to academia and contradicts findings by Dietz and Bozeman (2005).

Additionally we show that the success of the first patent application has a strong impact on future involvement in patenting. Researchers that had their first patent granted and received a large number of citations, are more likely to remain active inventors. This may be due to economic benefits associated to patenting in form of licensing income as well as subsequent grants (Audretsch et al., 2006; Jensen and Thursby, 2001) that in turn provide the necessary financial impetus for future research (Link et al., 2007; Meissner, 2011).

The remainder of the paper is structured as followed: Section 2 reviews some of the literature; section 3 describes the data and gives first descriptive statistics. Section 4 explains the methods, section 5 presents the results and section 6 discusses and concludes.

2. BRIEF BACKGROUND

Persistent participation in commercialization is rare and the majority of inventors own only one patent. These persistent inventors are not only producing innovative research, but they are able to turn their inventions into patents. A large body of literature in the economics of science has investigated academic inventors and tried to identify those factors that constitute an academic's involvement in commercialization (Azoulay et al., 2007; Breschi et al., 2005; Calderini et al., 2007; Carayol, 2007; Stephan et al., 2007). Fewer studies have focused on the difference between single and persistent inventors. Academics that have once entered the patenting process have shown that they are able to produce innovative research, but persistent inventors differ in their ability to recognize patenting opportunities and to take advantage of them.

Most papers on (academic) patenting have shown the number of previous patents as the main determinant (Azoulay et al., 2007; Le Bas and Bouklia-Hassane, 2010). Unlike with publications, patent examiners are less prone to reputation but need to evaluate the uniqueness of an invention. Dynamics can hence not be explained by an accumulated prestige effect. However, initial success in patenting may encourage continuous involvement. Academics that fail to have their first patent application granted may find patenting too costly and little rewarding and abstain in future.

In addition, it has been shown that academic inventors attract more funding and that financial resources are necessary to produce patentable research (Jensen and Thursby, 2001; Link et al., 2007; Meissner, 2010, 2011). Academics that have successfully patented in the past might hence have access to the necessary funding and support needed for continuous commercial involvement.

Besides the importance of initial patenting success, the commercial socialisation of academics has been pointed out as a potential factor. Researchers that have been involved in patenting before joining academia may be more familiar with the patenting process and therefore more likely to patent their research than their peers without experience in industry. Dietz and Bozeman (2005), studying curriculum vitae of 1200 academics, indeed, report that researchers that spent some time in industry patent more than their peers.

Bercovitz and Feldman (2008) look at the disclosure activity of academics at two medical schools and find a local socialisation effect stating that the norms of the PhD awarding institution are important for future involvement in patenting. Researchers training universities that had already implemented technology transfer policies at the time of their PhD were more likely to disclose inventions than their colleagues in the same department that had trained at institutions without active TTOs. This training effect will also be examined in this paper.

Gay et al. (2008) have shown that prolific company inventors are part of large teams. Similarly, academic inventors may benefit from the experience of colleagues already involved in patenting. Bercovitz and Feldman (2008) find that the disclosure activity of those of similar rank within the same department has a positive effect on a researcher's disclosure choice. Accordingly, researchers involved in inventive teams may be more likely to patent persistently.

3. DATA

*3.1 **Data collection and sample***

We use a sample of 622 researchers from the CID-KEINS database. The methodology used to build the database largely follows what was implemented for the KEINS database (Lissoni et al., 2006; Lissoni et al., 2008). As such, the CID-KEINS database results from two different sources:

- the EP-INV database produced by Kites (Cespri) - Bocconi University, which contains all EPO applications filed between 1978 and 2001, reclassified by applicant and inventor;
- the Research Assessment Exercise (RAE) 2001 database, which contains data on individual scientists in British universities and higher education institutions in 2001.

The two sources have been combined by means of name matching (based upon surnames and first initials), and an extensive follow-up e-mail survey[1].

The procedure used takes into account the fact that the number of university patents is underestimated when only patents awarded to universities are counted (Geuna and Nesta, 2006; Lissoni et al., 2008). It has been shown repeatedly that a large share of patents with an academic inventor is owned by industry or the inventors themselves. Often academic researchers are engaged in research that leads to a patent, but the university (or the public research centre) does not appear as the patent's applicant[2], perhaps because researchers have private consulting contracts with firms or because the university is involved in a research project with a firm (Verspagen, 2006).

The final CID-KEINS database includes 622 British academic inventors who are responsible for 1622 patents up to the year 2002. 1376 patents have been applied for when the inventor was

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[1] See CID Deliverable D 8.4 for the detailed description of the methodology used to build the dataset.

[2] UK universities and their scientists entertain relationships much more similar to ordinary employer-employee ones, which include the employer's control of IPRs over the employee's inventions, and the empoloyee's duty of disclosure of his inventions to the employer (the only possible exception being Cambridge, where a social norm similar to the professor's privilege was held until recently).

working in a university, while the remaining 246 patents were filed while he was working in a company prior to moving to university.

FIGURE 1 ABOUT HERE

The most productive 25% (150 scientists) of inventors have applied for more than 3 patents (*prolific inventors*), while 47% (291 scientists) have only one patent application (single inventor). Figure 1 displays the distribution of academic inventors by the number of patent applications. The skewness with a long right tail confirms the well-known picture that the number of highly productive scientists is a relatively small fraction of all scientists (Lotka, 1926).

The average academic inventor obtained their PhD degree in 1980 – though there are few researchers, who obtained a PhD before 1960 and only one after 2000 – and applied for 3.10 patents (there is a strong heterogeneity at the discipline level, with an average of 3.81 in the chemical and 2.68 in the medical field).

FIGURE 2 ABOUT HERE

Because we miss personal information (such as the PhD institution) for some of the researchers, the final sample used in the analysis consists of 550 individuals.

3.2 ***Main variables***

Our main objective is to explain how inventors may become highly productive inventors. We use three different categories of academic inventors in relation to their productivity. We define *single inventors,* who have only one patent application, *one spell inventors,* who have more than one patent but who are active at most in two continuous years, and then we define *persistent inventors,* who are prolific (more than 3 patents) and kept on patenting throughout their inventive life (Hoisl, 2007). They represent 48.5%, 34% and 17.5% of total academic inventors respectively. The dependent variable is a categorical outcome, which corresponds to the three discussed categories of inventors.

The more represented universities (see Table A1 in Appendix) are Oxford University (with 53 inventors), Cambridge University (47) and Imperial College (41). The persistent inventors are over-represented in the first two institutions with the 23% and 32% respectively, while are account only for the 9% at the Imperial College.

Table A2 in Appendix shows the distribution of the UK academic inventors by discipline. The disciplines are aggregated unit of assessments which are collected from the RAE. The most represented one is the Medical Science with 170 inventors (around the 27% of the sample), followed by Pharmaceutical and Biology respectively with 102 and 100 inventors.

Interesting, within the disciplines, high heterogeneity emerges in terms of presence of *persistent* academic inventors. Around the 24% of professors patenting in Biological science are persistent, while this figure fall down to less than 13% in Engineering.

We consider two sets of factors, which may be correlated with the inventors' profiles. The first concerns the inventors' characteristics. Among them, we consider AGE, measured as the number of years after the PhD; the researcher's intrinsic ability proxied by SCIENTIFIC QUALITY, which is measured as the average impact factor of the journals of the publications selected for the RAE 2001[3], and DEPARTMENT QUALITY, which reflects the rank of the department according to the RAE 2001 classification. If patenting and publishing activities are correlated (Azoulay et al., 2007, Breschi et al. 2005, Carayol 2007)[4], then we expect a positive relationship of these variables with being a persistent inventor.

Other measures referring to individual characteristics are LATE START, which is the difference between the year of the first patent and the year of the PhD, and TRAINING EFFECT. Many authors have underlined that social institutions, by transmitting a particular set of behaviours and norms, are able to shape individuals sharing the same environment with similar attitudes. Following Bercovitz and Feldman (2008), "individuals trained at institutions where participation in technology transfer was actively practiced will be more likely to adopt these practices in their own careers" (pag.73). Universities differ extremely in the extent to which they support and succeed in the commercialization of academic research (Geuna and Muscio 2009), however since the mid-1990s the number of TTOs has increased dramatically (see Figure 3). In this logic, the presence of TTO may affect considerably the practices and behaviours of researchers in their

[3] We consider this measure as the unobserved and constant individual ability.
[4] Some authors (Fabrizio and Di Minin, 2008; Crespi et al., 2010) found evidence for a non-linear inverted U-shaped relationship.

own careers. TRAINING EFFECT is a dummy, which is equal to one if the inventor was at a university that had already established a TTO at the time of his PhD. A positive relationship with high profile inventors[5] is expected. As discussed in Section 2, scientists training in universities which had already realized technology transfer policies at the time of their PhD were more likely to socialize with patent-oriented norms and routines which in turn made them more likely to disclose inventions than their colleagues that had trained at institutions without TTO.

FIGURE 3 ABOUT HERE

The second set of factors concerns the first patent characteristics. First of all, as discussed in Section 2, initial success in patenting activity may encourage continuous involvement, both for psychological and for economic reasons - academics that have successfully patented in the past might have access to the necessary funding and support needed. We consider a patent as successful if it has been granted (FIRST GRANTED variable) and if it has received a great number of forward citations (PATENT QUALITY is defined as the number of forward citations in the 5 years after the priority date[6]). Positive signs are expected for both measures.

ACADEMIC is a dummy that refers to the inventor' employment status at the time of the first patent (it is equal to one if the scientist was working in university or zero otherwise). If researchers that have been involved in patenting before joining academia are more likely to be familiar with the patenting process (Dietz and Bozeman 2005), then we expect a negative sign. UNIVERSITY APPLICANT intends to capture the ownership of the patent and is a dummy equal to one if the first patent was applied for by the university.

SOLITARY INVENTOR is a dummy equal to one if the inventor is listed as the only inventor on her first patent application. Gay et al. (2008) presented some evidence that persistent inventors are part of large teams. Further, academics may be pulled into a project that results in patents by their older peers and this experience may benefit their future involvement in commercialization. Therefore a negative sign is expected.

Moreover, as controls, we consider dummy variables for different scientific disciplines of the researchers as the propensity to patent differs across sectors (Orsenigo and Sterzi, 2010). As the

[5] 20 UK academic inventors have taken their PhD abroad, the FOREIGN dummy captures this characteristics, and for 35 inventors we miss information on their PhD institutions, the No_PhD INFO captures this characteristics.
[6] The self-citations at the inventor level are excluded to avoid problems of endogeneity.

first patents at the EPO were filed in 1978 – before 1978 patents would need to be filed at different national patent offices – we also need to account for those academics that may potentially have started patenting before the establishment of the EPO. We include a dummy YOUNG that is equal to one if the inventor received her PhD after 1980 to control for this.

The variable definitions and their relevant summary statistics are shown in Table 1.

TABLE 1 ABOUT HERE

4. METHOD

A simple way to estimate the patent productivity characteristic of an inventor is simply to define a categorical variable that is equal to one if the inventor is "prolific", in the sense that he has applied for more than three patents, and 0 elsewhere. This allows us to estimates the role of institutional, personal and invention based characteristics through a simple binary framework (logit and probit models).

However, we think that this approach simplifies the patenting behaviour at the individual level too much: for example, prolific inventors who applied for all patents in a single spell (in the course of one or two years) could be seen as a special case of single inventor, who use several patents to protect one single invention. For this reason, we prefer to consider three different categories as expressed before, to better analyse academic inventors' patenting behaviour.

Thus, we estimate the probability that inventor *i* stays a single inventor, or becomes a one-spell inventor or a persistent inventor. We thus generate a variable Y that assumes 3 different categorical values equal to 1, 2, 3 respectively for the three cases.

We then refer to a simple ordered logit as the following:

$$P(Y_i > j) = g(\beta X_i) = \frac{\exp(\alpha_j + \beta X_i)}{1 + \exp(\alpha_j + \beta X_i)} \text{ , for J=1, 2}$$

(1)

where X_i is a vector of explanatory variables for inventor *i* and *a* and *β* are parameters to estimate. The idea of this model is that the slope parameters *β* of the link function are assumed to be identical across different categories. Only the constant cut-off parameters a_j may differ. An important assumption in this model is the so-called parallel odds assumption. If this assumption were not satisfied, we would not obtain consistent estimates. The Brant test[7] tell us that the proportional odds assumption (parallel odds assumption) is not violated.

5. RESULTS

We illustrate results from four logistic models in Table 2. Column 1-3 consider the simplest case of binomial logit model, where all three productivity categories are pooled into one dichotomous dependent event. Three different cases are considered. In the first case (column 1) the dependent variable is equal to one if the inventor is "occasional", in the sense that he has applied for more than one patents, and 0 elsewhere. In columns 2 and 3 we consider more stringent thresholds: in column 2 the dependent variable is equal to one if the inventor has applied for more than 2 patents, and in the column 3 for more than 3 patents.

TABLE 2 ABOUT HERE

Coefficient estimates show that, controlling for age, intrinsic ability and disciplines, the social imprinting variable (TRAINING EFFECT) and the first patent characteristics both imply a higher probability to become a prolific inventor. In terms of marginal effects, the changes in probabilities associated to inventors training in a university with a TTO during their PhD with respect to inventors training in universities without TTO is more than 16%[8]. Moreover, 34% is the change in probabilities associated to inventors who applied for their first patent while they were in universities rather than inventors in private company. If the discriminatory power of this model is high (as witnessed by a value of the pseudo R^2 of 30 %), we are also interested in evaluating the persistency of the academic patenting activity. We thus refer to a simple ordered logit (OLT).

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[7] We use the Brant command (part of Long anf Freese's spost routine (Long and Freese, 2006)), which gives both a global test on whether any variable violates the parallel-odds assumption and a test of the assumption separately for each variable.

[8] The marginal effects are calculated at the means of the independent variables.

Column 4 and 5 provide results for *Equation 1*. The difference between the two columns is that in column 4 only field dummy are considered, while in column 5 the model takes in to account also the affiliation dummies. The results are very similar and clear: the patenting categorical variable is increasing in TRAINING EFFECT, success of the first patent (PATENT QUALITY and GRANTED) and ACADEMIC. Moreover the positive and significant sign of SCIENTIFIC QUALITY, which is robust to accounting for the affiliation dummies, is in line with previous research and let us speculate on the complementarity of traditional academic publishing and commercialization activity. The SOLITARY INVENTOR dummy is negative but far from being significant; in Section 3 we speculated that academics that appear with co-inventors on their first patent application are receiving more local support and are integrated in a local group of inventors. However, we do not find a significant impact perhaps because we only consider patent applications from the EPO: academics that are less familiar with the patenting process and lack support would mainly patent at the UK Intellectual Property Office (UKIPO), where the cost for application is lower.

6. DISCUSSION AND CONCLUSION

The results presented in this paper present the first attempt to characterise persistent academic inventors and to identify those factors that may explain persistent participation in the innovation process.

We find that researchers, who undertook their PhD studies at a university that had already implemented mechanisms to support technology transfer at the time of the PhD, have a higher propensity to patent persistently throughout their career. This supports findings by Bercovitz and Feldman (2008), who showed that social imprinting at PhD level, is more important than local peer effects. We find, however, no evidence for a positive effect of socialisation in industry on inventorship. Researchers that first appeared as inventors on a patent while working for industry are less likely to become persistent inventors than their peers from academia. This may reflect their choice to return to academia and contradicts findings by Dietz and Bozeman (2005).

We further find that the success of the first patent application to be a good predictor for the propensity to become a persistent inventor. Researchers, whose first application was granted and who received a large number of citations are more likely to apply for more patents. This may be attributed to economic benefits associated with patenting. Patents can help to attract consulting and research contracts with industry by increasing an academic's visibility status and providing credibility to research projects (Audretsch et al. 2006, Jensen and Thursby, 2001). Empirical papers have confirmed this (Crespi et al., 2010; Meissner, 2010).

We do not find a group or team effect in our analysis perhaps due to the extensive costs associated with EPO patent applications. Academics that lack support of colleagues would mainly patent at the UK Intellectual Property Office (UKIPO), where the cost for application is lower.

In line with previous research (Azoulay et al., 2007; Breschi et al., 2005; Carayol, 2007; Meissner, 2011) we find a positive correlation between scientific and commercial output that lets us speculate about the complementarity of traditional academic publishing and commercialization activity.

In terms of policy implications, we conclude that extensive support from the TTO (or a commercial partner) is needed to insure the success of the first patent application. Therefore, it is essential for TTOs to employ knowledgeable patent managers able to file consistent applications. With the introduction of university commercialisation units (TTOs) across the UK, and the increasing emphasis on commercialisation already at PhD level at most universities, we should see more inventors that are persistent in future.

This paper has added some important evidence about the characteristics of academic inventors. Further data in panel structure is needed to address potential endogeneity and to better control for intrinsic ability of researchers.

References

Agrawal, A., Henderson, R. 2002. Putting patents in context: exploring knowledge transfer from MIT. Management Science, 48 (1), 44-60.

Audretsch, D.B., Aldridge, T., Oettl, A. (2006). The knowledge filter and economic growth: The role of scientist entrepreneurship. Max Planck Institute of Economics Discussion Paper No. 1106.

Azoulay, P., Ding, W., Stuart, T. 2007. The impact of academic patenting on the rate, quality, and direction of (public) research output. The Journal of Industrial Economics, 57 (4), 637-676.

Azoulay, P., Graff Zivin, J.S., Wang, J. 2010. Superstar extinction. The Quarterly Journal of Economics, 125 (2), 549-589.

Bercovitz J., Feldman M. 2008. Academic entrepreneurs: organizational change at the individual level. Organization Science, 19 (1), 69-89.

Breschi S., Lissoni F., Montobbio F. 2005. From publishing to patenting: Do productive scientists turn into academic inventors? Revue d'Economie Industrielle 120 (1), 75-102.

Breschi S., Lissoni F., Montobbio F. 2008. University patenting and scientific productivity: a quantitative study of Italian academic inventors. European Management Review, 5 (2), 91-109.

Calderini, M., Franzoni, C., Vezzulli, A., 2007. If star scientists do not patent: The effect of productivity, basicness and impact on the decision to patent in the academic world. Research Policy 36 (3), 303-319.

Carayol, N., 2007. Academic incentives, research organization, and patenting at a large French university. Economics of Innovation and New Technology 16 (1-2), 119-138.

Crespi, G., D'Este, P., Fontana, R., Geuna, A. 2010. The impact of academic patenting on university research and its transfer. Research Policy, forthcoming.

Dietz, J.S., Bozeman, B. 2005. Academic careers, patents, and productivity: industry experience as scientific and technical human capital. Research Policy, 34, 349–367.

Ernst, H., Leptien, C., Vitt, J. 2000. Inventors are not alike: the distribution of patenting output among industrial R&D personnel. IEEE Transactions in Engineering Management, 47 (2), 184–199.

Fabrizio, K.R., DiMinin, A. 2008. Commercializing the laboratory: faculty patenting and the open science environment. Research Policy 37, 914–931.

Gay, C., Latham, W., Le Bas, C. 2010. Collective knowledge, prolific inventors and the value of inventions: an empirical study of French, German and British patents in the US, 1975–1999. Economics of Innovation and New Technology, 17 (1), 5-22.

Geuna, A., Muscio, A. 2009. The governance of university knowledge transfer: A critical review of the literature. Minerva, 47 (1), 93-114.

Geuna, A., Nesta, L., 2006. University patenting and its effects on academic research: The emerging European evidence. Research Policy 35 (6), 790–807.

Goldfarb, B., Marschke, G., Smith, A. 2009. Scholarship and inventive activity in the university: complements or substitutes? Economics of Innovation and New Technology, 18 (8), 743-756.

Goktepe-Hulten, D. 2008. Academic inventors and research groups: entrepreneurial cultures at universities. Science and Public Policy, 25 (9), 657-667.

HEFCE, 2009. Higher education – Business and community interaction survey 2007-2008. HEFCE, London.

Hoisl K. 2007. Tracing mobile inventors-The causality between inventor mobility and inventor productivity", Research Policy, 36, 619-636.

Jensen, R., Thursby, M., 2001. Proofs and prototypes for sale: The licensing of university inventions. American Economic Review, 91 (1), 240–259.

Le Bas, C., Bouklia-Hassane, R. 2010. Prolific inventors: who are they and where do they locate? Evidence from a five countries US patenting data set. ICER Working Paper No. 14/2010.

Link, A.N., Siegel, D.S., Bozeman, B. 2007. An empirical analysis of the propensity of academics to engage in informal university technology transfer. Industrial and Corporate Change 16 (4), 641-655.

Lissoni, F., Llerena, P., McKelvey, M., Sanditov, B. 2008. Academic patenting in Europe: new evidence from the KEINS database. Research Evaluation, 17 (2), 87-102.

Lissoni, F., Sanditov, B., Tarasconi, G. 2006. The Keins Database on Academic Inventors: Methodology and Contents. KITeS Working Paper No. 181.

Long, J. S., Freese, J. 2006. Regression Models for Categorical Dependent Variables Using Stata. 2nd ed. College Station, TX: Stata Press.

Lotka, A.J. 1926. The frequency distribution of scientific productivity. Journal of the Washington Academy of Sciences, 16 (12), 317–323.

Meissner, C., 2010. Can Industry Collaboration Change the Face of Science? The Importance of Research Productivity for Grantsmanship. Mimeo. City University London.

Meissner, C., 2011. Academic Patenting: Opportunity, Support or Attitude. Mimeo. City University London.

Narin, F., Breitzman, A. 1995. Inventive productivity. Research Policy, 24 (4), 507–520.

OECD. 2003. Turning science into business. Patenting and licensing at public research organisations. OECD Publications, Paris.

Orsenigo, L., Sterzi, V. 2010. Comparative Study of the Use of Patents in Different Industries. KITeS Working Paper No. 033.

Rothwell, R. 1992. Successful Industrial Innovation: Critical Factors for the 1990s. R&D Management, 22 (3), 221–239.

Siegel, D.S., Veugelers, R., Wright, M. 2007. Technology transfer offices and commercialization of university intellectual property: Performance and policy implications. Oxford Review of Economic Policy, 23(4), 640–660.

Stephan, P.E., Gurmu, S., Sumell, A.J., Black, G. 2007. Who's patenting in the university? Evidence from the survey of doctorate recipients. Economics of Innovation and New Technology 16 (2), 71-99.

Stuart, T.E., Ding, W.W. 2006. When do scientists become entrepreneurs? The social structural antecedents of commercial activity in the academic life sciences. American Journal of Sociology, 112 (1), 97-144.

Verspagen, B. 2006. University research, intellectual property rights and European innovation systems. Journal of Economic Surveys, 20, 633-690.

William, R. 2006. Generalized ordered logit/partial proportional odds models for ordinal dependent variables. Stata Journal, 6 (1), 58-82.

Zucker, L.G., Darby, M.R. 1996. Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry. Proc. Natl. Acad. Sci. USA, 23 (93), 12709–12716.

Zucker, L.G., Darby, M.R. 1998. Capturing Technological Opportunity via Japan's Star Scientists: Evidence from Japanese Firms' Biotech Patents and Products, NBERWorking Paper No. 6360, Cambridge, Massachusetts.

Zucker, L.G., Darby, M.R., Armstrong, J.S. 2002. Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology. Management Science, 48 (1), 138–153.

Figures and Tables

Figure 1. Distribution of academic inventors by the number of patent applications

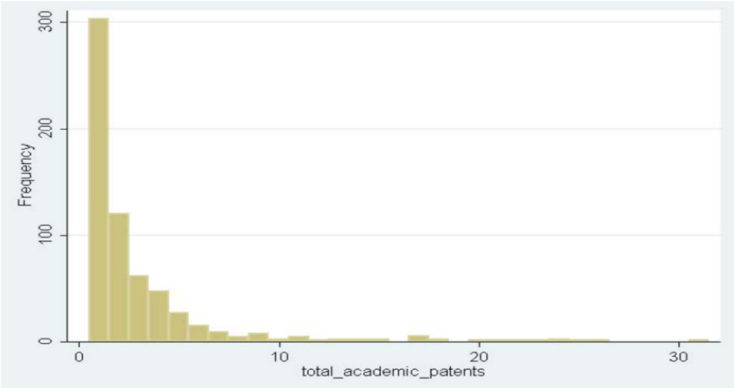

Figure 2. Distribution of academic inventors by PhD year

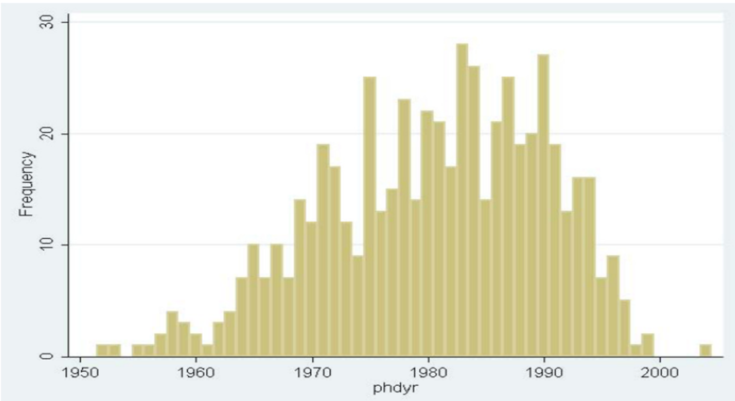

Figure 3. University TTOs foundation by year

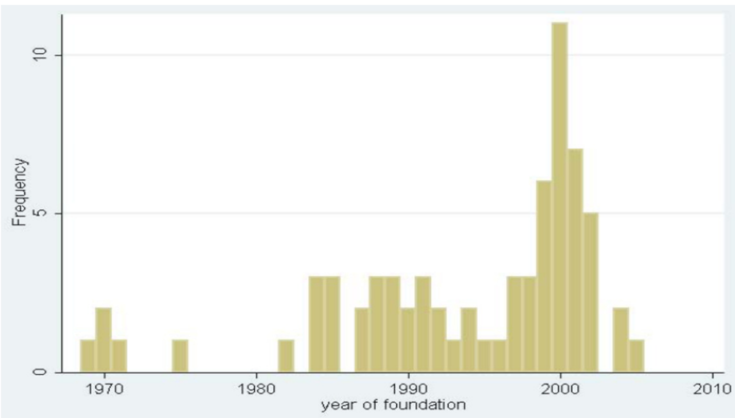

Table 1. Definitions and summary statistics

Variables	Definition	Obs	Mean	Std. Dev.	Min	Max
dependent variable						
single inventor	Inventor with only one patent application	550	0.48	0.5000546	0	1
one spell inventor	Inventor with more than 1 patents and all of them applied in a single spell	550	0.3509091	0.477689	0	1
persistent	"persistent" inventor with more than 3 patents in at least two spells	550	0.1690909	0.3751734	0	1
inventor's characteristics						
age	number of years after the PhD	550	20.29091	9.40773	2	49
female	dummy which is equal to one if woman	550	0.0763636	0.2658208	0	1
scientific quality	average impact factor of the journals of the selected publications sent to the RAE 2001	550	4.794767	4.908495	0.055	29.567
department quality	dummy which equals one if the inventor is in a department evaluated as 6 or 6+ in 2002	550	0.7490909	0.433931	0	1
late start	FIRST PATENT YEAR - PHD YEAR	550	13.47273	8.644053	-5	45
training effect	Dummy = 1 if the inventor was in a university with the TTO during his PhD	550	0.2054545	0.4044012	0	1
foreign PhD	dummy which is equal to 1 if the inventor has taken his PhD abroad	550	0.0672727	0.2507218	0	1
young	young=1 if PhD year >1980	550	0.5436364	0.4985457	0	1
first patent characteristics						
patent quality	Number of forward citations, 5 years window, self citations (at inventor level) excluded	550	2.138182	3.523406	0	33
Academic	it is equal to one if the scientist was working in university or zero otherwise	550	0.9472727	0.2236919	0	1
solitary inventor	is a dummy equal to one when the inventor is listed alone in his patent application	550	0.1072727	0.3097414	0	1
first granted	dummy which is equal to one if the first patent has been granted	550	0.5872727	0.4927727	0	1
university applicant	dummy which is equal to one if the first patent has been applied for by a company	550	0.4218182	0.4942993	0	1

Table2. Logistic estimations of UK academic inventor categories

VARIABLES	(1) Logit >1 patents	(2) Logit >2 patents	(3) Logit >3 patents	(4) OLT	(5) OLT
inventor's characteristics					
age	0.34***	0.31***	0.34***	0.35***	0.40***
	(0.065)	(0.060)	(0.073)	(0.054)	(0.067)
age2	0.00044	-0.00019	-0.0010	0.00065	0.00091
	(0.0012)	(0.0011)	(0.0014)	(0.00095)	(0.0011)
female	0.067	0.27	0.29	0.29	0.10
	(0.40)	(0.43)	(0.46)	(0.35)	(0.41)
scientific quality	0.013	0.037	0.053*	0.047*	0.076**
	(0.027)	(0.029)	(0.031)	(0.027)	(0.030)
department quality	-0.032	0.045	0.044	0.090	-0. 24
	(0.26)	(0.27)	(0.33)	(0.23)	(0.31)
Late start	-0.34***	-0.26***	-0.26***	-0.35***	-0.42***
	(0.041)	(0.031)	(0.033)	(0.030)	(0.040)
TRAINING EFFECT	0.73**	0.62*	0.67*	0.62**	0.78***
	(0.29)	(0.32)	(0.36)	(0.27)	(0.30)
foreign PhD	0.47	0.20	0.13	0.26	0.086
	(0.51)	(0.52)	(0.66)	(0.48)	(0.55)
young	0.53	0.71*	0.70	0.56	0.67*
	(0.41)	(0.42)	(0.48)	(0.36)	(0.40)
first patent characteristics					
patent quality	0.16***	0.082**	0.068**	0.11***	0.13***
	(0.045)	(0.040)	(0.033)	(0.026)	(0.030)
academic	1.46**	1.50***	1.46**	2.15***	2.38***
	(0.63)	(0.54)	(0.57)	(0.46)	(0.58)
solitary inventor	-0.27	0.17	0.063	-0.11	-0.096
	(0.35)	(0.34)	(0.36)	(0.33)	(0.36)
granted	0.52**	0.54**	0.44	0.37*	0.21
	(0.24)	(0.25)	(0.27)	(0.21)	(0.24)
university ownership	0.16	-0.22	-0.29	0.058	0.19
	(0.23)	(0.25)	(0.31)	(0.21)	(0.25)
Constant	-4.63***	-6.25***	-7.11***		
	(1.08)	(1.14)	(1.32)		
cut 1				5.43***	4.91***
				(0.93)	(1.48)
cut 2				8.45***	8.44***
				(0.99)	(1.54)
Field dummy	yes	yes	yes	yes	yes
Observations	550	550	550	550	550
Pseudo R2	0.34	0.31	0.32	0.32	0.41
Log Pseudo-Likelihood	-252.60259	-237.99902	-200.35622	- 383.41637	-332.6256
Brant test (p-value)				0.178	

In the Ordered logit models the dependent variables assumes three different values: 1 if the inventor has applied for only one patent; 2 if the inventor has applied for more than three patents but in the same spell; 3 in the other cases, i.e. when the inventor has applied for more than three patents and in different years. A dummy controls for the scientists for which we miss information on their PhD (4% of the sample). Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

APPENDIX

Table A2. Top 10 universities.

	single inventors	*one spell* inventors	*persistent* inventors	*all* inventors
University of Oxford	21	20	12	53
University of Cambridge	19	13	15	47
Imperial College	19	18	4	41
University College London	15	12	2	29
University of Nottingham	9	12	5	26
University of Sheffield	13	11	1	25
University of Bristol	14	5	2	21
University of Manchester	8	9	3	20
King's College London	9	6	2	17
University of Southampton	9	5	3	17
Queen Mary, University of London	7	6	3	16
University of Strathclyde	8	6	2	16

Table A1. Breakdown of academic inventors by discipline.

Discipline	single inventors	one spell inventors	persistent inventors	*all inventors*
Medic	47.6%	36.5%	15.9%	*170*
Pharma	51.0%	34.3%	14.7%	*102*
Biol	37.0%	39.0%	24.0%	*100*
Chem	59.2%	22.4%	18.4%	*49*
Phys and ElecEng	53.2%	33.8%	13.0%	*77*
ChemEng	42.2%	46.7%	11.1%	*45*
MechEng and GenEng	55.7%	31.6%	12.7%	*79*

International Cooperation in Pharmaceutical Research

Anna Rita Bennato* Laura Magazzini†‡

August 2, 2011

Abstract

This paper aims at examining whether an increased stringency of Intellectual Property Right (IPR) protection is apt to stimulate international cooperation on research projects between developed and emerging countries. To address this issue, we look both at scientific and technological collaborations within the pharmaceutical domain, and we adopt a gravity framework to assess the impact of the IPR level on bilateral R&D cooperation. The analysis is conducted using data from patent and publication databases, and the results provide a sound test of conflicting theories on IPR enforcement and international collaborations in pharmaceutical research.

Keywords: IPR, pharmaceutical products, R&D co-operation.
JEL classification: F13; O34; O57.

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1 Introduction

In the last decades the need to have a stronger system of Intellectual Property Rights (IPR) has been one of the most debated questions for many countries. On this regard, the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) has represented an important evolution of the IPR regime at the international level. The new rules have been introduced to establish a minimum standard in the protection of the IPR, with the aim to facilitate the transfer of innovation among countries, and to foster the cooperation between the developed and developing world.

It is widely recognized that an effective IPR system may facilitate the transfer of technology in the market for ideas (Nelson and Merges, 1990; Arora *et al.*, 2001; Gans *et al.*, 2002), where organizations prefer to rely on cooperative agreements rather than engage in competition, especially among R&D intensive industries (see D'Aspremont and Jacquemin, 1988; Lerner and Merges, 1998; Hagedoorn, 2002). By cooperating, firms take the advantage to share the cost related to the R&D investments along with a reduction of those investments connected with the commercialization of the invention (Gans *et al.*, 2002). Moreover, R&D collaboration with other sources located in different countries allows firms to engage in joint research programs that offer additional resources targeted to the local needs (Correa, 2007).

To this end, the degree of IPR protection represents a crucial factor in the decision-making about international R&D partnering (Hagerdoorn, *et al.*, 2005). An effective protection of IPR may create incentives to invest in those countries where the development of new invention was based on the imitation process.

Despite the growing theoretical literature about the role played by patents in the innovation process, only scattered empirical evidence is available about the effect of the new IPR system on cooperation and technology transfer at the international level.

In this paper we report a novel empirical strategy to examine whether the increased strength of IPR protection, introduced by the TRIPs agreement, is able to effectively spur the technology transfer measured by international cooperation between selected WTO members. We consider both technological and scientific collaborations focusing on the pharmaceutical industry. The selected industry is the leading example of a science-based sector (Pavitt, 1984), therefore it is important to look at the dynamics characterizing the collaborations both in science and technology. The drug development process heavily relies on the advances in basic understanding of biological processes.

Using a gravity approach, we build a dataset covering a broad international panel of countries over the period from 1978 to 2010, and count the number of patented drugs and health-related publications jointly signed by researchers located in the developed and developing world. Patents and scientific publications are widely used to proxy, respectively, technological and scientific capabilities of economic agents (Griliches, 1990; Han, 2007).

We use as a natural experiment the new regulations introduced by the TRIPs agreement. Although, the agreement came into force on January 1st, 1995, all developing countries were allowed to retain their own national patent regime until 2000, with special transition rules applied to areas of technology where patent protection was not provided at signing. Pharmaceutical products are the leading example of such a sector, and full protection was required from 1st January 2005.[1] The required changes led by the reform provide an unique opportunity to estimate the impact of a stricter IPR system on technological and scientific cooperation.

Of course the patent system is not the only mechanism available to spur innovation efforts (Chin and Grossman, 1990). Secrecy and licensing agreements can be more effective than patents in the appropriation of the returns from R&D (Cohen *et al.*, 2000; Gallini and Scotchmer, 2001). However, patent protection is particularly relevant in our field of exploration, i.e. the pharmaceutical industry, as this sector does widely rely on patents to appropriate the returns from R&D investments (Cohen *et al.*, 2000; Guellec, 2007).

Our results indicate that the stronger protection of IPR has failed to provide a stimulus to technological pharmaceutical collaborations between the analyzed WTO members, as measured by joint patents. Our finding is in line with the theory that sustains a positive causal relationship between competition and innovation. A reduction in the imitation process due to a stronger patent protection causes a fall in the rate of innovation (see, among others, Aghion *et al.*, 2001, 2005). On the contrary, we find that scientific collaborations benefit from a stronger IPR regime, providing new evidence in the literature discussing the effect of IPR on scientific research (Heller and Eisenberg, 1998; Murray and Stern, 2007; Lach and Schankerman, 2008).

The paper is organized as follows. Section 2 reviews the main literature about international technology transfer and cooperation. Section 3 describes the data and empirical measures used in the analysis, while in Section 4 we test the effect of increased protection of IPR on technological and scientific collaborations and we report our findings. Finally, Section 5 concludes.

[1]The least-developed members of WTO have been recognized the possibility to postpone the enforcement of the new rules to 2016 (see http://www.wto.org/english/tratop_e/trips_e/factsheet_pharm04_e.htm).

2 Literature Review

By means of technology transfer, scholars refer to the wide process by which institution and organizations *interact* with the aim to generate and promote new ideas (see, among others, Bozeman, 2000). No direct measure of international technology transfer exists, and both theory and empirical evidence have relied mainly on material measures, such as foreign direct investments (FDI), trade flows, as well as royalty payments and patents (Gans *et al.*, 2002). Following Bozeman's definition, we compute technology transfer by counting the number of joint patents and publications at the international level. Even though this is admittedly one of the many forms of collaborative research, it has been chosen because it involves direct communication between researchers in the two countries. As a matter of fact, face-to-face situations are essential for ensuring the transfer of both codified and uncodified (tacit) knowledge (Teece, 1981).

The theoretical literature provides grounds to the idea that an increase in the stringency of the IPR can be beneficial for the transfer of technology (e.g. Grossman and Lai, 2004; Valletti and Szymanski, 2005). With an effective IPR system the innovator is more willing to operate where the imitation process is not allowed (Lai, 1998). In a model with endogenous imitation and innovation, a tighter patent law makes more costly the imitation process. As a result, innovators find it advantageous to reallocate their production in those countries where the new IPR system have been introduced (Branstetter and Saggi, 2009). These models follow the Schumpeterian approach according to which the innovation is driven by those firms which become monopolist thanks to the exclusive use of their invention. However from an opposite point of view, if the imitation process is allowed, due to the presence of a neck-to-neck competition, a firm may have incentive to innovate as first (see, among others, Blundell *et al.*, 1999; Aghion *et al.*, 2001, 2005).

Although the theory indicates that the scales are tipped in favor of a positive relationship between IPR and FDI, the empirical evidence is far from being sufficient to confirm this conjecture. It seems that the relationship weakens at higher levels of protection, and the effect is largely dependent upon the characteristics of the country in terms of FDI, import flows, and income level. In particular, in assessing the effects on FDI, we have to consider also that a stronger IPR system causes a reduction in the cost of enforcing licensing contracts, making the use of licensing more attractive, further enhancing the volume of FDI (Yang and Maskus, 2001). Much of this literature underlines how IPR alone is not able to work as incentive to knowledge transfer, also large markets and strong technological capabilities are required (Grossman and Lai, 2004).

Under a different perspective, other studies underline the role of trade in driving innovation and technology transfer between countries. The basic idea builds on the fact that imports act as a means through which new technologies can be introduced in the receiving countries. Maskus and Penubarti (1995) have used an extended version of the Helpman-Krugman model of monopolistic competition to measure the effect of the patent protection on international trade flows. Their study points out how an increase in the stringency of the IPR can have a positive impact in terms of increased flows of bilateral trade in developing countries. Their results are confirmed by Primo Braga and Fink (1997), who show a positive link between tighter patent protection and manufacturing trade flows. Empirical works analyzing the impact of IPR reforms often do not take into account the efficacy of enforcement, strictly correlated with country's characteristics. Branstetter *et al.* (2006) analyze whether a stronger IPR system accelerates technology transfer. Building on affiliate-level data and aggregate patent data of US multinational firms over the period 1982-1999, they study the effect of patent protection reforms on the royalty payments and R&D expenditures. Their results show that stronger IPR encourages multinational firms to engage in larger technology transfer, as they find a significant rise in the number of patents filed by nonresidents after the IPR reform.[2] More recently, Park and Lippoldt (2008) have studied how trade flows (including licensing and FDI) for different sectors could serve as a means for technology transfer directed toward the developing countries. They investigate the role played by the strength of the new IPR system, as proxied by a set of indicators that includes patents, copyrights and trademark rights. Their results show that trade inflows in developing countries are positively associated with the strength of patent protection, where an enforced IPR system facilitates foreign investments for the development of new innovations.[3] On the contrary, evaluating the effects of TRIPs agreement on new medical treatment, Kyle and McGahan (2011) show that litte R&D efforts have been addressed outside developed countries.

Despite the growing literature about the strategic use of R&D cooperation (e.g. Katsoulacos and Ulph, 1998; Hagedoorn, 2002; Belderbos *et al.*, 2004), little evidence has emerged on its employment under a strengthened IPR system. Firms and institutions may resort to cooperation with the aim to source new ideas for innovations, reducing at the same time the uncertainty associated with these investments. Parallel to this scope, the use of R&D partnerships might be driven by the need to open up new markets or to enlarge market share, and cooperation is likely to happen among rivals (d'Aspremont

[2]However, nothing can be inferred on the welfare effects of a stronger IPR system for these countries, because the analysis does not take into account the impact of the reforms at the national level.

[3]Even though the IPR system encourages firms to invest in R&D devising new technology, the same system discourages them to introduce the second generation products (Scotchmer, 1991).

and Jacquemin, 1988).

International R&D partnerships are very much dependent on the legal system in place in the country partners. A well define IPR system might work as an attraction force for R&D cooperation, especially at an international level where it is expected to be a decisive factor (Coe, *et al.*, 2009). Exhibiting the characteristic of public good, the introduction of new knowledge may be prevented from a weak patent system especially in those countries where innovation has relied mainly on the imitation process. Instead, with certain appropriability of property rights, joint R&D investments are able to generate positive spillovers, especially among those industries that hinge mainly on patents for the appropriation of R&D returns (Griliches, 1990).

In the Science domain, a growing "anti-commons" argument points to the negative effect of IPR on the free flow of scientific knowledge, by limiting researchers in building on available discoveries (Heller and Eisenberg, 1998). Cooperation within universities and research institutes is generally aimed at different targets, for which the patent system is thought to be irrelevant (Dasgupta and David, 1994). On the contrary, some evidence is provided of a negative impact of IPR protection on the diffusion and utilization of scientific knowledge. Murray and Stern (2007) compare publications whose knowledge is also covered by a patent with publications that are not associated to any patents. By taking into account the dynamics in the citation rate, the authors find that the citation rate of patent-paper pairs (i.e. patent and paper exploiting the same piece of knowledge) declines approximately 10 to 20 percent after the associated patent is granted. However, in a recent analysis Lach and Schankerman (2008) show that research outcomes benefit of pecuniary incentives. Royalty share have some real effects on university research and licensing outcomes, thus suggesting that the IPR regime can positively affect scientific productivity (Lach and Schankerman, 2008).

In this paper we take a dual approach, and we analyze the effect of strengthening IPR both on technological and scientific *collaborations* at the international level in the pharmaceutical domain. We take into account the joint signature of patent documents and scientific articles by researchers located in different countries, providing novel empirical evidence on the role of IPR regime in affecting international cooperation in pharmaceutical R&D.

3 Data and measures

Data about the international cooperation in pharmaceutical R&D are drawn and integrated from different sources. Our measure of technological and scientific collaboration pivots on the information contained in patents and publications. The variables were constructed employing ad hoc queries on *FreePatentsOnline* search engine for inventions (patents) related to pharmaceuticals,[4] and from *ISI Web of Knowledge* for the peer-reviewed research articles published about health-related subjects.[5]

The analysis focuses on collaboration between the developed world and emerging economies. On the one side, we considered North America, i.e. USA and Canada, European countries (including Switzerland due to the presence of the headquarter of top pharmaceutical firms), and Japan. On the other side, emerging pharmaceutical markets are considered, namely Brazil, China, India, Mexico, Russia, South Korea, Turkey. [6]

Based on patents, a measure of technological collaboration between two countries is computed exploiting the information about the country reported in the address of the applicant(s).[7] An international collaboration is counted if a patent is signed by applicants located in two different countries. With this regard, empirical literature has shown that alliances promote technological transfer (Gomes-Casseres *et al.*, 2006); and we use the number of jointly-signed patents as a proxy for successful alliances (Kim and Song, 2007). In order to identify pharmaceutical patents, the classes A61K and A61P of the International Patent Classification (IPC) are considered.[8] The patents granted over the period 1978-2010 have been extracted from the database.

Information about health-related research articles published over the same time period are drawn from *ISI Web of Knowledge*.[9] The database reports the affiliation of all the authors involved in a publication, along with their full address. A scientific col-

[4]The *FreePatentsOnline* search service enables full-text search of published international patent applications from 1978 (see http://www.freepatentsonline.com). The analysis of international collaboration is based on the count of patents submitted to the World Intellectual Property Organization (WIPO), i.e. patents under the Paris Convention Treaty (PCT) are considered. These patents have been preferred to patents applied for at national offices (e.g. NBER patent database comprising patents granted by the US patent and trademark office, or patents at the European patent office), as we expect patents jointly applied for by developed and emerging countries to be intended to protect innovations both in the developed and emerging countries, and WIPO-PCT is intended to get such a wide coverage.

[5]See http://apps.isiknowledge.com.

[6]The selected countries were originally identified by a leading consultant firm in the health care industry as the emerging pharmaceutical markets (IMS Health; see http://www.imshealth.com). These countries are included among the developing countries by the World Bank with the exception of South Korea (among high-income countries from 1997).

[7]The applicant (or assignee) is the organization who first claims to be the inventor and holds full rights to the innovation.

[8]The class A61K includes "preparations for medical, dental, or toilet purposes", whereas the class A61P considers the "therapeutic activity of chemical compounds or medicinal preparations". For further details see: http://www.wipo.int/classifications/ipc/ipc8/?lang=en.

[9]Since journals publish scholarly material in a variety of matters, we confine our data to research articles that are defined by their health-related contents. Particularly, the database was queried for articles containing the following terms: pharma OR biotech OR drug OR therapeutic OR disease OR medical.

Park index		1995	2000	2005
Emerging markets	Mean	2.570	3.493	3.904
Developed countries	Mean	4.273	4.506	4.555

Table 1: Average value of Park index for the emerging markets in our study (Source: our computations on Park, 2008).

laboration between two countries is considered if the publication is jointly signed by researchers located in both countries (Glänzel and Schubert, 2005).

Besides the number of collaborations, *FreePatentsOnline* and *ISI Web of Knowledge* are also employed to measure the total production of each countries, respectively in terms of pharmaceutical patents and scientific publications (Griliches, 1990; Han, 2007).

Two measures of the level of IPR protection are considered. We rely on data provided by the *World Economic Forum* (WEF) and also published by the *Economic Freedom Network* (EFN, see Gwartney *et al.*, 2008), henceforth referred to as PIPR (protection of IPR) index,[10] as well as on the index of IPR protection developed by Park and colleagues (Ginarte and Park, 1997; updated in Park, 2008). The latter measures the strength of patent protection by aggregating five separate scores on coverage, international treaties, duration of protection, enforcement mechanisms, and restrictions (Park, 2008). On the contrary, the index developed by the WEF is based on a survey capturing the opinion of business executives about IPR protection. It comprises information not only based on the subject matter that can be patented, but also about the length of protection, the mechanisms for enforcing patent rights, the evolution of the international patent laws (Park and Wang, 2002). The index measures the strength of the legal structure and security of IPR.

Average values of the Park index for the countries included in the study is presented in Table 1, whereas the evolution of the PIPR index is reported in Figure 1.

[10]The Global Competitiveness Report relies on the Executive Opinion Survey, by which participants evaluate on scale of 1 (the lowest) to 7 (the highest), the current conditions of their operating environment. The Survey is carried out among (mainly large) firms representing the main sectors of the economy, asking questions about different aspects of the economy (including, e.g. institutions, infrastructures, higher education and training, etc.). As for our analysis, executives are asked to provide a rate to intellectual property protection (including anti-counterfeiting measures) in their own country, with 1 corresponding to very weak protection and 7 to very strong protection. This index is the source of the data published by the EFN (Gwartney *et al.*, 2008), that is tranformed on a 0-10 scale. We used data from both sources keeping the 0-10 scale measure (For complete methodological details see www.weforum.org and www.fraserinstitute.org). More specifically, the EFN reported the index of protection of IPR before the year 2005 and then switched to the more general index of protection of property rights. For the years 2005-2009, we accessed the data by the WEF for the index of protection of IPR (transforming the index from the 1-7 to the 0-10 scale).

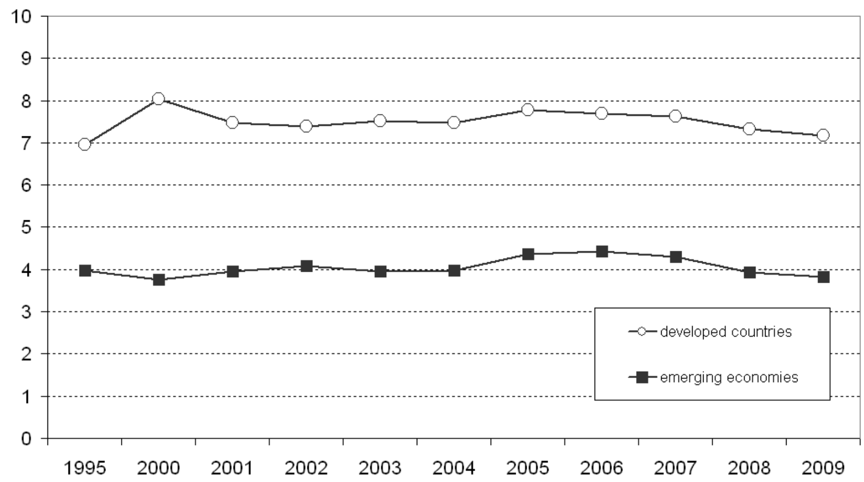

Figure 1: Average value of the index of protection of IPR, 1995, 2000-2009 (Source: our computations on WEF and EFN data)

The Park index shows an increase in the protection of IPR by emerging economies (from 2.570 in 1995, to 3.904 in 2005), even though the index is still lower than the corresponding value for developed countries (3.904 versus 4.555 in the latest avaiable time period). The PIPR index shows a slight increase in the year 2005 for the emerging markets, but in the year 2009 figures are back to pre-2005 values. The general perception about the effect of TRIPs on IPR protection decreases few years after its full adoption in the emerging markets.

4 Methodology and results

Gravity models have been successfully employed for studying the determinants of bilateral flows (Anderson and van Wincoop, 2003). Building on the Newton's law of universal gravitation, the model posits that the flow F_{ij} between two countries i and j is proportional to their "masses" (respectively M_i and M_j) and inversely proportional to the distance between them D_{ij}:

$$F_{ij} = \frac{\beta_0 M_i^{\beta_1} M_j^{\beta_2}}{D_{ij}^{\beta_3}} \tag{1}$$

The gravity equation has been most commonly applied to study trade flows, but it has also been employed to study migration flows, equity flows, FDI, and knowledge flows (see e.g. Portes and Ray, 1998; Peri, 2005). Previous literature has also considered a gravity framework for studying the internationalization of R&D activities looking at joint patents by inventors/applicants from different countries (Picci, 2010).

The empirical literature has taken into consideration various forces on the right hand size, such the effect of common language or international treaties (see e.g. Anderson and Van Wincoop, 2003). We investigate whether there is a role for more stringent IPR in fostering technological and scientific collaborations between developing and developed world. Particularly, we aim at understanding whether the increased stringency in IPR in the emerging markets has resulted in an increased collaboration with the developed world.

In order to obtain an estimate of the parameters in equation (1), the model is customarily log-linearized and ordinary least squares is applied. This traditional approach has been recently subject to a strong critique, as it fails to provide a consistent estimate of model elasticities if heteroschedasticity is present in the original equation (Santos Silva and Tenreyro, 2006). As a robust alternative, the Poisson pseudo-maximum likelihood estimator is to be preferred, allowing the researchers to solve the consistency issue, as well as the possibility of zero flow between two countries.

In our analysis, the empirical assessment of the technological and scientific collaboration relies, respectively, on the number of patents co-applied by agents located in countries i and j, and on the number of joint publications by scientists located in countries i and j.

Let C_{ijt} be the measure of technological and scientific collaboration between country i and country j at time t. Collaboration between North American and European countries (i) and selected emerging markets (j) is taken into account. A gravity equation is considered, where we include the IPR regime of country j ($PIPR_{jt}$; $ParkI_{jt}$, generally referred to as IPR_{jt}) among the attraction forces:

$$E[C_{ijt}|X_{ijt}] = \exp(\beta_0 + \beta_1 \log M_{it-1} + \beta_2 \log M_{jt-1} + \beta_3 \log IPR_{jt} + \tau_t + \alpha_{ij}), \qquad (2)$$

with α_{ij} representing a dyad-specific characteristics that are invariant over time (including geographical distance), M_{it-1} and M_{jt-1} the "masses" of, respectively, country i and j,[11] and IPR_{jt} measures the level of enforcement of IPR, proxied using both the index of IPR protection published by WEF/EFN (PIPR) and the Park index (Park, 2008). Time dummies are included in all specifications (τ_t).[12]

[11]One-year lag is considered in order to avoid endogeneity, as masses at time t also include cooperation at time t.

[12]Over the analyzed time period, the Park index is only available for two years: 2000 and 2005.

In order to proxy M, the international trade literature has relied on GDP and population measures. Following the Schumpterian tradition, here we make use of the patent stock per country when analyzing the technological collaborations, and the publication stock in the case of scientific collaborations in order to measure technological and scientific capabilities at the country level within the pharmaceutical domain (Han, 2007).[13] The stocks are defined as

$$G_{k,t} = P_{k,t} + (1 - \delta)G_{k,t-1}, \tag{3}$$

with k representing the country index and t is measured yearly from 1978 to 2010.[14] We rely on the industry-specific estimate of the depreciation rate provided by Park and Park (2006). We apply the value for the chemical sector (also comprising pharmaceuticals) considering $\delta = 13.11\%$.[15]

The model is estimated using the pre-sample mean estimator (PME) proposed by Blundell *et al.* (1995; 2002) that allows for correlated fixed effects α_{ij} and predetermined variables (see also Windmeijer, 2008).[16] The estimator allows us to explicitly tackle the possibility for correlation between the regressors included in the model and the dyad-specific component α_{ij}.[17] The pre-sample mean estimator is preferred to a fixed effect Poisson estimator as it also allows for the presence of feedback effects between the variables on the right hand side and the error term. We expect a dynamic effect to be at work in this context, where collaborations at time t could produce beneficial effects for both countries at time $t + 1$ and enhance the production of knowledge. Standard errors are estimated using the methodology proposed by Cameron *et al.* (2006) that allows cluster-robust inference in the case of non-nested two-way clustering.[18]

Therefore the number of available observations is drastically reduced. In order to solve this issue, we follow Picci (2010) and "extend" the Park index, imputing the value for the year 2000 to the years 2001 and 2002, and the value for the year 2005 to the year 2003-2007.

[13] In (unreported) preliminary analysis we experimented with various measures including GDP, R&D expenditure, the number of researchers, and pharmaceutical production. The results were largely unsatisfactory as the coefficients associated to these measures were largely insignificant posing concerns about the ability of selected proxies to act as a measure of the "mass" of the countries.

[14] As the number of international patent applications were negligible before the year 1990, in the case of patent, the knowledge stock is computed considering data from 1990.

[15] Pharmaceuticals and chemicals patents are characterized by slow rates of depreciation (Schankerman, 1998). Different studies show that the pharmaceutical R&D (both basic research and applied research and development) use a declining balance formula with a depreciation rate no greater than 15% (Hall *et al.*, 2005).

[16] Estimates are performed using Stata 11 (`gmm` command).

[17] As a result, we are not able to estimate the effect of the distance between the two countries (as time-invariant, and therefore included in α_{ij}). However, this effect is not directly of interest to our research.

[18] In our context, it is not possible to assume independence among the dyads. As an example, dyad ij is correlated with dyad ik even if $j \neq k$, due to the presence of county i in both dyads.

Variable	Mean	Std. error	Min	Max
Patents				
pt_coop	3.886	15.74	0	152
M_i (patent)	3780	7647	5.035	47444
M_j (patent)	702.6	957.6	4.248	8634
Publication				
pu_coop	58.48	145.6	0	2561
M_i (publication)	51891	80845	1194	457312
M_j (publication)	13054	12163	3117	156464
Protection of IPR				
PIPR	4.056	1.089	1.900	7.300
Park index	3.699	.4936	2.270	4.330

Table 2: Descriptive statistics

As in the case of technological collaboration, our data record a large incidence of zeroes (about 75% of observations record no jointly signed patent), we also take into account the decision to enroll in a collaboration where the dependent variable identifies a binary outcome: $\tilde{C}_{ijt} = 1$ if at least one joint patent/publication is recorded between country i and country j at time t , i.e. $\tilde{C}_{ijt} = 1$ if $C_{ijt} > 0$. A probit model is considered.[19]

Application of the pre-sample estimator is allowed by the availability of information on the dependent variable before the year 2000 (corresponding to the first year from which data about IPR protection as measured by PIPR are continuously available). Particularly, we collected information about joint cooperation in patents and scientific publications from the year 1978.[20] Descriptive statistics of the variables included in the regressions are reported in Table 2.

Figure 2 depicts the dynamics of the average value of our dependent variables. The year 2004 (right before the deadline for TRIPs enforcement) seems to be a break-point in the dynamics characterizing collaboration in patents, whereas this is not the case for scientific publications. Need it here to stress the fact that patents are recorded according to the application date, that is closer to the actual timing of the patented invention than the publication date. This explains the lower value of collaborations in patents recorded in 2010.[21]

[19] In the case of scientific publications, only 3% of the observations record no collaboration, therefore the analysis only relies on count data models.

[20] However, in the case of patents, due to the limited number of PCT application before the year 1998, only the years 1998 and 1999 are used to compute pre-sample averages.

[21] Put it differently, patent data for the year 2010 are censored, due to the time lag between the

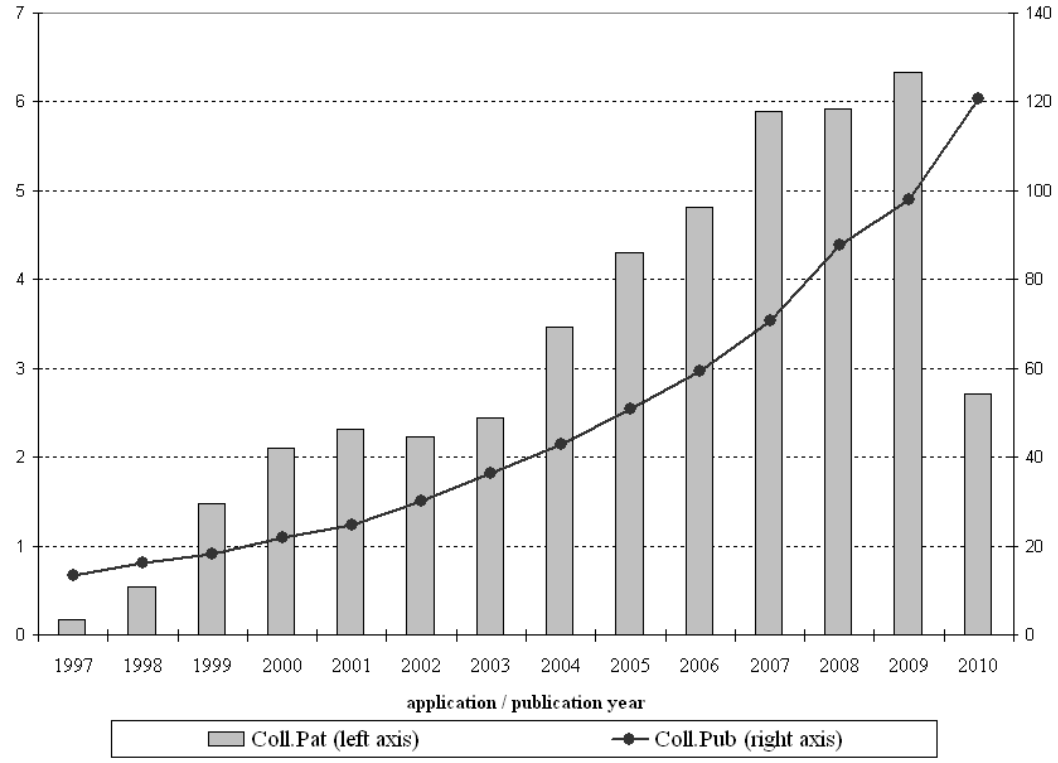

Figure 2: International R&D collaboration in patents (bar, left axis) and publications (line, right axis), sample average

Table 3 reports the estimation of the model of technological collaboration as in equation (2), taking into account the number of, respectively, patents and publications jointly located in country i and j.

The country masses M_i and M_j (as measure by knowledge stock), all have the expected sign and are statistically significant. The larger the knowledge base of each countries involved in the collaboration, the higher its "attraction force".

With regards to the stringency of IPR, a different effect of the new rules introduced by the TRIPs agreements on technology and science is highlighted by the regressions.

The index of IPR protection exerts a negative effect on research cooperation gauged by patents in pharmaceuticals. Stronger protection of IPR fails to provide a spur to technological collaboration between countries, as measured by the joint ownership of the rights to innovation (trough patents) in pharmaceuticals. One possible explanation is that these results represent a premature investigation on the effects of the stringency of IPR in those countries for which the patent protection belongs to the recent history. However, these results confirm the theoretical prediction of some studies for which increased national patent protection cuts competition, diminishing the incentives for more investment in R&D (Helpman, 1993; Aghion *et al.*, 2005).

Within the pharmaceutical domain, although the increased strength of IPR protection has not risen technological collaborations, we find a positive influence on the number of joint publications. The opposite sign of our results on technological and scientific collaborations could be explained considering the dual nature of scientific knowledge. In the long term R&D investments, in particular, the distinction between basic and applied research tends to vanish. Following the "Pasteur's Quadrant" terminology (e.g. Stokes, 1997), joint research projects are carried out with the complementary goals of creating a product having a commercial value (patents), and broadening the scientific knowledge (publications) (Gans *et al.*, 2011). What our results seem to suggest is that the use of the patent in pharmaceuticals is likely to be postponed to later stages in order to favor further efforts in the research process starting from the initial idea (Heller and Eisenberg, 1998). In particular, this is true when scientists are independent to address their research following their own interests (Aghion *et al.*, 2008). The "anti-commons" literature points exactly to the proliferation of patents as the cause of resources underutilization, since the presence of numerous patent owners obstacles future cooperation

application date and the publication date (on average 1 year when PCT-WIPO patents are considered, based on our computations). The data for the year 2009 and 2010 will not be used in the regressions analyzing collaboration in patents. On the contrary, all available observations are exploited in the estimation of the publication equation. Still, data about $PIPR$ are available over the period 2000-2009. On the contrary, all available time periods are used in the analysis of joint publications.

	Patents						Publications		
	Probit MLE	Probit MLE	Probit MLE	Count PME	Count PME	Count PME	Count PME	Count PME	Count PME
IPRR measure	PIPR	Park	Park[(a)]	PIPR	Park	Park[(a)]	PIPR	Park	Park[(a)]
M_{it-1}	.7123***	.6965***	.7357***	.6386***	.7459***	.6975***	.3218***	.2685***	.2927***
	(.0435)	(.0881)	(.0625)	(.0753)	(.0300)	(.0041)	(.0383)	(.0547)	(.0514)
M_{jt-1}	.5397***	.6625***	.4315***	.6847***	.7753***	.6700***	.6531***	.6405***	.6552***
	(.0804)	(.0906)	(.0391)	(.0886)	(.1395)	(.0799)	(.1759)	(.2152)	(.1865)
$IPRR_{jt}$	-.9881**	-2.675***	-.8803***	-.3634	-3.689***	-1.020***	.3432**	1.157***	.3901***
	(.4867)	(.8491)	(.3116)	(.5844)	(.4246)	(.1381)	(.1586)	(.3467)	(.0837)
Pre-sample				.9760***	.9362***	.9238***	.7992***	.8769***	.8427***
				(.0639)	(.0670)	(.0498)	(.0813)	(.0653)	(.0753)
Constant	-6.022***	-4.478***	-3.985***	-7.139***	-5.166***	-5.027***	-7.538***	-8.005***	-8.242***
	(.4364)	(.9994)	(.7758)	(1.030)	(.1929)	(.6508)	(1.542)	(2.258)	(1.865)
Obs.	1071	238	952	1071	238	952	1190	238	952
Log-lik.	-403.86	-80.97	-343.76	–	–	–	–	–	–

Time dummies included in all specifications.
Statistical significance: *** 1%, ** 5%, * 10%.
Standard errors robust to multi-way clustering in parenthesis (Cameron *et al.*, 2006).
[(a)] Value of the Park Index for the year t is used for the period $(t-2, t+2)$ (Picci, 2010).

Table 3: Gravity model of research cooperation, patents and scientific publications

in research (among others see Heller and Eisenberg, 1998). The likelihood of this contention, of course, needs to be verified in the future using a longer time span. Moreover, the decline in joint patents following the IPR reform might be explained considering that a better defined system of rules about IPR presumably favors scientific cooperation among scientists in developed and emerging countries, making unnecessary the recourse to the patent to protect an idea at the early stage of the research process.

5 Concluding remarks

In this paper we answered the question whether the dynamics of the international cooperation in pharmaceutical research changes in response to an increased stringency of the IPR protection. This research has been motivated by the recent trends in the protection of the IPR system at the global level. Little evidence is available about this issue and we contributed to the literature by exploring the effect of IPR on the research cooperation at the international level.

Cooperation in R&D is a key factor in the pace of innovation if we consider that the disclosure of new ideas depends on a complex and interacting set of institutions, and the joint ownership in R&D investment is a widely used strategy.

We estimated a gravity framework on the number of joint patents and scientific publications, focusing on the pharmaceutical research cooperation between developed and developing countries. We obtained evidence of a negative effect of the stringency of the IPR protection on the level of technological collaboration (joint patents), whereas positive influence seems to be exerted on scientific collaboration (joint publications). This opposing results might be explained referring to the recent "anti-commons" literature where the use of patents at the early stage of the research process curbs the competition, slowing down the rate of innovation. On the other hand, a decline in joint patents could be explained by arguing that a more reliable system of IPR makes patents no more necessary to be applied at the very beginning of the innovation process.

Two limits of our work have to be acknowledged. First, we examined the research efforts between countries, but not tackle the issue of the effectiveness of a stricter IPR system in promoting technological innovation at the country level, along with an assessment in terms of economic growth. Second, our definition of collaboration relies on jointly signed patents and papers, which is admittedly a narrow form of collaboration, but nonetheless entailing the transfer of both codified and uncodified knowledge.

Finally, since the reform of the IPR system is very recent, interesting would be in future to consider a longer time span, along with a wider set of industries, in order to let the countries develop the institutions and capabilities apt at fostering collaboration between the developed and the developing world.

References

[1] Aghion, P., Harris, C., Howitt, P., Vickers, J. (2001), "Competition, Imitation and Growth with Step-by-Step Innovation," *Review of Economic Studies*, 68(3), pp. 467-492.

[2] Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P. (2005), "Competition and Innovation: An Inverted-U Relationship", *The Quartely Journal of Economics*, 120(2), pp. 701 - 728.

[3] Aghion, P., Dewatripont, M., Stein, J. (2008), "Academic freedom, private-sector focus and the process of innovation", *RAND Journal of Economics*, 39(3), pp. 617-635.

[4] Anderson, J.E., van Wincoop, E. (2003), "Gravity with Gravitas: A Solution to the Border Puzzle", *The American Economic Review*, 93(1), pp. 170–192.

[5] Arora, A.A., Fosfuri, A. Gambardella (2001), *Markets for Technology: The Economics of Innovation and Corporate Strategy*, MIT Press, Cambridge.

[6] Belderbos, R., Carree, M., Diederen, B., Lokshin, B., Veugelers, R. (2004), "Heterogeneity in R&D cooperation strategies", *International Journal of Industrial Organization,* 22(8), pp. 237-1263.

[7] Blundell, R., Griffith, R., Van Reenen, J. (1995), "Dynamic Count Data Models of Technological Innovation", *The Economic Journal*, 105, pp. 333–344.

[8] Blundell, R., Griffith, R., Van Reenen, J. (1999), "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms," *Review of Economic Studies*, 67, pp. 529-554.

[9] Blundell, R., Griffith, R., Windmeijer, F. (2002), "Individual Effects and Dynamics in Count Data Models", *Journal of Econometrics*, 108, pp. 113–131.

[10] Bozeman, B. (2000), "Technology transfer and public policy: a review of research and theory", *Research Policy*, 29, pp. 627–655.

[11] Branstetter, L., Fisman, R., Foley, F. (2006), "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data", *Quarterly Journal of Economics*, 121 (1), pp. 321–349.

[12] Branstetter, L., Saggi, K. (2009), "Intellectual Property Rights, Foreign Direct Investment, and Industrial Development," *NBER Working Papers* 15393.

[13] Cameron, A.C., Gelbach, J.B., and Miller, D.L. (2006), "Robust Inference with Multi-Way Clustering", *NBER Technical Working Paper* n. 327

[14] Coe, D.T., Helpman, E., Hoffmaister, A.W. (2009), "International R&D spillovers and institutions," *European Economic Review*, 53(7), pp. 723–741.

[15] Cohen, W., Nelson, R.R. and Walsh, J.P. (2000), "Protecting Their Intellectual Assets," *NBER Working Paper 7552*, National Bureau of Economic Research, Inc.

[16] Chin, J., Grossman, G.M. (1990), *Intellectual Property Rights and North-South Trade*, in R. W. Jones and A. O. Krueger, eds., *The political economy of international trade*, Cambridge, MA: Basil Blackwell Publishers, pp. 90–107.

[17] Correa, C. (2007), *Intellectual property rights, the WTO, and developing countries: the TRIPS agreement and policy options*, Oxford University Press, Oxford.

[18] Dasgupta, P., David, P. (1994), "Towards a New Economics of Science", *Research Policy*, 23, pp. 487-521.

[19] D'Aspremont, C., Jacquemin, A. (1988) "AssociationCooperative and Noncooperative R&D in Duopoly with Spillovers", *The American Economic Review*, 78(5), pp. 1133-1137.

[20] Gallini, N., Scotchmer, S. (2001), "Intellectual Property: When is it the Best Incentive Mechanism?", *Innovation Policy and the Economy*, 2, pp. 51–78, Adam Jaffe, Joshua Lerner and Scott Stern, MIT Press.

[21] Gans, J.S., D.H. Hsu and S. Stern (2002), "When Does Start-up Innovation Spur the Gale of Creative Destruction?" *RAND Journal of Economics*, 33, pp. 571-86.

[22] Gans, J.S., Murray, F.E., Stern, S. (2011), "Contracting Over the Disclosure of Scientific Knowledge: Intellectual Property and Academic Publication", available at SSRN: http://ssrn.com/abstract=1559871.

[23] Ginarte, J., Park, W. (1997), “Determinants of Patent Rights: A Cross-National Study”, *Research Policy,* 26, pp. 283-301.

[24] Glänzel, W., Schubert, A. (2004), *Analyzing scientific networks through co-authorship*, in Handbook of Quantitative science and Technology Research.

[25] Gomes-Casseresa, B., Hagedoornb, J., Jaffe, A.B. (2006), “Do alliances promote knowledge flows?”, *Journal of Financial Economics*, 80(1), pp. 5-33.

[26] Griliches, Z. (1990), “Patent Statistics as Economic Indicators: A Survey,” *Journal of Economic Literature*, 28, 1661-1707.

[27] Grossman, G.M., Lai, E.L.C. (2004), “International Protection of Intellectual Property”, *American Economic Review*, 94(5), pp.1635–53.

[28] Guellec D. (2007), “Patents as an Incentive to Innovate” in *The Economics of the European Patent System* eds. by D. Guellec and B. van Pottelsberghe de la Potterie, Oxford University Press.

[29] Gwartney, J.D., Lawson, R., Norton, S. (2008), *Economic Freedom of the World: 2008 Annual Report*, Economic Freedom Network, Vancouver, BC: The Fraser Institute.

[30] Han, Y. (2007), “Measuring industrial knowledge stocks with patents and papers”, *Journal of Informetrics*, 1(4), pp. 269–276.

[31] Hagedoorn, J. (2002), “Inter-firm R&D partnerships: an overview of major trends and patterns since 196”, *Research Policy*, 31, pp. 477–492.

[32] Hagedoorn, J., Cloodt, D. , van Kranenbutg, H. (2005), “Intellectual property rights and the governance of international R&D partnerships”, *Journal of International Business Studies*, 36, pp. 175–186.

[33] Hall, B.H., Jaffe, A., Trajtenberg, M. (2005), “Market Value and Patent Citations”, *RAND Journal of Economics*, 36(1), pp. 16–38.

[34] Heller, M., Eisenberg, R. (1998), “Can Patents Deter Innovation? The Anticommons in Biomedical Research”, *Science,* 280, pp. 698–701.

[35] Helpman, E. (1993), “Innovation, Imitation, and Intellectual Property Rights”, *Econometrica*, 61(6), pp. 1247–80.

[36] Katsoulacos, Y., Ulph, D. (1998), "Endogenous Spillovers and the Performance of Research Joint Ventures", *The Journal of Industrial Economics*, 46(3), pp. 333-357.

[37] Kim, C., Song, J. (2007), "Creating new technology through alliances: An empirical investigation of joint patents", *Technovation*, 27(8), pp. 461-470.

[38] Kyle, M., McGahan A. (2011), "Investments in Pharmaceuticals Before and After TRIPS", *Review of Economics and Statistics*, forthcoming.

[39] Lach, S., Schankerman, M. (2008), "Incentives and invention in universities", *RAND Journal of Economics*, 39(2), pp. 403–433.

[40] Lai, E.L.C. (1998), "International Intellectual Property Rights Protection and the Rate of Product Innovation", *Journal of Development Economics*, 55, pp. 133–153.

[41] Lerner, J., Merges , R.P. (1998), "The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry", *Journal of Industrial Economics,* 46(2), pp. 125–156.

[42] Maskus, K.E., Penubarti, M. (1995), "How Trade-Related are Intellectual Property Rights?", *Journal of International Economics*, 39, pp. 227–248.

[43] Murray, F., Stern, S. (2007), "Do formal intellectual property rights hinder the free flow of scientific knowledge? An empirical test of the anti-commons hypothesis", *Journal of Economic Behavior & Organization,* 63(4), pp. 648–687.

[44] Nelson, R.R., R. Merges (1990), "On the Complex Economics of Patent Scope", *Columbia Law Rev*, 90, pp. 839-916.

[45] Park, W.G., Wangh, S. (2002), *Index of Patent Rights,* in Gwartney, J.D., Lawson, R., Norton, S., *Economic Freedom of the World: 2002 Annual Report*, Economic Freedom Network, Vancouver, BC: The Fraser Institute, pp. 33–41.

[46] Park, W. (2008), *Intellectual Property Rights and International Innovation*, in, Maskus, K., eds., *Frontiers of Economics and Globalization: Intellectual Property Rights and Globalization*, Elsevier, Amsterdam.

[47] Park, W.G., Lippoldt, C.D. (2008), "Technology Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries," *OECD Trade Policy,* Working Papers 62, OECD, Trade Directorate.

[48] Park, G., Park, Y. (2006), "On the measurement of patent stock as knowledge indicators, *Technological Forecasting & Social Change*, 73, pp. 793–812.

[49] Pavitt, K. (1984), "Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory", *Research Policy,* 13(6), pp. 343-373.

[50] Peri, G. (2005), "Determinants of Knowledge Flows and Their Effect on Innovation", *The Review of Economics and Statistics*, 87(2), pp. 308-322.

[51] Picci, L. (2010), "The Internationalization of Inventive Activity: A Gravity Model Using Patent Data", *Research Policy*, 39, pp. 1070-1081.

[52] Primo Braga, C.A., Fink, C. (1997), "The Economic Justification for the Grant of Intellectual Property Rights: Patterns of Convergence and Conflict", in F.M. Abbott and D.J. Gerber (eds), *Public Policy and Global Technological Integration*, Kluwer Academic Publishers, The Netherlands.

[53] Portes, R., Ray, H. (1998), "The Euro and International Equity Flows", *Journal of the Japanese and International Economies*, 12(4), pp. 406–23.

[54] Santos Silva J.M.C., Tenreyo, S. (2006), "The log of gravity", *Review of Economics and Statistics*, 88, pp. 641–658.

[55] Schankerman, M. (1998), "How Valuable is Patent Protection? Estimates by Technology Field", *RAND Journal of Economics*, 29(1), pp. 77–107.

[56] Scotchmer, S. (1991), "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law", *Journal of Economic Perspectives*, 5(1), pp. 29–41, reprinted in The Economics of Technical Change, Edwin and Elizabeth Mansfield, eds., Edward Elgar Publishing Company, 1993**.**

[57] Stokes, D.E. (1997), "Pasteur's Quadrant: Basic Science and Technological Innovation", *The Brookings Institute*, New York.

[58] Teece, D.J. (1981), "The Market for Know-How and the Efficient International Transfer of Technology", *The Annals of the American Academy of Political and Social Sciences*, 458, pp. 81–96.

[59] Valletti, T., Szymanski, S. (2005), "Parallel trade, price discrimination, investment and price caps", *Economic Policy*, 20(44), pp. 704–749.

[60] Yang, G., Maskus, K.E., (2001), "Intellectual property rights, licensing, and innovation in an endogenous product-cycle model", *Journal of International Economics*, 53(1), pp. 169–187.

[61] Windmeijer, F. (2008), "GMM for Panel Count Data Models", in *The Econometrics of Panel Data*, eds. Matyas, L., Sevestre, P., Springer Berlin Heidelberg, pp. 603–624.

R&D coordination in standard setting organizations: The role of consortia

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Abstract

We analyze R&D competition and cooperation between firms involved in the development of a technology standard. Our model captures the two counterweighting types of incentives these firms are subject to: free-riding due to the public good nature of the standard, and patent races in order to derive royalties from essential patents. As a consequence, R&D may be excessive or insufficient as compared to the collective optimum. Our purpose is to test empirically whether consortia can address any type of inefficiency, by either reducing or increasing collective R&D investment. We address this question empirically on a large dataset of ICT standards, by assessing the effect of consortia on the number of standard-related patents filed by companies. After sorting standards entailing over or underinvestment, our results confirm that in the first case consortia have a chilling effect on patent filings, while it has an inflating effect in the second case.

WORK IN PROGRESS

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1 Introduction

Standards in Information and Communication Technologies (ICT) are subject to highly dynamic innovation and generational change. New generations of standards (e.g., 2G to 3G, or DVD to BluRay) tend to embody much more components and functionalities. The sharply rising number of essential patents claimed on standards (Simcoe, 2005) reflects this growing complexity. It also denotes the substantial licensing profits firms may derive from the large diffusion of their innovations if they are adopted in standard specifications.

In this context, standard setting has evolved from mere coordination on common specifications to the joint development of complex technology platforms. Standardization takes place along the whole process of developing new technologies. Standards play their various roles at different development stages, ranging from the settlement of the fundamental architecture to the development of interoperable applications. Many of these tasks are carried out at formal standard development organizations (SDOs), which are open to all interested parties. Standard development can thus be seen as an original type of open innovation.

However, the joint development of technological standards is subject to coordination failures and vested interests (Simcoe, 2011). SDOs are perceived as particularly sensitive to conflicts of interest, as they are designed to be very inclusive and open to a broad range of different stakeholders and interest groups. SDOs are therefore often supplemented by consortia, less formal alliances between sub-groups of firms (Cargill, 2001). While some consortia may substitute for formal SDOs and issue their own standards, many of them accompany formal standardization.

While the precise relationship between consortia and SDOs is very heterogeneous, recent economic research highlights several underlying mechanisms by which consortia influence the innovation for technological standards (Leiponen, 2008; Delcamp & Leiponen, 2010). This paper is however the first attempt to assess the ability of consortia to improve coordination of R&D in the standard development process. We first develop a theoretical framework highlighting the different types of R&D coordination failures that may arise in a standard setting environment. We use this setting to derive testable assumptions on the ability of consortia to address such coordination failures. We finally validate these assumptions empirically against a comprehensive database of contemporary ICT standards.

Our theoretical framework accounts for user-driven and royalty-driven incentives to invest in R&D. We show that, depending on the SDO's IP policy, firms' contributions may lead to either insufficient or excessive R&D investment in equilibrium. Equilibriums with excessive R&D occur when a too large share of the standard's value is appropriated by essential patent owners. Interestingly, they are also the only case in which pure R&D firms will engage in standard development.

Based on this model, we expect R&D coordination through consortia to either reduce or boost joint R&D depending on the type of inefficiency that prevails initially. We test these hypotheses against a comprehensive database of contemporary ICT standards. We identified firms' participation in standard development through the patent declaration database of the respective SDO. Furthermore, we matched our standards to a high number of informal consortia listed in the CEN standards consortia survey. We then tracked back the information of consortium membership over 20 years. Using Patstat and the IPC classification of essential patents, we identified the patents filed by company by year in the technological field of the standard. These patents indicate the R&D effort undertaken by participating firms in view of obtaining essential patents. Our aim is thus to assess the effect of consortia on this variable.

Drawing on the theoretical framework, we use the participation of pure R&D firms to sort standards involving over- or underinvestment. R&D coordination within consortia would then imply a deflating effect of consortia on R&D for standards with pure R&D firms, and an inflating effect on R&D for the rest. The econometric results largely confirm the coordination hypothesis. Controlling for the development stage of the standard and fixed effects for the firm-standard pair, firms entering a consortium significantly reduce patent files in standards where pure R&D firms participate, while they increase patent files in the sample of other standards. At the aggregate level, the same effect is observed on total patent files when a firm joins the consortium.

These results can be related to other studies of consortia in other fields than standardization. The literature on R&D alliances (Katz 1986, Branstetter & Sakakibara, 2002) shows that alliance members can internalize positive externalities from spillovers or complementary capabilities, and therefore increase R&D. There is also case study evidence that some R&D alliances were beneficially reducing wasteful duplication of R&D (Irwin and Klenow, 1996).

The remainder of this article is organized as follows. Section 2 discusses the role of consortia and their relationship with formal standardization. Section 3 outlines the theoretical model and the empirical implications. Section 4 discusses the empirical strategy, the database and first descriptive findings. Section 5 presents the econometric results. We conclude in Section 6.

2 The interplay of standards consortia and formal standardization

Informal standards consortia have evolved to be a new player in the standard setting arena (Cargill, 2002). Over the past twenty years, numerous standards consortia were created, merged with other organizations but also terminated over time (Pohlmann, 2010). Since 1995 the CEN survey provides a list of around 250 current ICT standards consortia, while Andrew Updegrove lists over 700 consortia under less restrictive criteria. The consortia landscape is very heterogeneous and organizations differ in their membership structures, IP rules or technical focus, but also in their function along the standard setting processes. Among the various functions of consortia identified by the literature, we can highlight proof of technology, implementation and application of standards (Weiss and Cargill, 1992). Updegrove (1995) further identifies consortia to be specification groups, research consortia or even strategic consortia. While consortia have become an inevitable player in ICT standardization, there is also unease about this evolution. When standards consortia compete with formal bodies, firms may choose the best forum to push their technology. These forum shopping activities may be a "threat" for formal standardization and coordination between standards (Lerner and Tirole, 2006). Several literature sources have dealt with legal concerns and the role of informal consortia in the standard setting environment (Lamley, 2003; Egyedi, 2003).

In practice, consortia coexist with formal standardization rather than replacing it. In an empirical analysis Blind and Gauch (2008) find a mostly complementary relationship between standards consortia and formal standard bodies. Hawkins (1999) further stresses that consortia may influence formal standardization both at upstream and downstream levels and thus coordinate technological development. There are several examples in practice that evidence cooperative standard setting between formal and informal institutions. Gauch (2008) shows how ECMA (European Computer Manufacturers Association) specified DVD technologies that were later approved at ISO (International Organization for Standardization). ISO has a formal fast track agreement, the PAS (Publicly Available Specifications), which allows sponsoring organization to receive a formal accreditation of their specification within six and nine month.[1] JTC1 has a similar policy of featuring Approved References Specifications (ARS).

In these cases standards are entirely developed by an informal consortium, and only eventually submitted to the SDO for formal approval. In other cases the cooperation between SDOs and consortia takes the form of a sustained division of tasks. Standardization of complex technologies is a long process, taking place over the whole development of a technology. Standardization implies a continuous investment in the upgrade, maintenance and deployment of standards.[2] A substantial part of the technology that is essential for the use of the standard (as measured by the applications of patents that are declared essential to a standard) is developed after the date of release of the first standard version. This continuous investment in standardization is often carried through as a joint effort of SDOs and informal consortia. ISO for example welcomes contributions to existing ISO standards from consortia accredited as Partner Standards Development Organization (PSDO).[3] ISO follows the strategy to become a leading platform for international standards, while increasing the cooperation with other partner organizations.[4]

A rather broad framework for such a division of tasks is a liaison agreement

[1] For further information please read the draft of the PAS approval cycle by ISO http://www.bsigroup.com/upload/Standards%20&%20Publications/PSS/PSS_servicecycle.pdf

[2] A comprehensive analysis of 6.000 ICT standards in PERINORM reveals that, on average, each formal international ICT standard is replaced more than three times by incrementally improved versions.

[3] IEEE published a document that describes possibilities to cooperate with ISO http://www.ieee802.org/minutes/jul2008/opening_reports/psdo1.pdf

[4] For further information find the ISO strategy plan under http://www.iso.org/iso/isostrategies_2004-en.pdf

between standards consortia and standard bodies, whereby both organizations state to work together. In some cases these agreements precisely list the degree of cooperation for each standard project.[5] Liaison agreements are in most cases “ad hoc” cooperations on a certain topic or problem that arises. David and Shurmer (1996) describe the case of the DVB (Digital Video Broadcasting) Group, a private industry consortium which was responsible for drafting specifications that were later approved by ETSI (European Telecommunications Standards Institute).

At a firm level, there are many cases where firms are member of both organizational forms. In this regard Hawkins (1999) names different coordination benefits that arise from simultaneous participation in formal and informal standard setting. In a study of the Third Generation Partnership Project (3GPP), Leiponen (2008) finds that especially consortia with a close technical relationship to 3GPP tend to have a high degree of member overlap with the ETSI working groups. Leiponen (2008) further evidences a connection between consortia membership and influence in the formal standard setting groups. Other empirical contributions also confirm a positive effect of consortia participation on the ability to introduce essential IPRs in standards (Blind and Pohlmann, 2011). A recent finding of Delcamp and Leiponen (2011) provides evidence for an increasing R&D cooperation between firms that enter standards consortia.

While these recent contributions provide insights into the incentives and benefits for companies to join consortia, they do not analyze the contribution of consortia to the efficiency of standard setting. However, we have seen that main formal SDOs seek to intensify their cooperation with informal consortia. Indeed, many consortia explicitly state as one of their objectives to “promote”, to “facilitate”, to “support” or to “foster” the development of a technology standard.[6] Updegrove (1995) stresses that the main incentive for a firm to join a consortium is to promote the standard. Given that this qualitative evidence indicates that the promotion of formal standards is a major goal of informal consortia, it is surprising that this function has so far not received much attention in the economic literature. It is the goal of our paper to understand and to assess the underlying effect of consortia participation.

We will therefore propose a model of informal consortia accompanying formal standardization. We suggest that consortia help to commit the participants on successfully producing certain technology components for the standard, and abstaining from rent-seeking strategies that are damageable to the collective interest in developing the standard. The coordination effect of consortia may in practice be implicit; and in any case limited. We acknowledge that standards consortia might not enable firms to actually collude on the socially optimal levels of R&D investment. We will present a theoretical model wherein consortia are modeled as if their members were effectively pursuing a collective interest; and we will then test against the data whether the empirical effect of consortia tends

[5] The IETF (Internet Engineering Task Force) publishes all liaison agreements per specification https://datatracker.ietf.org/liaison/

[6] 483 out of the 753 consortia listed on www.consortiuminfo.org explicitly mention at least one of these goals for their activity.

toward the direction predicted by the theoretical analysis.

3 Theoretical framework

We first develop a simple model describing collective investment to develop a standard. We consider a standard which implementation generated a profit market V in the industry. There are n firms investing in the standard. The R&D investment made by firm $i = 1, ., n$ is noted cx_i where c is a constant R&D cost parameter and x_i is the number of patented inventions developed by firm i. The total number of patents related to the standard is thus $X = \sum_{i=1}^{n} x_i$. The value V of the standard increases with the total R&D X dedicated to the standard development: $V'(X) > 0$. We also posit that the marginal benefit of R&D is decreasing $V''(X) < 0$.

A share θ of the the value of teh standard is appropriated by the patent owners. This parameter θ reflects the friendliness of the IPR policy vis-à-vis the patent owners (we have in particular $\theta = 0$ if essential patents are licensed royalty free). The ability of firm $i = 1, ., n$ to appropriate part of the value θV depends on its share of the total R&D expense x_i/X. This ratio may be interpreted as the likelihood that firm i owns the single essential patent associated to the standard or (which is probably more realistic) as firm i's share of all the patents that are essential to the standard. Firms finally differ according to their share s_i of the market revenue θV generated by the standard, where $\sum s_i = 1$ and $s_i = 0$ denotes a pure R&D firm.

3.1 R&D coordination failure in equilibrium

We study as a first step the case where each firm makes its investment decision separately. We will use this case as a benchmark to highlight possible coordination failure in R&D investments. The investment decision x_i of firm i results from the program below:

$$\max_{x_i > 0} V(X) \left[s_i (1 - \theta) + \frac{x_i}{X} \theta \right] - cx_i \quad (1)$$

where

$$X = \sum_{j=1}^{n} x_j$$

The R&D investment made by the other firms affects firm i' profit in two different ways. A large X first increases the chances $P(X)$ that the standard will be successfully developed, but it also reduces the share x_i/X firm obtains of the total licensing revenue. These two mechanisms are captured in two different terms of the FOC of program (1):

$$V'(X) \left[s_i (1 - \theta) + \frac{x_i}{X} \theta \right] + V(X) \frac{X - x_i}{X^2} \theta = c \quad (2)$$

The term in brackets captures the public good nature of the standard. It implies in particular firm i's incentive to develop the standard is proportional to the share of the profit it can derive from it. The second term on the right hand side captures a patent race effect: To appropriate some part of the expected profit, firm i needs to invest more the higher the aggregate investments of its R&D competitors. While the first effect may induce underinvestment in R&D wrt to the optimal solution, the second effect plays in the opposite direction.

Solving the program of all firms $i = 1, n$, we can derive the joint R&D investment X^* in equilibrium. Comparing it with the outcome of the joint profit maximization program leads to the following proposition.

Proposition 1 *As compared with the collective optimum, there is overinvestment (underinvestment) in equilibrium when the total revenu from licensing is exceeds (does not exceed) the the total R&D cost. In any case, the discrepancy between total R&D at optimum and in equilibrium increases with the number of firms involved in the standard setting process.*

Proof. See Appendix ■

This Proposition firstly states that either free riding or patent race may prevail in equilibrium, coordination failure then resulting respectively in insufficient or excessive R&D spending. Which type of coordination failure depends on the value of the standard, V, the share θ of it that is appropriated by patent owners, and the unit R&D cost c. By contrast, the number n of firms investing in R&D does not determine the type of coordination failure that prevails, but simply its magnitude. The key result is that the condition for either type of failure to prevail is captured by the balance between total licensing profit and the total R&D cost in equilibrium:

$$\theta V(X^*) - X^* c \tag{3}$$

If this expression is positive, licensing essential patents is profitable per se. The patent race pattern then prevails in equilibrium, entailing excessive joint investment. By contrat, if expression (3) is negative, firms cannot count on licensing revenue only to recover their R&D costs. The free riding pattern is then dominant, entailing insufficient investment in equilibrium.

This simple condition provides us a simple and intuitive way to distinguish between two types of equilibria and coordination failure. It is especially interesting to observe that it can be disaggregated at the firm level. Indeed, we can derive directly from (3) that pure R&D firms are profitable only in a patent race equilibrium entailing excessive investment:

$$\theta V(X^*) - X^* c > 0 \qquad \Leftrightarrow \qquad \theta \frac{x^*}{X^*} V(X^*) - x^* c > 0 \tag{4}$$

We will thus use this corollary in our empirically strategy to infer the existence of a patent race equilibrium from the participation of one or more pure R&D firms.

Corollary 2 *The participation of pure R&D firms is profitable only in a situation of overinvestment.*

3.2 R&D coordination through a consortium

Our purpose is to test whether the formation of a consortium between a subset of the n firms involved in the standard development can improve the R&D efficiency of teh standard setting process. At this point it is important to keep in mind that consortia are not formal cooperation agreements between their members: There is in particular no contracting between members. Coordination is thus only based on voluntary information sharing between members, who make no binding commitment in the process. Since such interactions are akin to cheap-talk, it is questionnable whether they can effectively result in a better R&D coordination.

Rather than trying to explicitate the type of coordination mechanisms that may take place within consortium, our approach consists in testing whether the formation of a consortium amplifies or mitigates the R&D coordination failures associated to collective standard development. Based on the previous analysis of fully uncoordinated decisions, we have identified two possible patterns of coordination failures, from which we can induce the effect of a better coordination enabled by consortia. For this purpose, we first characterize R&D equilibria under the heroic assumption of a fully cooperative consortium. We can then infer from this extreme scenario several testable assumptions regarding a weaker coordination effect that should play in the same direction.

We define a full coordination consortium as an R&D alliance between k firms undertaking R&D to develop the standard. For each firm $i = 1, .n$ we will note $\delta_i = 1$ if the firm is part of the alliance and $\delta_i = 0$ otherwise. The consortium then maximizes the following program, where x_k denotes the R&D investment of one of the k members:

$$\max_{X_k} V(X)\left[s_k(1-\theta)+\frac{X_k}{X}\theta\right]-X_k \tag{5}$$

By solving this program and combining the result with the other FOC as expressed in (2), we can derive the following Proposition:

Proposition 3 *Full cooperation between the members of a consortium induces an increase (respectively a decrease) in total R&D when the initial equilibrium involves insufficient (excessive) R&D. The type of coordination failure prevailing in absence of a consortium is mitigated but is not suppressed unless the consortium involves all n firms.*

Proof. See Appendix ■

The Proposition establishes that full cooperation between the $k \in [2, n]$ members of a consortium alleviates the coordination failure–be it free riding or patent race– at the aggregate level of total R&D performed by members and non-members. Hence the effect of perfect coordination within the consortium is either an increase or a decrease in total R&D depending on the type of R&D equilibrium prevailing initially. This result is quite intuitive: It can be understood as a decrease (from n to $n-k+1$) of the number of firms involved in the standard, entailing in turn a decrease thus of the magnitude of the coordination problem.

It is possible to go further in the analysis of R&D decision at firm level by specifying the relation between total R&D and the standard's value. We assume here that the standard's value is a Poisson function of total R&D, where the expected duration of the standard development process depends on the total R&D initially invested by the firms. Letting r and λ denote respectively the discount rate and the Poisson hit rate, and taking V as the exogenous market value of the standard, we have then:

$$V(X) = \frac{\lambda X V}{r + \lambda X}$$

Assuming symmetric market shares for the sake of simplicity, we can then calculate how a firm would change its R&D strategy following its entry as a new member in the consortium:

Proposition 4 *A new member of a full-cooperation consortium increases (respectively decreases) its R&D effort when the initial equilibrium involves insufficient (excessive) R&D.*

Proof. See Appendix ■

This Proposition establishes that the R&D inflating or deflating effect of a consortium is borne by its members. In a situation of underinvestment, the members of the consortium will coordinate so as to increase their joint R&D effort, thereby increasing the likelihood that the standard be developed quickly. In the reverse situation of excessive investment, the members of the consortium will jointly reduce their R&D, thereby mitigating wasteful investments due to strategic patent race.

Although these results rely on the strong assumption of full cooperation between a coalition of firms, they point towards clear and simple effects of a better coordination between the members of the consortium. Indeed, the expected effect of better coordination is basically driven by the type of coordination failure that prevails initially, and it is borne by the subgroup of firms that coordinate with each other. It seems thus reasonable to use the full cooperation scenario as a reference point to derive a set of more general testable hypotheses about the expected effect of a weak coordination form within a consortium:

Hypothesys 1

1a: When standard development entails underinvestment, a firm joining a consortium will increase its R&D spending

1b: When standard development entails overinvestment, a firm joining a consortium will decrease its R&D spending

Hypothesys 2

2a: When standard development entails underinvestment, a larger consortium induces more total R&D.

2b: When standard development entails overinvestment, a larger consortium induces less total R&D.

4 Empirical analysis

4.1 Methodology

In order to test our theoretical model and to measure the effect of consortia on R&D investment in the standard setting context, we constructed a comprehensive dataset of technological standards including essential patents. Our sample includes all ICT standards complying with objective selection criteria: for instance, they are issued between 1992 and 2008, and they are issued by one of the major formal SDOs which operate on an international level: ISO, IEC, JTC1 – a joint committee of ISO and IEC – CEN/CENELEC, ITU-T, ITU-R, ETSI, and IEEE. We thereby exclude standards that are exclusively developed by informal consortia, such as BluRay. We restrict the analysis to formal standards, as our analysis deals with the interaction between formal standardization and R&D cooperation in a companion consortium. Furthermore, formal SDOs abide to comparable rules. This makes sure that no major bias results from different procedures for selecting technological components. Finally, restricting the analysis to the SDOs in our sample guarantees that we observe a type of standard development that is open in the sense of our model.

We furthermore restrict the analysis to standards including at least one essential patent. Companies that own IPRs which are essential to a standard, provide this information to the respective standard setting organization. We downloaded these patent declarations at the websites of the above-mentioned SDOs in March 2010. In total we identified over 1400 technological standards for which at least one essential patent has been declared. We concentrate upon these standards, as the prospect of royalty income from essential patents is a determinant driving factor of the model. As we can include only standards where at least two companies contribute, and as we can measure R&D investment only in the cases where the essential patents are clearly designated, the sample that is available for econometric analysis is limited to 578 standards.

In a next step, we identified for each standard in our sample the firms contributing relevant R&D. For our purposes, contributing firms are defined as the firms declaring essential patents. This definition yields a list of 242 different companies. These firms are observed over the whole period, we therefore do not assume that companies "enter" the R&D market for a specific standard at any specific point. We inform these firms by the amount of sales per year, R&D expenditure per year and employees per year. Using the specific sector code of the firm's main active industry (SIC), we are able to classify our sample by sector dummies[7]. In addition we classified each company with respect to its vertical integration[8]. Thus we distinguish between pure R&D firms, manufacturer and net provider.

We connected the firm level data to the specific standard information and

[7] We used the Thomson one Banker database to match the respective firm level data.

[8] We used the extended business model description in the Thomson One Banker database and compared our classification to the list of companies identified by Layne-Farrar and Lerner (2010)

built up a panel of company-standard pairs observed over a time span of 17 years (1992-2008). Thus we are able to work with 1081 company standard pairs and a maximum of 20.652 observations[9]. For each of these observations, we build up variables with specific information on company-standard pairs over time. For instance, these variables include the amount of patents filed by the respective company in the technological field of the respective standard, and a dummy variable indicating whether the company takes part in a consortium for this particular standard. We furthermore inform a large series of control variables relative to the company (overall R&D spending, sales) and the standard (age of the standard, releases, amendments, number of pages). Time-invariant factors affecting the firm, the standard or the relationship between both are captured by company-standard pair fixed effects.

As we are interested in measuring the R&D investment regarding a particular standard, we build up a standard-specific measure of firm R&D investment. We use patent files in the relevant technological field as our explained variable. The relevant technological field for each standard is identified using the 7-digit IPC classification of the declared essential patents. We are thereby able to identify the relevant technological classes (IPC) that are relevant for each standard at a very precise level. The distinct combination of IPCs per standard was then used to identify the patent filing behavior of each firm with respect to each standard.

We identified all ICT patents filed from 1992 to 2008 by the companies in our sample at the three major patent offices (USPTO, JPO and EPO), using the PatStat database and the merging methods of Thoma et al. (2010). This merging yields 13 million patent files. We aggregated these patents to INPADOC patent families and informed for each patent the IPC classification and the year of application. To create our explained variable, we computed for each company-standard pair and year the number of patents filed this year by this company in the relevant IPC classes.

This method is a novel way of measuring standard-specific R&D investment, and deserves robustness analyzsis proving that our methodology is successful in measuring R&D related to an important formal ICT standard. An important argument corroborating our measurement strategy is shown in Figure 1. We run Negative Binomail regressions on our proposed dependent variable, controlling for fixed effects and year dummies. Furthermore, we include dummies for each full six-month period since or up to first release of the standard. The figure plots the coefficients of these single values of periods before and after standard release. It can be seen in this figure that the coefficients are highest for the periods preceeding standard release, and decrease the further we move away from this period. This finding reassures us that our variable captures the innovation for a specific standard, which indeed is expected to culminate in the period immediately preceeding standard release.

[9] Due to data constraints, the actual number of observations for our econometric analysis is however limited to approximately 6.000 observations.

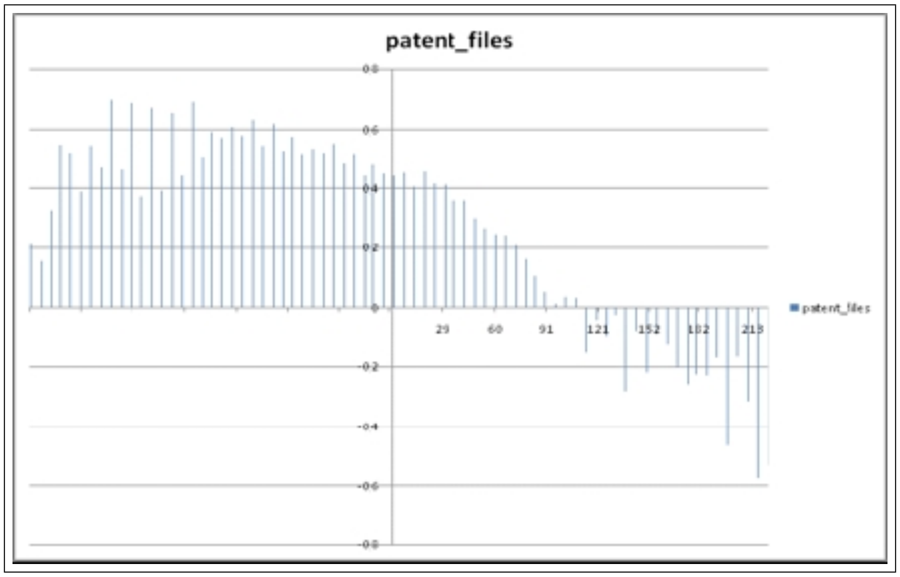


Figure 1.

In our model we assume that firms are able to join a R&D alliance to develop a standard. In the context of standard setting firms often participate in informal standards consortia that either produce standards that are later accredited by formal standard bodies, or follow up standards and later accomplish important contributions to standard setting. To identify consortia which are connected to the standards of our sample, we use data from the 15 editions of the CEN survey of ICT consortia, identifying 453 informal consortia since 1998. In a first step, we select appropriate consortia by informing the technological field in which they operate. The concrete connection to a standard in our sample is made using information from liaison agreements and information on the consortia and SDO web pages. For instance, a connection can be identified, when a consortium explicitly references a formal standard, or when a standard has been submitted to the formal SDO by an informal consortium. We are conservative in establishing the connections, resulting in a narrow list of 14 consortia. The list of consortia and their linkage to formal standards is provided in Appendix. Using information on the websites of the consortia as well as internet archives (www.archive.org) and internet databases (www.consortiuminfo.org), we inform consortium membership over time. We are thus able to connect the membership data of each consortium to the respective company standard pair of our sample.

4.2 Measurements of over and under investment

One basic contribution of our analysis is the comparison of over- and under investment in standardization. We assume that situations of overinvestment can be identified when pure R&D firms participate to a standard. These firms find it only profitable to invest in standards when they are able to generate returns, for instance royalties under RAND conditions. We use this prediction as identification strategy for our empirical sampling of standards.

It is the aim of this section to provide evidence that our methodology is successful in identifying different situations of investment behavior. Therefore we label our observations of company standard pairs with overinvestment when pure R&D firms participate in the respective standard. We apply the same method for underinvestment vice versa. We measure participation in a standard with our database of co-declaring companies. We thus observe only firms that declare patents on a respective standard to be participants. The classification of pure R&D firms is grounded on the extended business description of the Thomson One Banker database and the list of companies identified by Layne-Farrar and Lerner (2010). To further validate and extend this classification we plot residual values of two regression results (Figure 2). We first run a cross section poisson regression of the mean number of patent files from 2000 until 2009. We connect our firm specific variables (sales, employees, R&D expenditure, sector) with the information of our standards (number of pages, cumulative number of version releases, standard age, technological standard classes) to create explanatory variables and controls. We use these same independent variables for our second regression to explain the mean number of patent declarations (regression results in appendix1). Using the label of over- and underinvestment as to the classification discussed above, we plot the residual results of both regression in a graph (figure 2). The X values are residuals from the patent files regression; the Y values represent residuals from the patent declaration regression.

We assume negative residuals to be an indicator of underinvestment, whereas positive results represent the opposite. This visual sampling further differentiates our classification of over- and underinvestment. When comparing residuals of patent files, our first labeling of over- and underinvestment apparently proves to be a sufficient classification, but lacks to exclusively identify all standards with overinvestment. Residuals of patent declarations however illustrate ambiguous results. We interpret results from our second regression to less likely measure standard specific R&D investment, but rather a strategic interest in declaring essential patents (Baron and Pohlmann, 2011).

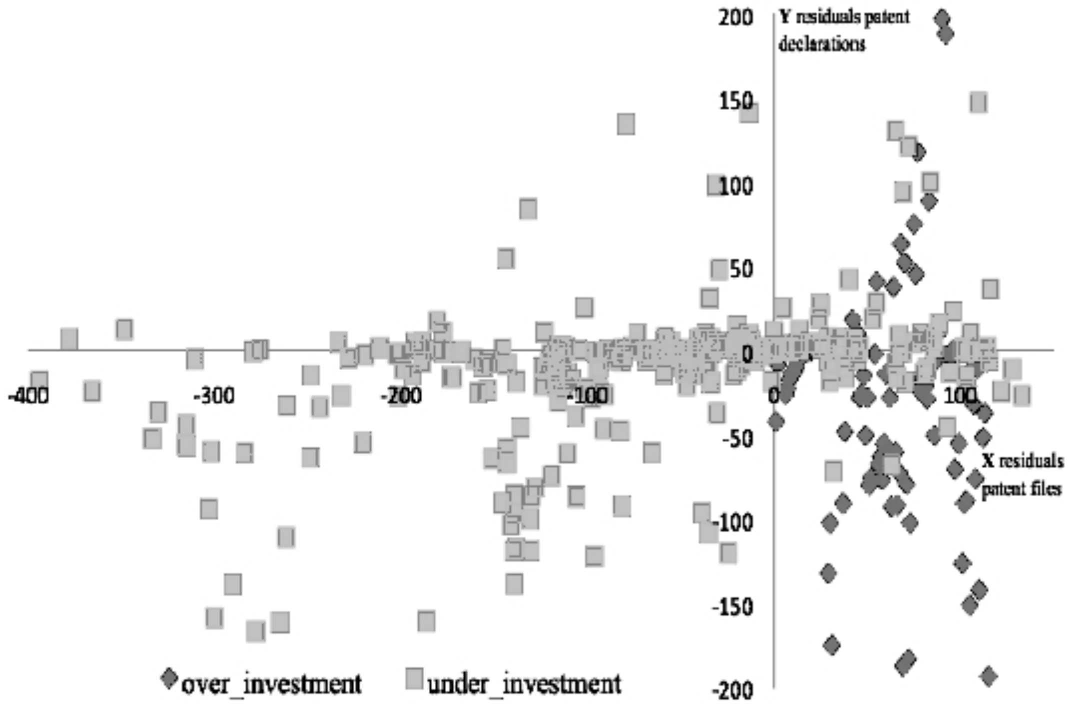


Figure 2. Scatter plot of residual values labeled with over- and underinvestment

Our results verify our classification of overinvestment, since all residual values of the patent file regression are positive (positive X values). The classification of underinvestment seems to be not yet sufficient. The majority of labeled underinvestment standards have negative residuals (negative X values), but we still find a group of observations with positive residual values. To further test the robustness of our regressions, we can apply the classification as to residual values of the patent files regression.

5 Empirical results

We run panel regressions to test the empirical implications of our theoretical model. As explained, we have constructed a panel of company-standard pairs for a time-span covering 17 years from 1992 to 2008. Our explained variable is patent files per year, per company and per standard. We only count patent files of one company when they touch the technical classes that are relevant for the respective standard in question. Since our explained variable is over-dispersed with respect to a poisson distribution, we are using a negative binominal estimator. We run a fixed-effects regression to control for time-invariant company and standard characteristics. The baseline investment scenario over the life-cycle of the standard is controlled for using the standard age variable, i.e. the difference between the year of observation and the year of standard release. As discussed, patent files peak close to the year of standard release. In order to control for this inverted U-shape, we include both standard age and its square. We furthermore include year dummies to control for policy and other shocks affecting the overall number of patent files.

We measure two different effects of consortia on the number of patent files. First, we measure a direct coordination effect on the patenting strategies of consortia members. Therefore, a first model is tested with a dummy variable for consortia membership. This dummy variable is time-variant, and we can exploit substantial variation in the data resulting from entries and exits observed over time. Second, we measure the overall coordination effect of consortia on the patenting strategies of all firms. We assume that this effect depends upon the degree of coordination among firms. We therefore propose a second model, in which the effect of consortia is tested using a variable indicating the share of consortia members among firms contributing patents to a standard. This variable is equal for all companies on the same standard and in the same year.

As discussed, we predict that the effect of consortia on patenting depends upon whether the standard is initially characterized by over- or underinvestment. We have proposed and discussed an identification strategy for standards characterized by overinvestment. For this purpose, we will rely upon the presence of pure R&D firms among the contributors of essential patents. We acknowledge that the presence of pure R&D firms is a sufficient, but not a necessary indicator for an equilibrium of overinvestment. However, this strategy should in principle be reliable in identifying a sample of standards all characterized by overinvestment.

We therefore estimate the two econometric models separately in the two samples of standards. Table 2 presents the results of the regressions on the sample of standards classified in the sample of overinvestment. As predicted by the theory, consortia membership significantly reduces patent files related to the standard in this sample. This finding is coherent with our hypothesis on the effects of consortia in cases of overinvestment. However, we do not find a significant effect of the share consortia members in the number of patent holding companies. The standard age controls show once again the strongly significant link of our explained variable to the standard life cycle.

Dependent variable: Annual patent files per company-standard pair

	Model 1	**Model 2**
Consortia membership	-.3372597***	
Share of firms in consortia		.1471959
Standard age	.008687***	.0384031***
Standard age (squared)	-.0000162***	-.0000449***
Year dummies	Yes	Yes

Notes: Fixed effect estimation by negative binomial on firm-consortia pairs. 2,729 observation, 152 groups.

Table 2: Standards with pure R&D firms

Table 3 presents the results on the sample of standards with no pure R&D firms. These results are fully in line with our theoretical model. As predicted, we find that consortia membership has a positive and significant effect on patent files in this sample. Furthermore, also the share of consortia members in the number of participating firms has a positive and significant effect. This finding corroborates the theoretical proposition on the role of consortia in a case of free riding. Also in this sample the standard age controls provide significant support to our claim that we measure innovation related to the standard setting process.

Dependent variable: Annual patent files per company-standard pair

	Model 1	**Model 2**
Consortia membership	.1422048**	
Share of firms in consortia		.1471959*
Standard age	.0040118***	.0117448***
Standard age (squared)	-6.78e-06***	-.0000153***
Year dummies	Yes	Yes

Notes: Fixed effect estimation by negative binomial on firm-consortia pairs. 2,729 observation, 152 groups.

Table 3: Standards without pure R&D firms

6 Conclusion

This paper investigates the role of consortia in coordinating the R&D investments of firms involved in the development of new standards. Based on a theoretical model capturing the firms' incentives to invest in R&D for standards, we have highlighted two possible coordination failures of such joint innovation. When the licensing revenue from essential patents is low, R&D for standards is mainly driven by market incentives for future producers of standard-compliant products. In this case standards are a form public good, and their R&D development is subject to free-riding, entailing inefficiently low R&D investments. By contrast, some standards also give firms an opportunity to derive substantial licensing revenue from their essential patents. The equilibrium may then involve a patent race for preempting the essential patents, and therefore socially wasteful investment. We also show that pure R&D firms will participate in the standard setting development process only in the latter type of equilibrium.

We test empirically the capability of consortia to address these two types of inefficiency by improving R&D coordination. More precisely, our theoretical setting suggests that a firm joing a consortia will increase (respectively) decrease its R&D effort when standard development is subject to a free-riding (respectively a patent race) problem. We also expect to observe the relative size of the consortia to have same effect at the aggregate R&D level (including non-member firms). Our empirical analysis is based on a rich dataset of 242 firms claiming patents on 578 ICT standards. We use essential patents declarations to identify firms those firms, and the technology fields (as defined by their IPC classes) that are closely related to the standard. Drawing on this information, we can then use the number of patents filed by the firms in these technology fields as a proxy of their R&D output related to the standard. We finally use the participation of pure R&D firms as a filter to identify the subset of standards that are subject to a patent race equilibrium. We use the remaining standards to test results about free riding, although the sample may also include false negatives.

Controlling for the development stages of the standard, we find significant effects of consortia that are broadly consistent with our theoretical model. Joining a consortia has a positive (respectively negative) effect on the new member's patent filing when pure R&D firms are (not) involved in the standard setting process. The relative size of the standard has a significant effect only for standards that do not involve pure R&D firms, and as expected this effect is positive. These results thus seem to confirm both the existence of two opposite types of coordination failure (free riding or patent race) depending on the standards, and the capability of consortia to alliviates those failures.

References

[1] Baron, J., Pohlmann, T. (2010) "Patent Pools and Patent Inflation – The effects of patent pools on the number of essential patents in standards", Cerna working paper

[2] Benner, M., Waldfogel, J. (2008) "Close to you? Bias and precision in patent-based measures of technological position", Research Policy, 37: 1556-1567.

[3] Blind, K., Gauch, S. (2008) "Trends in ICT standards: The relationship between European standardization bodies and standards consortia", Telecommunications Policy 32 (2008) 503– 513.

[4] Branstetter, L., Sakakibara, M. (2002) "When Do Research Consortia Work Well and Why? Evidence from Japanese Panel Data", American Economic Review, vol. 92, no. 1, March 2002, pp. 143-159.

[5] Cargill, C., Weiss, M. (1992) "Consortia in the Standards Development Process", Journal of the American Society for Information Science, Volume 43 Issue 8, 559 – 565.

[6] Cargill, C. (2002) "Intellectual Property Rights and Standards Setting Organizations: An Overview of failed evolution", A Report Issued By the U.S. Department of Justice and the Federal Trade Commission, March 2002.

[7] David, Paul A, Shurmer, Mark (1996) "Formal standards-setting for global telecommunications and information services. Towards an institutional regime transformation?", Telecommunications Policy, Volume 20, Issue 10, December 1996, Pages 789-815.

[8] Egyedi, T.M. (2003) "Consortium Problem Redefined: Negotiating 'Democracy' in the Actor Network on Standardization", International Journal of IT Standards & Standardization Research, 1(2), 22-38.

[9] Gauch, Stephan (2008) "Dynamics and effects of competing standards of recordable DVD-media Author(s)" Gauch, S. Source Egyedi, T.M. ; Blind, K.: The dynamics of standards Cheltenham: Elgar, 2008 ISBN: 978-1-84720-486-8 ISBN: 1-84720-486-4 pp.47-67.

[10] Hawkins, Richard (1999) "The rise of consortia in the information and communication technology industries: emerging implications for policy" Telecommunications Policy, Volume 23, Issue 2, March 1999, Pages 159-173.

[11] Katz, M. (1986) "An Analysis of Cooperative Research and Development", RAND Journal of Economics, The RAND Corporation, vol. 17(4), pages 527-543, Winter.

[12] Leiponen A. E. (2008) "Competing Through Cooperation: The Organization of Standard Setting in Wireless Telecommunications", Management Science Vol. 54, No. 11, November 2008, pp. 1904–1919.

[13] Lemley, M. A. (2002) "Intellectual Property Rights and Standard Setting Organizations", University of California, Berkeley School of Law, Berkeley.

[14] Lerner, J, Tirole, J. (2006) "A Model of Forum Shopping". American Economic Review.

[15] Pohlmann, T. (2010) "Attributes and Dynamic Development Phases of Informal ICT Standards Consortia", Working Paper

[16] Scotchmer, S. (2004) Innovation and Incentives, MIT Press.

[17] Shapiro, C. (2001) "Navigating the Patent Thicket: Cross Licences, Patents Pools, and Standard Setting", in A. Jaffe, J. Lerner et S. Stern (Ed.), Innovation Policy and the Economy, Vol 1, MIT Press.

[18] Thoma G., S. Torrisi, Gambardella, A., Guellec, D., Hall, B. H., Harhoff, D. (2010) "Harmonizing and Combining Large Datasets – An Application to Firm-Level Patent and Accounting Data", NBER Working Paper No. 15851, March 2010.

[19] Updegrove, A. (1995) "Consortia and the Role of the Government in Standard Setting", in B. Kahin & J. Abbate (Eds.). Standards Policy for Information Infrastructure, Cambridge: MIT Press, 321-348.

Appendix:

Proof of Proposition 1

Optimal R&D investment. Since R&D costs are linear, a social planner would choose the total investment $X = \sum_{i=1}^{n} x$ according to the program below:

$$\max_{X} V(X) - cX$$

The first order condition is straightforward:

$$V'\left(\widehat{X}\right) = c \tag{6}$$

R&D investment in equilibrium. By summing the FOC for all firms, we can obtain an implicit definition of the total R&D effort X^* at equilibrium. Taking into account the participation constraint of pure R&D firms, we obtain two different cases

$$\frac{1}{n}\left[V'(X^*) + V(X^*)\frac{n-1}{X^*}\theta\right] = c \tag{7}$$

From equations (7) and (2), we define the private and social marginal benefits of R&D such that $MR(X) = c/V$:

$$\begin{aligned} MR_n(X) &= \frac{1}{n}\left[V'(X) + V(X)\frac{n-1}{X}\theta\right] \\ MR_w(X) &= V'(X) \end{aligned}$$

By comparing them it comes easily that

$$\begin{aligned} MR_w &> MR_{\widetilde{n}} \\ &\Leftrightarrow \\ \theta V(X) - XV'(X) &< 0 \end{aligned} \tag{8}$$

From (7) it comes in turn that:

$$\theta V(X^*) - X^*V'(X^*) = \frac{n}{V}\left[V(X^*)\theta - X^*c\right]$$

Hence:

$$\begin{aligned} MR_w &> MR_{\widetilde{n}} \\ &\Leftrightarrow \\ \theta V(X^*) - X^*c &< \theta \end{aligned}$$

Effect of the number of firms.By applying the envelop theorem to (7) we can identify the effect of n:

$$\frac{dX^*}{dn} = -\frac{\theta V\left(X^*\right) - cX^*}{X^* V''\left(X^*\right) V + \frac{X^* V'(X^*) - V(X^*)}{X^*}\left(n-1\right)\theta}$$

It can be checked easily that denominator of this expression is always negative. Hence

$$sign\frac{dX^*}{dn} = sign\left[V\left(X^*\right)\theta - cX^*\right]$$

Proof of Proposition 3

The FOC of program (5) is:

$$V'\left(X\right)\left[s_k\left(1-\theta\right) + \frac{X^k}{X}\theta\right] + V\left(X\right)\frac{X - X^k}{X^2}\theta = c$$

where $X^k = \sum x_k$ and $X^{-k} = X - X^k$. Summing this condition with the $(n-k)$ individual FOC of the remaining firms (as given by equation (2)) and simplifying gives the total R&D at equilibrium as an implicit function of the size of the coalition:

$$V'\left(X^*\right) + \left(n-k\right)\frac{V\left(X^*\right)}{X^*}\theta = \left(n-k+1\right)c$$

By implicit differentiation of X^* with respect to k, we can establish the following result:

$$\frac{dX^*}{dk} = \frac{\theta V\left(X^*\right) - cX^*}{X^* V''\left(X^*\right) + \frac{X^* V'(X^*) - V(X^*)}{X^*}\left(n-k\right)\theta}$$

The denominator of thus expression is clearly negative. Hence:

$$sign\frac{dX^*}{dk} = sign - \left[\theta V\left(X^*\right) - cX^*\right]$$

We then know from the previous section that the effect of an R&D alliance depends on the comparison beween total investment at equilibrium and the social optimum.

Proof of Proposition 4

In equilibrium, the FOC of a firm within and outside the consortia are:

$$\begin{cases} V'\left(X^*\right)\left[s_k\left(1-\theta\right) + \frac{X_k^*}{X^*}\theta\right] + V\left(X^*\right)\frac{X^* - X_k^*}{X^{*2}}\theta = c \\ V'\left(X^*\right)\left[s_i\left(1-\theta\right) + \frac{x_i^*}{X^*}\theta\right] + V\left(X^*\right)\frac{X - x_i^*}{X^{*2}}\theta = c \end{cases}$$

where x_k^* and x_i^* denote respectively the individual investment of a consortium member and outsider in equilibrium. By rearranging these expressions, we can obtain:

$$\begin{cases} V(X^*)\frac{X_k^*}{X^*}\theta - X^*V'(X^*)\left[s_k(1-\theta)+\frac{X_k^*}{X^*}\theta\right] = \theta V(X^*) - cX^* \\ V(X^*)\frac{x_i^*}{X^*}\theta - X^*V'(X^*)\left[s_i(1-\theta)+\frac{x_i^*}{X^*}\theta\right] = \theta V(X^*) - cX^* \end{cases}$$

and consequently (the terms on the right hand sides being equal):

$$(s_k - s_i)(1-\theta)X^*V'(X^*) + \theta\left[X^*V'(X^*) - V(X^*)\right]\left[\frac{X_k^* - x_i^*}{X^*}\right] = 0$$

When can then obtain a measure of the firms' contribution to the total R&D investment:

$$\frac{x_i^* - X_k^*}{X^*} = (s_i - s_k)\frac{1-\theta}{\theta}\frac{X^*V'(X^*)}{V(X^*) - X^*V'(X^*)}$$

and

$$x_i^* = (s_i - s_k)A + X_k^*$$

where

$$\begin{aligned} A &\equiv \frac{1-\theta}{\theta}\frac{(X^*)^2V'(X^*)}{V(X^*) - X^*V'(X^*)} > 0 \\ &= \frac{1-\theta}{\theta}\frac{r}{\lambda} \end{aligned}$$

Since $X_k^* = X^* - \sum x_i^*$ we have:

$$\begin{aligned} X_k^* &= X^* - \sum(s_i - s_k)A - (n-k)X_k^* \\ &= X^* - A\left[1-(n-k+1)s_k\right] - (n-k)X_k^* \\ &\Leftrightarrow \\ X_k^* &= \frac{X^*}{n-k+1} + A\left[s_k - \frac{1}{n-k+1}\right] \end{aligned}$$

and thus

$$\begin{aligned} x_i^* &= (s_i - s_k)A + X_k^* \\ &= \frac{X^*}{n-k+1} + A\left[s_i - \frac{1}{n-k+1}\right] \end{aligned}$$

using the poisson specification and rearranging, this becomes:

$$\begin{aligned} X_k^* &= \frac{X^*}{n-k+1} + \frac{1-\theta}{\theta}\frac{r}{\lambda}\left[s_k - \frac{1}{n-k+1}\right] \\ x_i^* &= \frac{X^*}{n-k+1} + \frac{1-\theta}{\theta}\frac{r}{\lambda}\left[s_i - \frac{1}{n-k+1}\right] \end{aligned}$$

Effect of a firm joining the consortium on this firm's R&D: Noting $s_i = \frac{s_k}{k} = \frac{1}{n}$ we have:

$$\begin{aligned} \frac{X_{k+1}^*}{k+1} &> x_{i,k}^* \Leftrightarrow X_{k+1}^* - X_k^* > \frac{k(n-k)-1}{n-k+1}\left(X_k^* - \frac{1-\theta}{\theta}\frac{r}{\lambda}\right) \\ x_{i,k+1}^* &> x_{i,k}^* \Leftrightarrow X_{k+1}^* - X_k^* > \frac{1}{n-k+1}\left(\frac{1-\theta}{\theta}\frac{r}{\lambda} - X_k^*\right) \end{aligned}$$

where

$$\frac{X_k^* P'(X_k^*)}{P(X_k^*)} < \theta \Leftrightarrow \frac{1-\theta}{\theta}\frac{r}{\lambda} < X_k^*$$

Hence a firm joining a consortium will invest more (respectively less) if the standard entails insufficient excessive total R&D. By contrast, an increase in the size of the consortium has an ambiguous effect on the R&D investment of firms that remain out of the consortium.

Consortia and their linkage to formal standards

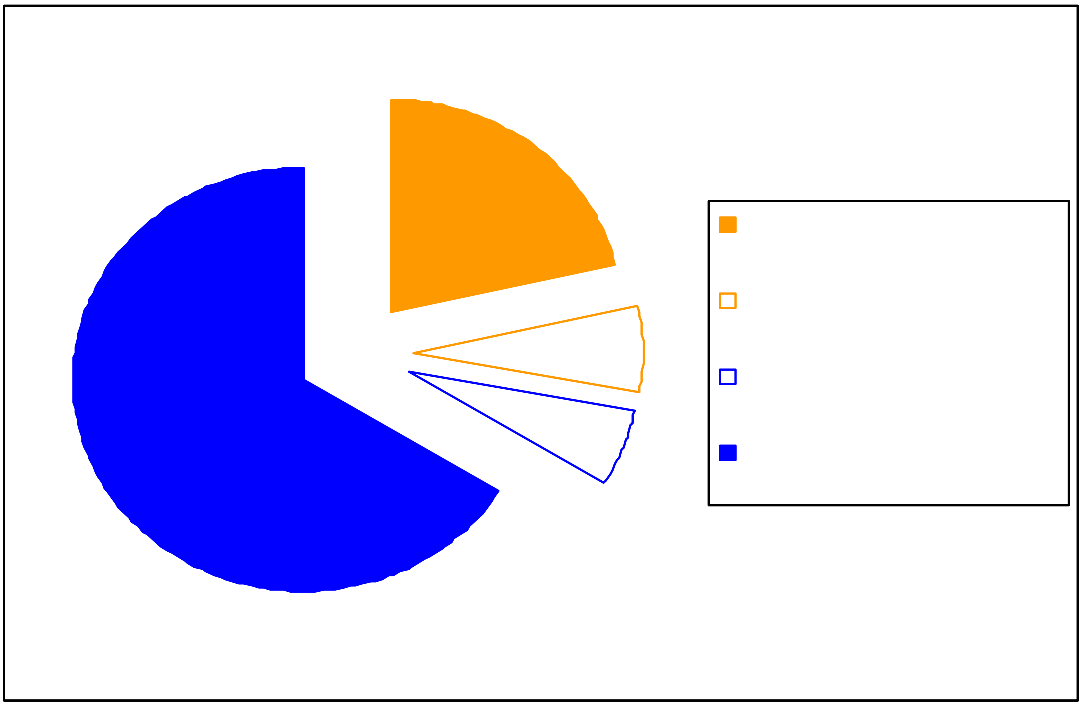
Standard	Consortia	Members
IEEE1394	1394 Trade Association	61
IEEE1800/IEC62530	ACCELLERA	27
IEEE1801	ACCELLERA	27
ISO/IEC18092	ECMA	23
ISO/IEC18000-6	EPCglobal	
IEEE802.21	IETF	125
H.323	IMTC	41
ISO/IEC14496-10/ITUH.264	ISMA	18
ISO/IEC14496-2	ISMA	18
ISO/IEC14496-1	MPEGIF	53
ISO/IEC14496-10/ITUH.264	MPEGIF	53
ISO/IEC14496-12	MPEGIF	53
ISO/IEC14496-14	MPEGIF	53
ISO/IEC14496-15	MPEGIF	53
ISO/IEC14496-16	MPEGIF	53
ISO/IEC14496-18	MPEGIF	53
ISO/IEC14496-19	MPEGIF	53
ISO/IEC14496-2	MPEGIF	53
ISO/IEC14496-20	MPEGIF	53
ISO/IEC14496-3	MPEGIF	53
ISO/IEC14496-4	MPEGIF	53
ISO/IEC14496-5	MPEGIF	53
ISO/IEC14496-6	MPEGIF	53
ISO/IEC14443-1	NFC Forum	150
ISO/IEC14443-2	NFC Forum	150
ISO/IEC14443-3	NFC Forum	150
ISO/IEC14443-4	NFC Forum	150
ISO/IEC18092	NFC Forum	150
IEEE1003.1/ ISO/IEC9945	TOG (The Open Group)	254
ISO/IECDIS29341	UPnP Forum	891
IEEE802.11/ ISO/IEC8802-11	Wi-Fi Alliance	309
IEEE802.16	WiMax	462
IEEE802.15.3	WiMedia Alliance	374

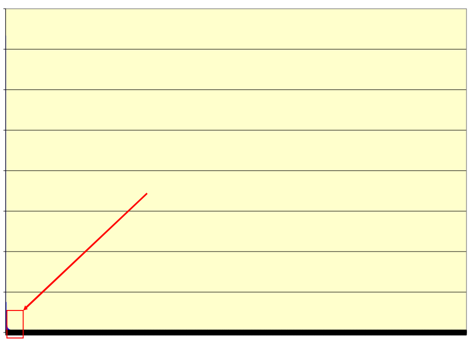
Cross section regression of the mean number of patent files and patent declarations

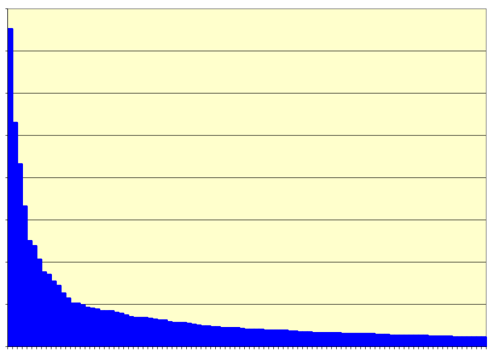
	poisson regression of the mean number of patent files	poisson regression of the mean number of patent declarations
number pages	0.0002292**	-.0002408
	(0.0000995)	(.0004423)
version releases	-0.0059018	-.1395566
	(0.0139882)	(.1035427)
standard age	-0.0288434	.3278869*
	(0.0224759)	(.1737296)
standard age sq	0.0000249	-.0002868**
	(0.000019)	(.0001487)
Sales (mean)	-0.000021**	-.0000538**
	(3.25E-06)	(.0000215)
Employees (mean)	5.55E-06**	7.85e-06**
	(7.10E-07)	(4.41e-06)
R&D expense (mean)	0.0002431***	.0003204***
	(0.0000168)	(.0001217)
cons	12.92451	-92.75688**
	(6.591821)	(50.37273)
observations	504	505
Pseudo R2	0.4333	0.3297
Log pseudolikelihood	-25784.352	-1587.5084

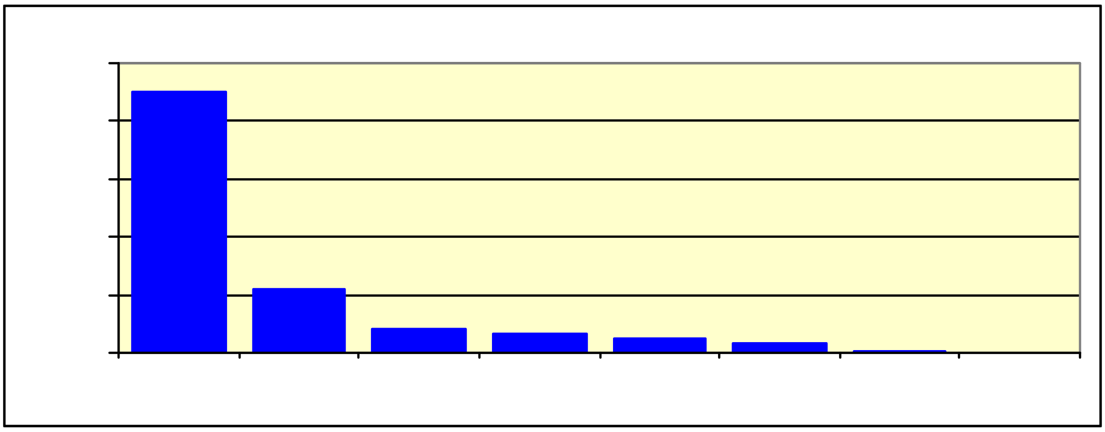
* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level, robust standard errors in brackets

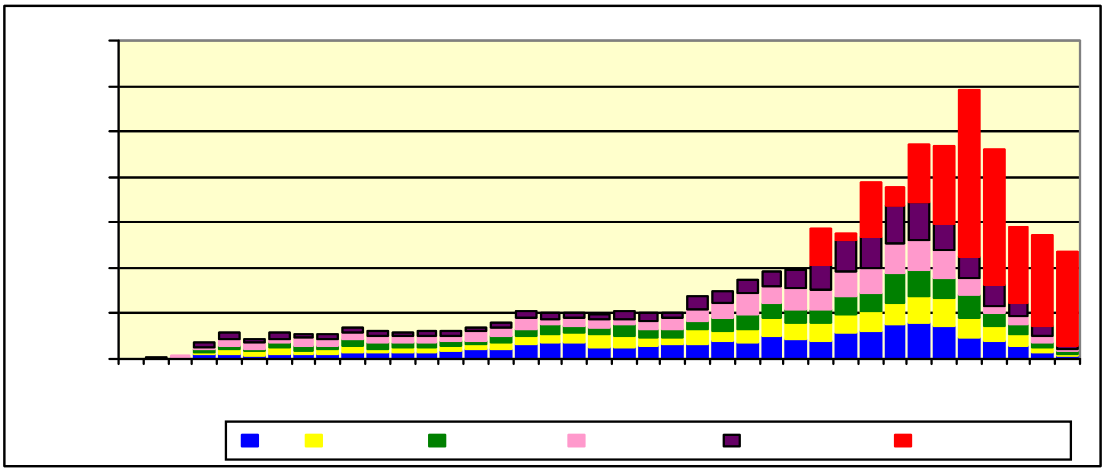
note: note: control variables for industry SIC codes and technical classes (ICS) are not displayed in the results

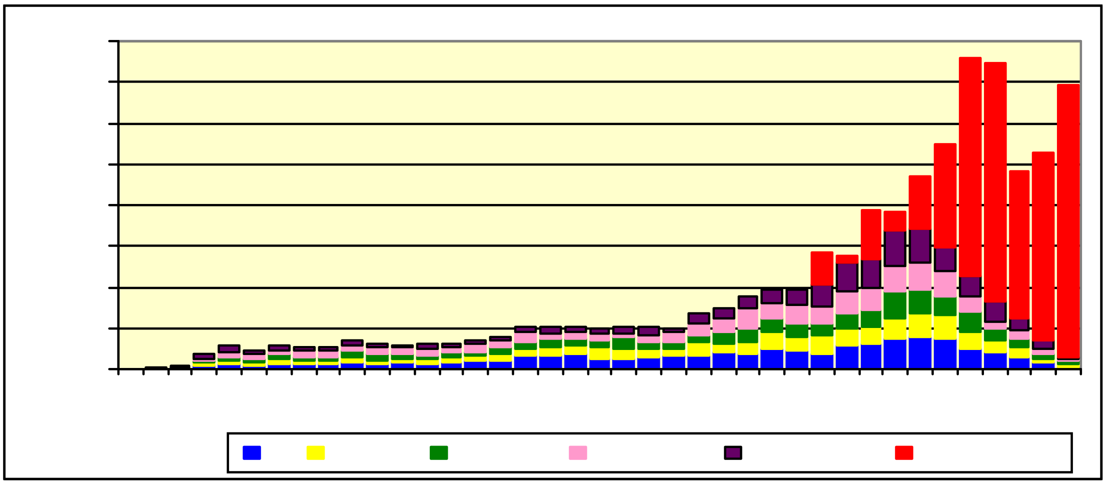












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Access to Intellectual Property for Innovation: Evidence on Problems and Coping Strategies from German Firms

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Access to Intellectual Property for Innovation: Evidence on Problems and Coping Strategies from German Firms

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Abstract

Transaction costs and contracting problems associated with proliferation of patents may have a negative impact on innovation. We present novel data on the frequency with which innovative German firms encounter problems with access to intellectual property (IP) for innovation. While only a small percentage of all firms report halting or not starting innovation projects because of IP issues, larger fractions report taking actions such as modifying projects or use of "coping mechanisms" such as acquisition or exchange of IPR in the market for technology. Much of this activity is concentrated in firms which are larger, more R&D intensive, and have more patents. Firms operating in technology areas in which IP ownership is more concentrated appear to be better able to prevent problems of access to IP from arising by using coping mechanisms, suggesting that transacting in the market for technology may be less costly where ownership of IP is less fragmented. Interestingly we find no evidence that problems of access to IP are more severe in the complex/cumulative industries where patent thickets are thought to present the most serious challenges.

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I. Introduction

The monopoly rights represented by patents have classically been viewed as a short-run sacrifice of consumer surplus for the sake of long-run increases in economic growth through the promotion of investment in R&D. Recent decades have seen a sharp increase in patent applications in most OECD countries, and much policy discussion appears to presume that greater patenting activity reflects higher levels of innovation in the economy and concomitantly greater long-run gains, even if short-run losses are difficult to assess. The reality may be more complex. On the one hand, increases in patenting may not be driven solely by increases in innovative activity. Although technological opportunity appears to have increased significantly in areas such as software and biotechnology, leading to more innovation, and thus more patenting, patenting activity may also have increased independently of the underlying rate of innovation. The institutions that grant and enforce patents have evolved, lowering the costs and raising the benefits of acquiring patents, while patent applicants appear to have become more aware of the competitive value of patents and more sophisticated and strategic in their use (Hall and Ziedonis (2001), Reitzig, Henkel and Schneider (2010)). On the other, greater numbers of patents may have negative effects on innovators, stifling rather than stimulating technical change.

A theoretical literature has shown that when research is sequential and builds upon previous innovations, stronger patents may discourage follow-on inventions (Merges and Nelson 1990, Scotchmer 1991, etc.), and a debate has emerged over the extent to which patent "thickets" may stifle innovation. Defined by Shapiro (2001) as "a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology", patent thickets may be particularly onerous in the context of cumulative innovation and multiple blocking patents where the costs associated with patents may outweigh any positive impact on R&D incentives. While the literature has focused largely on the relationship between patents and incentives to innovate from the perspective of the patent holder, the impact of one firm's decisions to patent on its competitors as well as the impact of patents held by non-competitors is less well understood. In this paper we present some empirical evidence of the impact of patenting on the activities of firms other than the patent holder, specifically the incidence of firms reporting problems with "freedom to operate" caused by lack of access to relevant intellectual property, and the extent to which they utilize "coping mechanisms" to mitigate these problems.

Faced with a blocking patent, or otherwise lacking clear freedom to operate, a firm can try to invent around the problem with a non-infringing innovation or can seek licenses to practice the technology (or acquire patents outright). Such transactions may be able to effectively resolve problems of access to intellectual property, particularly when patent holders are not direct competitors in the product market, or where the patent holder and the inventor of an improvement are able to contract for an efficient sharing of surplus. But one question of particular interest is whether the proliferation of patents and fragmented ownership of intellectual property can create transaction costs that prevent efficient exchange in the market for technology. In principle, such transactions costs associated with "patent thickets" may stifle innovation and limit competition. Where proliferation of intellectual property makes it very difficult to invent around existing patents, or raises transaction costs of contracting with patent holders to prohibitive levels, the "stimulating" effects of patents on R&D incentives may break down. Large numbers of patents may be particularly challenging for firms which have limited resources, and may not be able to participate in some of the mechanisms available to larger firms with more extensive patent portfolios, such as cross-licensing or pooling.

Despite the potential importance of patent thickets for innovative firms and for competition policy, we have to date little evidence on how many and which types of firms experience their ill effects. While much of the existing empirical evidence has focused on whether firms in more "fragmented" IP markets may have higher costs due to the higher transaction costs associated with negotiating with multiple parties over access to patented technologies, the evidence on the link between patent thickets and the stifling of innovation remains at best indirect. This paper provides what is to our knowledge the first cross-industry survey evidence on the rate at which problems of access to IP lead to project abandonment, avoidance, or modification, which types of firms and industries are most likely to face these problems, and the degree to which they were able to mitigate any negative effects by participating in the "market for technology".

Our data on these phenomena are taken from the 2008 wave of the Mannheim Innovation Panel (MIP), a survey in which respondents self-reported the occurrence of various "events in connection with the right to use intellectual property rights." These events include problems such as not starting, abandoning, or modifying innovation projects because their firm did not have rights to the relevant IP, or alternatively taking the potentially risky course of proceeding without access to that IP. They also include events that can be viewed as attempts to deal with problems of access to IP such as exchanges or acquisitions of IP, attempting to limit competitors' IP by participating in patent opposition proceedings, or negotiations to avoid legal disputes. We examine variation in these responses across different types of firms and different industrial sectors, and across markets and technologies where we are able to measure the degree of concentration of ownership of IP in the market for technologies. Our findings suggest that the impact of competitors' patents on innovation activity is significant only for a minority of firms in the economy overall. However, if we focus on sectors of the economy where such problems are more likely to be relevant (e.g., where patents are more important mechanisms for protecting innovation), we observe a significantly higher incidence of both problems and coping mechanisms.

Literature Review

Much economic analysis of the patent system has focused on the effectiveness of patents as a means of appropriating returns for the innovator. Surveys of R&D performing firms[1] have identified the patent paradox: increases in patenting across many industrial sectors and types of firms, but at the same time general agreement that (outside a few sectors) the effectiveness of patents in preventing imitation or securing returns from R&D is limited. In most sectors of the economy, and for many firms, other mechanisms such as reliance on trade secrets, speed to market or control of complementary assets appear to play at least as important a role in capturing returns from commercializing new technology.

[1] These go back to Mansfield (1986) and the Levin et al. (1987) "Yale Survey", and more recently the Cohen et al. (2000) "CMU Survey" and various rounds of the Community Innovation Surveys in EU countries.

Recent research in economics has increasingly highlighted a variety of other roles for patents beyond their direct role in creating a monopoly over the patented technology for the patent holder. These include supporting transactions in the "market for technology" (Arora, Fosfuri, and Gambardella (2001), Gans, Hsu, and Stern (2002)), disclosing information (Anton and Yao (2004)), signaling to investors (Hall and MacGarvie (2010)), Hsu and Ziedonis (2008), Häussler, Harhoff and Müller (2009)), mitigating expropriation risks (Ziedonis (2004), or creating opportunities to extract industry-wide rents through holding up standards-setting (Rysman and Simcoe (2008)). Patents may be surprisingly valuable in these indirect roles, stimulating innovation by raising returns to innovator companies through mechanisms other than directly foreclosing competitors' access to product markets.

But it has also been increasingly argued that the patent system may now be at risk of stifling innovation (Federal Trade Commission (2003), Bessen and Meurer (2008), Jaffe and Lerner (2004), and Merrill, Levin and Myers (2004)). While much of this criticism has focused on fixable flaws in the operation of the system, such as poor quality of examination, it has also highlighted the potential for significant costs associated with patents that fall outside of traditional tradeoffs between incentives for the innovator and high prices faced by consumers. These may include problems such as dissipative rent seeking in patent races (Reinganum (1983)), defensive investment in IP not directly related to an innovator's core business, or otherwise promising research projects stranded or abandoned when the innovator realizes it faces an unresolvable patent problem.

One increasingly influential line of research has pointed to potential costs associated with fragmentation of IP ownership, where transaction costs associated with patent thickets (Shapiro (2001)), and holdup or opportunistic behavior in contexts where a firm trying to obtain freedom to operate in an environment where it has to negotiate with multiple rival licensors (Noel and Schankerman (2006), Lemley and Shapiro (2007).) In the extreme, proliferation of patents may lead to an "anti-commons" situation where too many rights lead to gridlock among would-be innovators (Heller and Eisenberg (1998)). Evidence on these questions is mixed. For example, in software, a classic "complex/cumulative" technology where such stifling effects are thought to be particularly important, Bessen and Maskin (2007) and Bessen and Hunt (2007), have argued that more-and-stronger patent rights have induced a decline in R&D spending in industries affected by software patents. Yet other authors have found a positive impact of software patents or at least a positive correlation between patenting and performance, see Lerner and Zhu (2007), Merges (2006), Smith and Mann (2004), Mann (2005). Cockburn and MacGarvie (2009, 2010) find that while larger numbers of patents and patent assignees negatively impact rates of entry into markets for software products, potential entrants that have their own patent portfolios are more likely to enter markets.

One issue is the extent to which problems related to fragmentation of rights can be efficiently resolved through licensing transactions. Here the (limited) evidence is contradictory. Some authors argue that problems such as royalty stacking can be effectively resolved though negotiation (Geradin, Layne-Farrar, and Padilla (2007), Galasso and Schankerman (2008), Gerardin (2009)). However, Von Graevenitz and Siebert (2006) find a negative association between licensing activity and fragmentation, and Cockburn, MacGarvie and Mueller (2010) find more licensing activity but poorer innovation performance by licensees in industries with more fragmented IP ownership.

Potential negative effects of patents on the innovation process have been most closely examined in the context of biomedical scientific research, where there is conflicting evidence as to whether patenting of basic science has had an impact on subsequent innovation. Murray and Stern (2007) find that patented discoveries are cited less frequently by subsequent scientific papers than comparable unpatented discoveries, but Cohen and Walsh (2008) find little evidence of substantial negative effects in survey of practicing biomedical scientists. Interesting though this research is, it does not speak directly to transactions costs associated with the patent thicket problem, and its relevance to innovation and commercialization of new ideas by industrial firms is unclear.

We begin with a description of the data source used in this paper and the construction of the sample of firms which is analyzed. We then undertake a series of univariate analyses of the data, comparing the incidence of “patent problems” and “coping mechanisms” across different groups of firms, before moving to multivariate models of survey responses. A final section summarizes our findings and discusses their implications.

II. Data Source and Variable Definition

The analysis is based on the Mannheim Innovation Panel (MIP), an annual survey which focuses on the innovative activities of German companies. The survey is conducted annually by the Centre for European Economic Research (ZEW) on behalf of the German Federal Ministry of Education and Research since 1992. Every second year the survey is part of the Community Innovation Survey (CIS) sponsored by Eurostat. The questionnaire follows the guidelines of the Oslo Manual for collecting innovation data (OECD and Eurostat, 1997). The target population of the MIP covers legally independent firms in Germany with at least five employees and covers both the manufacturing and the service sector. For our analysis we use information from the survey wave conducted in 2008. Patent information from the European Patent Office (EPO) is merged at the company level to the MIP using the applicant name and address and comparing it with the respective company information. A computer algorithm was used to suggest potential matches which were then manually checked.

A total of 6,110 companies answered the survey. We restrict the regression sample to companies with innovative activities, i.e. companies which introduced a new product or process in the three years preceding the survey, abandoned an innovation project or are still working on an unfinished innovation project. The regression sample is further restricted to the industries covered by the current stratification scheme of the MIP to make the regression results comparable to the industries for which we have representative values. We have thus full information on 2,529 companies with innovative activities. For the parts of our analysis in which we require characteristics of technology markets, we need to restrict the sample to companies with at least one patent application, since we rely on information from patent applications to determine in which technology market the company is mainly active in. In this part we also control for the concentration of sales in the product market. This requires a further restriction to companies in the manufacturing and wholesale sector, since this information is not available for services. This part of our analysis is based on a total of 568 companies.

In the survey wave conducted in 2008 a series of questions focused on whether innovative activities were stifled by a lack of access to IPR and whether firms used certain coping strategies. More specifically, firms were asked whether any of the following events happened in their firm in conjunction with the access to intellectual property rights in the years 2005-2007: Innovation projects have not been started because there was no access to necessary IPR (*NOTSTARTED*); abandonment of innovation projects that have already started because there was no access to necessary IPR (*ABANDON*); modification of innovation projects to comply with available IPR (*MODIFY*); conducting innovation projects without access to all necessary IPR (*NOIPIR*); acquisition of IPR (purchase, licensing) (*ACQUIRE*); exchange of IPR (cross licensing, patent pools) (*EXCHANGE*); opposition/litigation of your company against IPR hold by other companies/institutions (*OPPOSING*); negotiations/out-of-court settlements to avoid disputes about IPR (*NEGOTIATE*). Detailed descriptive statistics on these variables will be discussed in the following section.[2]

Table 1 presents descriptive statistics for the remaining firm characteristics. Firms in this sample have on average 1102 employees with a substantially lower median of 65 employees. Only 25% of the companies are younger than 10 years. The R&D intensity measured as R&D expenditures divided by sales is on average 3.9%. 29% of these firms have at least one patent application at the EPO. On average firms have an application stock of 38 patents. The share of sales from the most important product is on average 68%. 70% of firms with patent applications state that patents are of high importance for the protection of the intellectual property of the firm. The alternative answers are medium or low importance. 28% of firms have only product innovations, 16% only process innovations, 39% have both product and process innovations and 17% have only started but not finished innovation projects or abandoned

[2] Companies were also asked for "Opposition/litigation of other companies/institutions against IPR hold by your company". We do not include this event in our analysis, since it is not a strategy of obtaining access to the IP held by others.

innovation projects. In the regression analysis we combine firms with only product innovations and with only started or abandoned projects in the reference category. 27% of firms have the highest share of their patent applications in a discrete technology. We use the classification described in OECD (1994) to differentiate technologies into 30 different classes. The discrete technologies are organic fine chemistry, macromolecular chemistry, pharmaceuticals/cosmetics, biotechnology, agriculture/food/chemistry, petrol industry/basic materials, chemical engineering, surface technology/coating, materials/metallurgy and materials processing/textiles/paper, and the remaining ones are complex.

The degree to which markets for technology can be characterized as fragmented or concentrated is an important issue for this paper. We measure this using the Herfindahl index of concentration of ownership of IP in a technology market, calculated as the sum of squared shares of patent applicants and then scaled by 10,000. The market share of a patent applicant is taken to be the share of the applicant's patent applications in a specific technology relative to all applications in the respective technology. Technologies are defined at the 3-digit level (section+class) of the International Patent Classification (IPC), for example A61 "Human Necessities: Medical or Veterinary Science; Hygiene" or F23 "Combustion Apparatus; Combustion Processes". All applications to the EPO are taken as basis without restriction to the country of origin of the applicant. We calculate the Herfindahl index for the years 2003-2007 and then use the average value in order to smooth out annual variations. There are markets with high concentration, e.g. IPC class A24 "Tobacco, Cigars, Cigarettes, Smokers' Requisites" with a Herfindahl of 58.0, and markets with very low concentration, e.g. E04 "Building" with a Herfindahl of 1.37. We determine in which technology market a MIP company is active from its patent applications, using the 3-digit technology class with the largest number of applications in its patent portfolio, and then apply the Herfindahl index of concentration of IP ownership in that market.[3] Note that we can therefore measure concentration at the technology market only for companies which have applied at least for one

[3] For about a quarter of the companies two IPC classes are equally important. In these cases we calculated the concentration in the technology market as the average of both technology areas.

patent. Overall, the MIP companies are active in 106 different technology markets. The Herfindahl index for the concentration in the technology market has a mean of 60.3.

The Herfindahl index of the product market measures the sales concentration defined at the 3-digit industry level to control for the competitive situation in the product market. Note that this calculation is based only on the sales of German companies within Germany. This index is calculated and published by the German Monopoly Commission. The Herfindahl index for the concentration in the product market is also scaled by 10,000 and has a mean of 48.4.

III. Economy-wide Incidence of Problems and Coping Strategies

We begin by describing the summary statistics of the dataset weighted to be representative of the German economy in Table 2. The weights are based on information of the number of firms in Germany with specific characteristics according to industry, size group and region.

Our analysis will focus on firms with innovative activities. However, it is also possible that lack of access to IP prevents firms from undertaking any innovative activities. For firms without innovative activities (excluded from our regression sample) we find that 1.2% did not start an innovative project because of lack of access to IP. Although this is a small number, it shows that IP can be an entry barrier to innovation for some firms. In representative values 44% of German firms have no innovative activities. There is no information on the other three problem categories, because firms without innovative activities currently do not work on innovative projects.

Among German companies with any innovative activities, approximately 2.8% of report that they were unable to start a project due to the lack of IP. A slightly higher percentage of German innovative companies – 3.13% – abandoned a project due to lack of IP, while 9.1% of such companies were required to modify an innovative project due to lack of access to IP. By contrast, 7.3% of companies proceeded with the project without access to the necessary IPR.

These rates differ in some cases between manufacturing and services firms. For example, manufacturing firms are three times as likely to report modifying a product (16.7% vs. 5.7%) and almost twice as likely to report going forward without access to IP (10.5% vs. 5.9%). These two responses are particularly prevalent among firms engaged in the manufacturing of chemicals and pharmaceuticals, glass, ceramics and mineral products, electrical engineering and electronics, instruments, transport equipment, transport equipment, and computers and telecommunications.

The second set of survey questions about trade in IP have somewhat higher rates of positive response. 13.9% of German companies with innovative activities reported acquiring IP, 7.6% of companies engaged in negotiation, and 5.3% of companies opposed another company's application. However, a surprisingly low share of firms – 1.5% – engaged in the exchange of IP via cross-licensing or patent pools.

The biggest differences between responses to these questions between manufacturing and services firms were for the use of opposition (9% of manufacturing firms had opposed other patents, while this figure for services firms was 3.3% respectively) and negotiation (12.6% for manufacturing and 5.4% for services). These differences no doubt reflect the relative strategic importance of patents in these sectors.

There are very substantial differences across industry sectors. Incidence of IP problems is well below the overall mean in business services, utilities, and wholesale trade, and well above the overall mean in industries such as pharmaceuticals, electronics, and instruments. The highest rates of patent acquisition are in chemicals and pharmaceuticals, computers and telecommunications, and (interestingly) financial intermediation, all of which are in the range of 30%. Slightly over half of companies in motion pictures and broadcasting report acquisitions of IP, which reflects the importance of licensing the rights to creative products in this industry.

The previous discussion provides an indication of the prevalence of problems and solutions to IP access across sectors of the German economy, and are weighted to be representative for firms with innovative activities. We now discuss in Table 2 the basic patterns in the dataset used for the regressions, and it should be noted that the statistics discussed here are not weighted to be representative of the population of German firms. Comparing various subsets of the data we see that the mean rate of reporting of adverse effects or use of coping mechanisms is substantially lower for smaller firms (with fewer than 60 employees, the median of employment in the sample) versus larger firms. As expected, large firms have more innovation projects and have therefore a higher probability of encountering any problems. We also see lower rates of adverse effects and coping mechanisms for firms with sales highly concentrated in a single product. However, this could reflect the smaller size of these firms. Interestingly, young firms do not report more problems than old ones. A younger age does not put firms at a disadvantage. Rates are lower for less innovative firms: non R&D performers, those who do not report sales of products new to the market and for firms who report no use of patents, or who report that patents are of low importance as a means of protection of intellectual property of their firm. In summary, no matter how innovativeness is measured, we see a higher incidence of both problems and coping activities for more innovative firms. It appears that the more a firm engages in the innovation, the more likely it is to both face a problem and seek a solution. It is reassuring that the firms experiencing problems with the patent system are also the ones most likely to benefit from it by seeking patent protection themselves. However, because we cannot measure the costs incurred due to coping with problems, nor can we measure the foregone opportunity reflected in abandoned projects, it is impossible to use this data to quantify the costs vs. the benefits to innovative firms of participating in the patent system.

No substantial systematic difference is apparent in the reporting of adverse effects or use of coping mechanisms between firms in discrete versus complex technology areas, though firms with complex products are somewhat more likely to report abandoning innovation projects in progress, while firms with discrete products are more likely to report abandoning projects before they start. This difference could potentially reflect greater ease of foreseeing and identifying potential problems in discrete areas, in contrast to complex technologies like software for which there may be hundreds of potentially related patents with uncertain validity.[4] Finally, firms in industries where innovation is more product focused than process focused report somewhat higher rates of encountering problems and engaging in coping mechanisms. This could point to a greater difficulty of enforcing IP rights over process innovation relative to product innovation.

For companies with at least one patent we are able to compute the concentration of ownership of IP. Firms for which the concentration of related IP rights is higher report lower rates of problems, with the exception of proceeding without access to IP, which is higher when IP is more concentrated. The reported rate of engagement in cross-licensing or pooling is almost two times higher for firms facing higher concentration of IP, and may reflect lower transaction costs of negotiating in more concentrated markets. In contrast to IP markets, problems appear to be *more* common for firms facing greater concentration in the product market (as measured by the Herfindahl of sales in the firm's 3-digit industry).

The incidence of reporting IP problems is correlated across the different kinds of problems as shown in Table 4. For example, 56% of firms that report abandoning a project due to lack of IP also report not starting a project. When we look at the incidence of engaging in coping mechanisms conditional on having reported a problem, we find that the use of mechanisms is 2 to 3 times more frequent for firms reporting problems such as not starting or abandoning innovation projects.

Interestingly, however, the reported rate of use of coping mechanisms is still quite high even for firms that do not report IP problems. We interpret this as evidence that these mechanisms are quite effective in allowing firms to avoid or mitigate difficulties presented by lack of freedom to operate.

IV. Determinants of Problems and Coping Strategies

Looking separately at problems and at coping strategies

Though interesting, these differences in means are vulnerable to confounding, and responses are correlated across answers (jointly determined). In Tables 5-7, we estimate multivariate discrete choice models that control for a variety of characteristics of the firm and technology area. Table 5 focuses on the

[4] See Bessen and Meurer (2008) for a description of this "notice failure" problem and its effects on litigation over inadvertent infringement of patents.

questions relating to problems or potential stifling effects of patents. In the first five columns of this table, we present results based on the sample of firms with innovative activities, and in columns 6-10 we present results restricted to firms that have filed at least one patent application in the past. Here we see clear evidence that firms that are more active in the production of new technologies are more likely to respond affirmatively to one of the survey questions. Across most of the outcome variables, firms are more likely to answer yes to the survey question if they are larger and more R&D-intensive. The notable exception to this finding is for *NOTSTARTED* and *ABANDON*, where these measures of firm size and competence are insignificantly related to the likelihood of abandoning or not starting a project. Larger size is also not significantly associated with *NOIPR*, after controlling for R&D intensity. Being younger than ten years old is insignificantly related to all the survey responses. If we use age or the logarithm of age as a continuous measure, we also find an insignificant influence. We therefore find that young firms are not especially vulnerable to problems.

The relationship between firm patenting and the survey questions displays an interesting pattern. Having any patent applications is positively and significantly associated with abandoning, not starting, and with proceeding without access to IPR (at the 10% level of significance) or modifying a project (at the 5% level). However, of those questions only modification is significantly related to the *number* of patent applications previously filed by a firm. Firms that have high shares of sales coming from one product are less likely to report abandoning a product or proceeding without access to IPR. Firms that have both product and process innovation are significantly more likely than firms with only product innovation to answer affirmatively to all of the questions.

Patenting firms were asked their views on the importance of patents for protecting their intellectual property, and we include a dummy equal to 1 if the firm reports that patents were “of high importance”. This variable is not significantly associated with any of the survey questions about problems, holding constant other RHS variables. We also include a variable capturing the concentration of patents over assignees in the classes cited by the firm (the Herfindahl of IP). The coefficients on this variable are negative and significant for abandoning, not starting, and modifying projects and the coefficient is positive and significant for proceeding without access to IPR. These results are consistent with the hypothesis that less concentrated holdings of IPRs may be associated with less potential hold-up of firms commercializing complementary technologies. A control for the Herfindahl in the product market is insignificantly related to all of the survey questions holding constant other covariates. There is also no significant difference in the responses to questions between firms in discrete vs. firms in complex technology areas.

In columns 5 and 10 we present results based on an aggregate *PROBLEM* variable equal to 1 if the firm answered affirmatively to any of *ABANDON, NOTSTARTED*, and *MODIFY*.[5] Using this as our measure of "problems with access to IP", we see that larger, more R&D-intensive firms with larger patent portfolios are more likely to experience problems, while firms facing less fragmented IP landscapes are less likely to experience problems.

In Table 6 we present results on the determinants of the questions relating to coping mechanisms. Large firms and R&D-intensive firms are more likely to use these mechanisms, although once we restrict to firms with patents the coefficients on R&D/sales become insignificant in the regressions for which the dependent variables are *OPPOSING* and *NEGOTIATE*. In contrast to the results on problems with access to IP, the fact of having patent applications alone is insignificantly associated with all of the various trade or legal mechanisms (except for opposition by the focal company, at the 10% level), but the number of applications filed is positively associated with each of these questions. Thus we see that the innovative firms that participate in trade, opposition, and negotiation are, all else equal, the firms with larger patent portfolios, while the size of a firm's patent portfolio appears unrelated to the probability of experiencing problems that lead to the abandonment, modification, etc. of a project.

Firms that have high shares of sales coming from one product are less likely to report acquiring necessary IPR. Firms that have both product and process innovation are significantly more likely than firms with only product innovation to answer affirmatively to all of the questions. Firms that responded

[5] We do not include NOIPR in this definition of "problems" because in some sense it is a solution. Taking this route allows firms to proceed with innovative projects, even though it may be a risky course.

that patents were of high importance were significantly more likely to acquire or exchange IPR, be involved in opposition, and be involved in negotiations. Perhaps not surprisingly, these are the same questions for which the size of the firm's patent portfolio is positively and significantly associated with an increase in the probability of a positive response.

We do not observe any significant relationship between the use of coping mechanisms and the concentration of patent holdings or the discrete vs. complex dummy. [6] The importance of patent protection is significant at the 10% level for the regression in which EXCHANGE is the dependent variable.

We also use the variable *COPING* capturing whether any of the "coping" questions, i.e. *ACQUIRE*, *EXCHANGE*, *OPPOSING* and *NEGOTIATE*, were answered affirmatively (columns 5 and 10). For our aggregate coping measure we see again that firms that are larger and more active in innovation are more likely to use coping mechanisms. We also observe that the firm's view of the importance of patent protection is positively associated with coping at the 10% level.

Joint determination of problems and coping strategies

The question-by-question analysis described above should be interpreted bearing in mind that a substantial share of firms answer more than one question affirmatively. This is related to the fact that firms that are more engaged in innovative activity may be more likely to encounter more than one problem or seek more than one type of solution to a problem. Table 7 presents results from a multinomial logit analysis of survey responses grouped into mutually exclusive categories.

Our *PROBLEM* variable is equal to 1 for firms that either did not start, abandoned, or modified a product due to the lack of access to IP. We distinguish between, firms that face problems without coping *(PROBLEM*=1, *COPING*=0), firms that face problems and cope (*PROBLEM*=1, *COPING*=1), firms that

[6] However, in results not reported here, we found that firms in discrete areas are more likely (at the 10% level of significance) to report being the target of opposition.

cope without facing problems (*PROBLEM*=0, *COPING*=1), and firms that face no problems and seek no solutions (*PROBLEM*=0, *COPING*=0). The former outcome can be thought of as an indication that firms were able to preempt a problem (e.g. by using the opposition system or acquiring the requisite IPR). Among innovative firms, 65% face no problems and use no coping mechanisms, while 7% face problems but use no mechanisms. Those facing problems and using mechanisms account for 13% of the sample, while 18% use mechanisms and face no problems. For patenting firms, these percentages are 39% (*PROBLEM*=0, *COPING*=0), 10% (*PROBLEM*=1, *COPING*=0), 29% (*PROBLEM*=1, *COPING*=1), and 22% (*PROBLEM*=0, *COPING*=1).

We would like to understand whether the legal or exchange coping mechanisms that firms report employing are associated with lower rates of problems. Or, alternatively, does the use of such mechanisms not completely solve or prevent such problems from arising? Can we identify firm-level factors associated with the prevention of problems via the use of mechanisms? In this analysis, we are seeking to determine whether the patent system prevents companies from bringing their product ideas to market or to realize their process ideas, or whether companies can effectively use the patent system to cope with problems. Our variable *COPING* (described above) captures strategies such as trade (buying, exchanging), opposition/litigation against patents held by other companies and negotiations to avoid legal disputes if the aim is to get a clear path for the own inventions. We find that being young is positively associated with the successful use of coping mechanisms (*PROBLEM*=0, *COPING*=1), while firm size is positively and significantly associated with increases in the likelihood of using a coping mechanism, either successfully (*PROBLEM*=0, *COPING*=1) or unsuccessfully (*PROBLEM*=1, *COPING*=1). The coefficient on R&D/Sales ratio is positive and significant across all categories, no doubt reflecting the fact that firms more engaged in innovative activity are more likely to both face problems and find solutions. Increases in the size of the patent portfolio are only significantly associated with increases in the likelihood of facing problems and coping. Thus it does appear that firms holding patents are more likely to face problems, and firms with larger patent portfolios are better able to use coping mechanisms to deal with those problems. However, if our interpretation of the outcome with *PROBLEM*=0, *COPING*=1 as "prevention of problems" is correct, it is surprising that firms with larger portfolios are not significantly more likely to prevent potential problems from arising via their use of the patent system. It may be that these firms are simultaneously better defended but also more likely to be targets, with the latter effect outweighing the former.

Firms for which the significance of patent protection is deemed high are significantly more likely to report the use of coping mechanisms with problems (at the 10% level). This may reflect the willingness on the part of these firms to invest in acquiring patents or filing oppositions. Alternatively, one could say that these companies receive benefits from patent protection but commensurately face costs associated with these benefits. We find that the concentration of IP rights is negatively related to facing problems and coping and positively related to coping without problems (the latter effect is significant at the 1% level). If we are to interpret the latter outcome as "prevention of problems," this may reflect greater ease of contracting with a smaller number of patent holders which results in the resolution of potential disputes through coping mechanisms.

How large are the aforementioned effects? An increase of one standard deviation in the log of employment is associated with an increase in facing problems of access to IP (*PROBLEM*) of 2.8 percentage points, where the baseline probability of *PROBLEM* is 16%.[7] A similar increase in the log R&D intensity and the log patent stock are associated with 5.7 and 5.5 percentage-point increases in *PROBLEM*, respectively. They are associated with even larger increases in the probability of using coping mechanisms, with a one standard deviation increase in log employment associated with a 10.0 percentage-point increase in *COPING*. Similar increases in log R&D-intensity and the log patent stock are associated with 5.3 and 9.3 percentage-point increases in *COPING*. The baseline probability of *COPING* is 30%, so these effects are fairly substantial. A one standard deviation increase in the concentration of IP rights is associated with a 5.6 percentage point decline in the rate of *PROBLEMS,* but this is only significant at the 10% level.

[7] The estimates of marginal effects described in this paragraph are taken from column 5 of Tables 5 and 6.

Looking at the multinomial results presented in columns 1-4 of Table 7, we see that increases in employment have the biggest effect on using coping mechanisms without facing problems (with an increase of 6.4 percentage points over a baseline probability of 20% for a one standard-deviation increase in log employment), while R&D intensity has a relatively larger marginal effect for facing problems and coping (with a marginal effect of 3.5 percentage points for a one standard deviation increase). A one standard deviation increase in the log patent stock is also associated with a 4.9 percentage point increase in this outcome. The latter outcome has a baseline probability of 9.4%.

The effect of increases in the patent stock is even larger for firms holding patents – with a marginal increase in the probability of *PROBLEM & COPING* of 11 percentage points for a one standard deviation increase in the log patent stock (with a baseline probability of 0.39, see column 6 of Table 7). For firms holding patents, a one standard deviation increase in the Herfindahl of IP is associated with a 5.3 percentage point increase in the probability of using coping strategies and facing no problems (with a baseline probability of 26%).[8]

Interpretation

One of the intriguing findings of this analysis is that large firms and R&D-intensive firms are so much more likely to face problems. Furthermore, young firms appear to be at no particular disadvantage relative to firms with greater experience. Clearly, large, R&D-intensive firms are more likely to be targets for problems due to their greater scale and often complexity of operation relative to smaller firms. It is striking, however, that these firms face problems at a greater rate in spite of their presumably greater resources for preventing problems, e.g. expertise with the legal and patent system, prior experience in product development and complementary assets. The multinomial analysis hints at the possibility that these firms may be better at using coping mechanisms (the positive and significant coefficients on size and

[8] We performed the Hausman test of the Independence of Irrelevent Alternatives (IIA). We found that in the sample restricted to firms with patent applications, we pass the IIA test no matter which base category is omitted when estimating the coeffients of the full model. In the model based on firms with innovative activity, we pass the test two times and fail two times (but only for one outcome each). This may reflect the fact that the sample restricted to companies with patent applications is more homogeneous.

R&D-intensity for outcomes 2 and 3 relative to the base category), yet it is not obvious that these firms are more likely to use coping *successfully* to prevent problems from arising (the lack of a significant difference between the coefficients on size and R&D intensity between columns 2 and 3 in the multinomial analysis). However, it is possible that the coefficient on R&D intensity in column 2 is biased upward by the fact that the firms that are more engaged in innovation are more likely to face problems. As a result, we should be cautious in pursuing the latter interpretation of the coefficients.

Another interesting result is found in the patent-related variables. Firms holding patents are significantly more likely to run into problems and have to abandon, not start, or modify projects, or proceed without access to IPR. Firms with more patents are also more likely to acquire or exchange IP or participate in negotiations to resolve disputes. However, it does not appear that filing more patents plays a role in preventing problems from arising (see the insignificant or positive coefficients on the patent stock for *NOTSTART, ABANDON*, *MODIFY,* and *NOIPR*). In the multinomial analysis we find that having a large patent portfolio makes firms more likely to experience problems and use mechanisms to cope with them (see the positive and significant coefficient on the log of the patent application stock in column 2). The fact that the coefficient on the patent stock is only significant for *PROBLEM & COPING*, suggests that increases in the size of the patent stock increase the use of coping mechanisms but that these increases in the use of mechanisms do not completely prevent or solve the problems. Interestingly, firms operating in areas in which IP is more concentrated among patent-holders may be better able to use coping mechanisms to *prevent* problems (as indicated by a greater use of coping mechanisms without reporting problems).

We find that the likelihood of facing problems has more to do with a firm-specific measure of the importance of IP protection to the firm than with a measure of whether the firm's patents lie in a discrete or complex technology area. This finding warrants notice, because it is sometimes assumed that problems relating to patent thickets are most significant in complex sectors like ICT, and yet we observe no difference in the rate of problems faced by firms between discrete and complex industries.

Finally, the fact that the share of sales from the most important product has a negative association with *ABANDON* and *MODIFY* (at the 10% level) may reflect a greater ability of firms with a less diversified product portfolio to survey the IP landscape and anticipate problems.

V. Conclusions

We examine evidence from a survey of innovative German firms asked about problems of access to IP required for innovation. We find that quite a small percentage of firms have abandoned or not started innovation projects because of a lack of access to IPRs. It is more common for firms to acquire IP or modify innovation projects to comply with existing IP, or proceed without access to requisite IP. Larger and more R&D-intensive firms appear more likely to use mechanisms to deal with problems of access to IP. In sectors in which patents are considered important mechanisms for the protection of IP, and among firms with patents, we observe a higher incidence of both problems and of actions taken to deal with problems. However, problems and solutions to problems are not concentrated in one or two sectors; rather, they are observed across a wide range of industries. Increases in the size of a firm's patent portfolio, all else equal, appears to facilitate the use of solutions like negotiation or exchange of IP, but does not prevent problems from occurring in the first place. There is an intriguing possibility that the concentration in the market for technology has rather a different effect than in the product market: we find suggestive evidence that increasing concentration of holdings of relevant IP may prevent problems of access.

Our findings on the incidence of problems must be understood relative to the use of coping mechanisms. It would be more worrisome if we saw a similar rate of problems, but little use of coping mechanisms. As it stands, we present evidence on relatively modest rates of problems of access to IP among innovative firms on average, and relatively high rates of "accommodation" in the form of modifying projects, acquiring or exchanging IP, and engaging in negotiations.

An important caveat to the latter point is that we observe little about the nature of the projects that are abandoned or not started; neither do we know the costs of accommodation. More research is needed to help us fully understand the financial and opportunity costs of these activities. When a product is modified, is the modification radical or minor? Did the cost of acquiring requisite IP all but eliminate the increase in revenues associated with the innovative project? Were the legal costs associated with negotiations conducted to avoid problems of access to IP large or small? How did the cost of engaging in opposition proceedings compare with anticipated benefits of removing a problem patent? Without answers to these questions, we lack a complete picture of the impact of patent thickets on innovation. However, the overall picture painted by the analysis described here is one in which firms rarely stop projects or avoid them because of access to IP. Rather, many firms are engaged in activities designed to deal with or avoid problems of access to IP.

It is also unclear how relevant these results are to contexts other than the German economy. In the US, for example, there is no opposition procedure, and not all patents are published prior to being granted, yet patents have proliferated at the same, or even higher, rate than in Germany. We speculate that US firms may therefore be both more likely to face some of the problems identified here (e.g. having to halt or modify innovation projects already underway), and to have fewer coping mechanisms available. Future innovation surveys in the US and elsewhere should consider collecting this type of data.

References

Anton, J.J. and Yao, D.A. (2004), "Little Patents and Big Secrets: Managing Intellectual Property", *RAND Journal of Economics*, 35, 1-22.

Arora, A., Fosfuri, A. and Gambardella, A. (2001), *Markets for Technology: Economics of Innovation and Corporate Strategy*, MIT Press, Cambridge MA.

Bessen, J. and Hunt, R. (2007), "An Empirical Look at Software Patents", *Journal of Economics and Management Strategy*, 16, 157-1589.

Bessen, J. and Maskin, E. (2007), "Sequential Innovation, Patents, and Imitation", *RAND Journal of Economics*.

Bessen, J. and Meurer, M. (2008), *Patent Failure. How Judges, Bureaucrats, and Lawyers Put Innovators at Risk*, Princeton: Princeton University Press.

Cockburn, I. and MacGarvie, M. (2009), "Patents, Thickets and the Financing of Early Stage Firms: Evidence from the Software Industry", *Journal of Economics & Management Strategy*, 18, 729-777.

Cockburn, I. and MacGarvie, M., (2010), "Entry and Patenting in the Software Industry", *Management Science,* forthcoming.

Cockburn, I., MacGarvie, M. and Mueller, E. (2010) "Fragmented Intellectual Property Rights, Licensing and Innovative Performance", *Industrial and Corporate Change,* 19, 899-925.

Cohen, W. and Walsh, J. (2008), "Real Impediments to Academic Biomedical Research", *Innovation Policy and the Economy*, 8, 1-30.

Cohen, W., Nelson, R.R. and Walsh, J. (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Paper 7552.

Federal Trade Commission (2003), *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy.* Washington, DC: Federal Trade Commission.

Galasso, A. and Schankerman, M. (2008), "Patent Thickets and the Market for Ideas: Evidence from Settlement of Patent Disputes", mimeo.

Gans, J., Hsu, D. and Stern, S. (2002), "When Does Start-Up Innovation Spur the Gale of Creative Destruction?", *RAND Journal of Economics*, 33, 571-586.

Geradin, D., Layne-Farrar, A. and Padilla, A. J. (2007), "Royalty Stacking in High Tech Industries: Separating Myth from Reality", CEPR Discussion Paper No. 6091.

Haeussler, C., Harhoff, D. and Mueller, E. (2009), "To Be Financed or Not… - The Role of Patents for Venture Capital Financing", CEPR Discussion Paper No. 7115.

Hall, B.H. and MacGarvie, M. (2010),"The Private Value of Software Patents" *Research Policy,* Volume 39, Issue 7, September 2010, p. 994-1009.

Hall, B.H. and Ziedonis, R.H. (2001), "The Patent Paradox Revisited: An Empirical Study of Patenting in the US Semiconductor Industry, 1979-95," *Rand Journal of Economics*, 32, 101-128.

Heller, M. A. and Eisenberg, R. S. (1998), "Can Patents Deter Innovation? The Anti-commons in Biomedical Research", *Science*, 280, 698-701.

Hsu, D. and Ziedonis, R. (2008) "Patents as Quality Signals for Entrepreneurial Ventures", *Academy of Management Best Paper Proceedings*.

Jaffe, A. B. and Lerner, J. (2004), "*Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It",* Princeton: Princeton University Press.

Lemley, M. and Shapiro, C. (2007), "Patent Holdup and Royalty Stacking", *Texas Law Review*, 85.

Lerner, J. and Zhu, F. (2007), "What is the Impact of Software Patent Shifts: Evidence from *Lotus v. Borland*", *International Journal of Industrial Organization*, 25, 511-529.

Levin, R., Kievorick, A., Nelson, R.R. and Winter, S. G. (1987), "Appropriating the returns from industrial R&D", *Brookings Papers on Economic Activity*, 783-820.

Mann, R. (2005), "Do Patents Facilitate Financing in the Software Industry?", *Texas Law Review,* 83, 961-1030.

Mansfield, E. (1986), "Patents and innovation: an empirical study", *Management Science,* 32, 173-81.

Merges, R.P. (2006), "Patents, Entry and Growth in the Software Industry", Working paper, UC Berkeley School of Law.

Merges, R.P. and Nelson, R. (1990), "On the Complex Economics of Patent Scope", *Columbia Law Review*, 90, 839-916.

Merrill, S., Levin, R. and Myers, M. (eds.) (2004), "*A Patent System for the 21st Century"*, Washington DC; National Academies Press.

Murray, F. and Stern, S. (2007), "Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-commons Hypothesis", *Journal of Economic Behavior & Organization,* 63, 648-687.

Noel, M. and Schankerman, M. (2006), "Patent Thickets and Software Innovation: Theory and Evidence from a Panel of U.S. Firms", CEPR Working Paper No. 5701.

OECD (1994), "Using patent data as science and technological indicators", Patent Manual.

OECD and Eurostat (1997), "Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data", OECD/Eurostat, Paris.

Rammer, C. and Bethmann, N. (2009), "Schwerpunktbericht zur Innovationserhebung 2008, Innovationspartnerschaften – Schutz und Verletzung von intellektuellem Eigentum", ZEW Dokumentation Nr. 09-01, Mannheim, Germany

Reinganum, J.F. (1983), "Uncertain Innovation and the Persistence of Monopoly", *American Economic Review*, 73, 741-47.

Reitzig, M., Henkel, J., and Schneider, F. (2010), "Collateral damage for R&D manufacturers: how patent sharks operate in markets for technology", *Industrial and Corporate Change,* 19(3), pages 947-967,

Rysman, M. and Simcoe, T. (2008), "Patents and the Performance of Voluntary Standard-Setting Organizations", *Management Science,* 54, 1920-1934.

Scotchmer, S. (1991), "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law", *Journal of Economic Perspectives*, 5, 29-41.

Shapiro, C. (2001), "Navigating the Patent Thicket: Cross-licenses, Patent Pools, and Standard-Setting", in: Jaffe, A., Lerner, J. and Stern, S. (eds.), *Innovation Policy and the Economy, Vol. 1.* MIT Press for the National Bureau of Economic Research.

Siebert, R. and von Graevenitz, G. (2006), "How Licensing Resolves Hold-Up: Evidence from a Dynamic Panel with Unobserved Heterogeneity", CEPR Discussion Paper 5436.

Smith, B.L. and Mann, S.O. (2004), "Innovation and Intellectual Property Protection in the Software Industry: An Emerging Role for Patents", *University of Chicago Law Review,* 71, 241-264.

Ziedonis, R. (2004), "Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms", *Management Science*, 50, 804-820.

Table 1: Descriptive statistics for regression variables

	Mean	Median	St dev	Min	Max	N
Employees	1102	65	11669	1	400,000	2529
Young (0/1)	0.25	0	0.43	0	1	2529
R&D/sales (in %)	3.88	0.53	11.39	0	133.7	2529
Application (0/1)	0.29	0	0.45	0	1	2529
Application stock	38.3	0	767.8	0	31,587	2529
Sales share main product	68.4	70	24.6	5	100	2529
Process inno only (0/1)	0.16	0	0.36	0	1	2529
Product and process inno (0/1)	0.39	0	0.49	0	1	2529
Manufacturing (discrete industries)	0.29	0	0.45	0	1	2529
Pharma	0.06	0	0.23	0	1	2529
Manufacturing (complex industries)	0.31	0	0.46	0	1	2529
Utilities, trade, transport	0.10	0	0.29	0	1	2529
Technical services	0.18	0	0.38	0	1	2529
Non-technical services	0.07	0	0.26	0	1	2529
Patent protection high importance (0/1)	0.70	1	0.46	0	1	568
Concentration of IP ownership	60.33	44.77	56.35	13.7	436.4	568
Concentration of product market sales	48.42	19.54	67.44	3.2	375.5	568
Discrete technology (0/1)	0.27	0	0.44	0	1	568

Table 2: Mean values of problems and coping strategies representative for German firms

	Problems				Coping strategies			
Variable	**NOTSTARTED**	**ABANDON**	**MODIFY**	**NOIPR**	**ACQUIRE**	**EXCHANGE**	**OPPOSING**	**NEGOTIATE**
				Firms without innovative activities				
Full sample	1.19	-	-	-	3.08	0.33	1.59	1.74
				Firms with innovative activities				
Full sample	2.79	3.13	9.07	7.34	13.90	1.54	5.30	7.64
Manufacturing, all	3.91	3.20	16.71	10.51	13.80	2.41	9.89	12.63
Services, all	2.29	3.10	5.69	5.94	13.95	1.16	3.27	5.42
Mining and quarrying (10-14)	0.00	0.98	1.31	1.31	5.90	0.00	2.95	0.00
Food/beverages/tobacco (15-16)	1.07	4.21	6.45	7.21	12.76	1.69	7.62	11.35
Textiles/clothing/leather (17-19)	1.22	0.00	10.12	6.25	19.46	0.52	10.82	16.04
Wood/paper/printing/ publish. (20-22)	2.66	3.57	8.76	4.96	10.33	0.99	1.85	4.29
Chemicals/pharmaceuticals/ oil (23-24)	9.98	5.43	26.16	18.09	29.63	5.33	17.65	21.03
Rubber/plastics (25)	3.29	3.18	12.51	12.81	8.11	3.03	16.58	13.88
Glass/ceramics/mineral products (26)	11.15	8.89	32.19	10.60	21.90	0.94	20.73	19.41
Metal production/ processing (27-28)	4.54	2.68	13.87	7.84	10.01	1.75	6.44	9.84
Mechanical engineering (29)	3.59	1.21	22.84	11.09	9.80	2.50	12.64	15.31

Electrical eng./electronics (30-32)	3.75	5.26	23.39	18.17	19.12	4.92	14.94	15.65
Instruments (33)	6.21	4.20	25.11	15.12	18.86	3.47	9.99	14.54
Transport equipment (34-35)	2.72	1.72	24.64	15.22	19.02	6.07	8.33	21.11
Furniture/toys/recycling (36-37)	0.65	2.59	9.01	11.48	18.78	0.71	7.18	11.24
Electricity/gas/water supply (40-41)	0.00	0.00	3.00	1.20	12.00	0.96	2.88	6.72
Wholesale trade (51)	1.07	4.80	0.28	6.50	8.73	0.00	9.88	9.15
Transport/post (60-63, 64.1)	0.62	2.27	2.29	0.21	14.42	5.04	0.19	7.56
Financial intermediation (65-67)	0.00	0.00	1.76	0.66	32.24	1.16	2.49	4.85
Computer activit./ telecomm. (72, 64.3)	6.39	7.77	16.13	17.20	27.85	1.25	6.10	9.33
Engineering services/R&D (73, 74.2-74.3)	1.61	0.92	12.44	2.86	11.87	0.71	3.06	2.36
Consultancy/advertising (74.1, 74.4)	3.69	3.73	3.84	7.86	9.55	0.00	0.23	3.51
Other business services (74.5-74.8, 90)	0.94	0.18	2.45	3.15	11.35	0.18	2.30	1.84
Motion picture/broadcasting (92.1, 92.2)	2.71	2.71	23.15	23.52	51.35	0.37	20.44	7.88

Note Values are representative for German firms. Values given in percent. NACE code is given in brackets. Manufacturing, all covers industries 10-41; services, all covers industries 51-92.2. The representative values are taken from Rammer and Bethmann (2009).

Table 3: Mean values of problems and coping strategies based on the regression sample

	Problems				Coping strategies				
Variable	**NOTSTARTED**	**ABANDON**	**MODIFY**	**NOIPR**	**ACQUIRE**	**EXCHANGE**	**OPPOSING**	**NEGOTIATE**	**N**
				Firms with innovative activities					
Full sample	4.55	3.24	19.34	11.59	20.21	3.91	11.82	14.47	2529
employment<=60	2.99	2.75	12.30	10.44	14.00	1.62	5.50	7.61	1236
employment>60	6.03	3.71	26.06	12.68	26.14	6.11	17.87	21.04	1293
age<=9 years	4.74	3.00	19.12	13.27	22.91	4.74	13.59	16.59	633
age>9 years	4.48	3.32	19.41	11.02	19.30	3.64	13.82	13.77	1896
R&D/sales =0	0.89	0.89	3.43	2.54	12.33	0.64	3.81	6.73	787
R&D/sales >0 and R&D/sales<=1.43	6.28	4.57	21.80	13.01	23.17	3.42	15.75	16.89	876
R&D/sales >1.43	6.12	4.04	31.29	18.36	24.36	7.39	15.13	19.05	866
No patent applications	2.50	1.95	10.29	8.01	16.02	1.28	6.79	8.29	1798
With patent applications	9.58	6.43	41.59	20.38	30.51	10.40	30.92	29.69	731
Share of sales new to the firm<=20%	4.63	2.95	21.16	14.00	22.53	4.11	13.37	16.95	950
Share of sales new to the firm>20%	6.33	5.74	29.75	15.61	24.15	6.33	17.53	20.18	679
Share of sales new to the market=0	2.42	1.82	15.01	8.96	17.92	1.94	8.11	10.90	826
Share of sales new to the market>0	8.34	6.57	34.51	20.99	28.19	7.84	22.00	25.54	791

Sales share main product <=70%	5.46	4.48	22.80	13.90	23.39	4.41	14.28	17.34	1338
Sales share main product>70%	3.53	1.85	15.45	8.98	16.62	3.36	9.07	11.25	1191
Process innovation only	2.00	1.00	6.75	4.00	14.00	1.25	3.75	7.75	400
Product innovation only	3.52	2.29	15.15	9.34	16.74	1.94	8.81	10.4	1135
Product and process innovation	6.74	5.23	29.18	17.2	26.66	7.24	18.51	21.83	994
				Firms with patent applications					
Full sample	10.74	6.87	46.83	21.13	34.68	12.15	32.04	34.68	568
Significance of patent protection: low or medium	8.88	5.33	34.91	21.30	24.85	3.55	23.08	24.85	169
Significance of patent protection: high	11.53	7.52	51.88	21.05	38.85	15.79	35.84	38.85	399
Discrete technology	15.23	5.96	47.68	23.18	34.44	11.92	37.09	33.77	151
Complex technology	9.11	7.19	46.52	20.38	34.77	12.23	30.22	35.01	417
Below median of concentration of IP ownership	12.09	8.79	47.99	17.22	37.00	8.06	30.40	33.70	273
Above median of concentration of IP ownership	9.49	5.08	45.76	24.75	32.54	15.93	33.56	35.59	295
Below median of concentration of product market sales	8.73	6.35	44.44	19.44	29.76	10.32	33.73	34.13	252
Above median of concentration of product market sales	12.34	7.28	48.73	22.47	38.61	13.61	30.70	35.13	316

Note Values show the variation in the sample but are not representative for German firms. Values given in percent.

Table 4: Cross-tabulation of problems and coping strategies based on the regression sample

	Problems				Coping strategies				
	NOTSTARTED	ABANDON	MODIFY	NOIPR	ACQUIRE	EXCHANGE	OPPOSING	NEGOTIATE	N
	Firms with innovative activities								
NOTSTARTED=0	0.00	0.015	0.169	0.107	0.191	0.035	0.106	0.131	2414
NOTSTARTED=1	1.00	0.400	0.696	0.304	0.444	0.130	0.383	0.444	115
ABANDONED=0	0.028	0.00	0.175	0.109	0.195	0.037	0.109	0.135	2447
ABANDONED=1	0.561	1.00	0.744	0.317	0.415	0.098	0.402	0.427	82
MODIFIED=0	0.017	0.010	0.00	0.076	0.157	0.014	0.064	0.082	2040
MODIFIED=1	0.164	0.125	1.00	0.282	0.391	0.143	0.344	0.407	489
NOIPR=0	0.036	0.025	0.157	0.00	0.189	0.030	0.096	0.120	2236
NOIPR=1	0.120	0.089	0.471	1.00	0.300	0.106	0.277	0.335	293
ACQUIRED=0	0.032	0.024	0.148	0.102	0.00	0.017	0.082	0.097	2018
ACQUIRED=1	0.100	0.067	0.374	0.172	1.00	0.125	0.262	0.333	511
EXCHANGED=0	0.041	0.031	0.172	0.108	0.184	0.00	0.098	0.122	2430
EXCHANGED=1	0.152	0.081	0.707	0.313	0.647	1.00	0.616	0.707	99
OPPOSING=0	0.030	0.023	0.131	0.094	0.161	0.015	0.00	0.077	2181
OPPOSING=1	0.144	0.095	0.583	0.256	0.463	0.190	1.00	0.569	348
NEGOTIATED=0	0.030	0.022	0.134	0.090	0.158	0.013	0.048	0.00	2163
NEGOTIATED=1	0.139	0.096	0.544	0.268	0.465	0.191	0.533	1.00	366

Note Values show the variation in the sample but are not representative for German firms.

Table 5: Marginal effects from logit models on problems

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Firms with innovative activities					Firms with patent applications				
Dep. variable	NOT STARTED	ABANDON	MODIFY	NOIPR	PROBLEM	NOT STARTED	ABANDON	MODIFY	NOIPR	PROBLEM
Young (0/1)	0.000	-0.003	-0.012	0.017	-0.014	0.037	0.004	-0.028	0.049	-0.008
	(0.007)	(0.006)	(0.016)	(0.013)	(0.017)	(0.029)	(0.020)	(0.057)	(0.044)	(0.057)
ln(employees)	0.001	-0.002	0.019***	-0.003	0.016**	0.020**	0.009	0.050*	-0.007	0.055*
	(0.002)	(0.002)	(0.005)	(0.004)	(0.006)	(0.007)	(0.006)	(0.022)	(0.014)	(0.022)
Ln(R&D/sales)	0.003	-0.002	0.054***	0.025***	0.057***	0.022	-0.015	0.086**	0.038*	0.095**
	(0.003)	(0.003)	(0.007)	(0.006)	(0.008)	(0.013)	(0.010)	(0.029)	(0.019)	(0.029)
Application (0/1)	0.028*	0.031*	0.064*	0.075***	0.065*					
	(0.012)	(0.012)	(0.025)	(0.020)	(0.027)					
ln(application stock)	0.005	-0.000	0.036***	-0.001	0.043***	0.001	-0.007	0.068***	0.000	0.062**
	(0.003)	(0.003)	(0.009)	(0.006)	(0.010)	(0.008)	(0.007)	(0.021)	(0.014)	(0.021)
Sales share main poduct	-0.0003	-0.000**	-0.000	-0.000	-0.001	-0.000	-0.001*	-0.001	-0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Process inno only (0/1)	-0.007	-0.010	-0.041	-0.040*	-0.046	0.128	-0.013	-0.029	-0.029	-0.010
	(0.011)	(0.009)	(0.022)	(0.017)	(0.024)	(0.096)	(0.041)	(0.108)	(0.090)	(0.107)
Product and process inno (0/1)	0.012	0.018*	0.058***	0.050***	0.073***	0.025	0.025	0.110*	0.028	0.113*
	(0.008)	(0.007)	(0.016)	(0.013)	(0.017)	(0.025)	(0.018)	(0.046)	(0.038)	(0.046)
Manufacturing (complex)	-0.009	-0.004	0.013	-0.016	0.006	-0.024	-0.003	0.017	-0.052	0.002
	(0.007)	(0.006)	(0.018)	(0.013)	(0.019)	(0.027)	(0.019)	(0.051)	(0.041)	(0.051)
Pharma	0.036	0.014	0.034	-0.013	0.055					
	(0.020)	(0.014)	(0.032)	(0.020)	(0.036)					
Utilities, trade, transport	-0.019	-0.011	-0.114***	-0.052**	-0.119***					
	(0.010)	(0.009)	(0.016)	(0.017)	(0.020)					

Technical services	-0.014	-0.003	-0.025	-0.042**	-0.039					
	(0.009)	(0.008)	(0.022)	(0.015)	(0.023)					
Non-technical services	-0.011	0.000	-0.031	-0.029	-0.025					
	(0.013)	(0.013)	(0.032)	(0.021)	(0.035)					
Patent protection high imp. (0/1)						-0.004	0.014	0.066	-0.012	0.050
						(0.028)	(0.018)	(0.051)	(0.039)	(0.051)
Concentration of IP ownership						-0.464*	-0.499*	-0.906*	0.516*	-0.927*
						(0.233)	(0.250)	(0.434)	(0.261)	(0.433)
Conc. of product market sales						-0.116	0.057	-0.184	0.034	-0.268
						(0.179)	(0.112)	(0.366)	(0.245)	(0.365)
Discrete technology (0/1)						0.051	-0.007	0.050	0.010	0.034
						(0.032)	(0.019)	(0.055)	(0.042)	(0.054)
Baseline probability	0.033	0.023	0.138	0.094	0.162	0.090	0.052	0.472	0.205	0.494
Log likelihood	-424.59	-333.39	-985.07	-833.34	-1057.25	-179.18	-131.42	-348.78	-286.58	-357.97
Observations	2529	2529	2529	2529	2529	568	568	568	568	568

Robust standard errors in parentheses, marginal effects shown. For dummies the effect for a change from 0 to 1 is given. Manufacturing (discrete) is the basis category.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Marginal effects from logit models on coping strategies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Firms with innovative activities					Firms with patent applications				
Dep. variable	AQUIRE	EXCHANGE	OPPOSING	NEGOTIATE	COPING	AQUIRE	EXCHANGE	OPPOSING	NEGOTIATE	COPING
Young (0/1)	0.032	0.003	0.008	0.028	0.038	-0.003	0.017	0.059	0.014	-0.021
	(0.019)	(0.004)	(0.012)	(0.015)	(0.024)	(0.051)	(0.022)	(0.052)	(0.051)	(0.057)
ln(employees)	0.036***	0.005***	0.018***	0.024***	0.057***	0.077***	0.026***	0.020	0.037	0.081***
	(0.005)	(0.001)	(0.004)	(0.004)	(0.007)	(0.019)	(0.008)	(0.017)	(0.019)	(0.021)
Ln(R&D/sales)	0.028**	0.008***	0.007	0.018**	0.053***	0.081**	0.029*	-0.019	0.026	0.083**
	(0.009)	(0.002)	(0.006)	(0.007)	(0.011)	(0.027)	(0.012)	(0.025)	(0.027)	(0.027)
Application (0/1)	-0.012	-0.002	0.033*	0.011	0.010					
	(0.024)	(0.006)	(0.017)	(0.019)	(0.035)					
ln(application stock)	0.029**	0.007***	0.021***	0.031***	0.073***	0.017	0.022**	0.073***	0.070***	0.054*
	(0.009)	(0.002)	(0.005)	(0.007)	(0.016)	(0.018)	(0.008)	(0.018)	(0.019)	(0.021)
Sales share main poduct	-0.001***	0.000	-0.000	-0.000	-0.001	-0.001	0.000	-0.001	-0.001	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Process inno only (0/1)	-0.019	0.001	-0.032*	0.002	-0.024	-0.163	0.025	-0.069	0.243*	-0.083
	(0.024)	(0.009)	(0.015)	(0.022)	(0.031)	(0.089)	(0.071)	(0.107)	(0.103)	(0.105)
Product and process inno (0/1)	0.035*	0.010*	0.027*	0.042**	0.088***	0.016	0.035	0.103*	0.157***	0.113*
	(0.018)	(0.005)	(0.011)	(0.014)	(0.022)	(0.045)	(0.022)	(0.044)	(0.045)	(0.045)
Manufacturing (complex)	-0.006	-0.003	-0.003	-0.010	-0.025	-0.067	-0.016	0.072	-0.027	-0.046
	(0.021)	(0.005)	(0.012)	(0.015)	(0.025)	(0.049)	(0.022)	(0.046)	(0.049)	(0.047)
Pharma	0.117**	-0.002	0.032	0.043	0.086					
	(0.044)	(0.007)	(0.026)	(0.030)	(0.048)					
Utilities, trade, transport	0.011	-0.013*	-0.033*	-0.039*	-0.053					
	(0.033)	(0.005)	(0.015)	(0.019)	(0.036)					

Technical services	0.036	-0.007	-0.037**	-0.059***	-0.026					
	(0.029)	(0.006)	(0.014)	(0.016)	(0.032)					
Non-technical services	0.160***	-0.010	-0.057***	-0.033	0.081					
	(0.045)	(0.007)	(0.014)	(0.023)	(0.048)					
Patent protection high imp. (0/1)						0.059	0.046*	0.042	0.041	0.114*
						(0.047)	(0.022)	(0.047)	(0.047)	(0.049)
Concentration of IP ownership						-0.523	0.226	-0.370	0.185	0.299
						(0.415)	(0.162)	(0.379)	(0.423)	(0.430)
Conc. of product market sales						0.267	-0.168	-0.266	0.058	0.050
						(0.332)	(0.149)	(0.363)	(0.364)	(0.372)
Discrete technology (0/1)						-0.009	-0.024	0.103	-0.025	-0.038
						(0.051)	(0.020)	(0.053)	(0.049)	(0.052)
Baseline probability	0.181	0.016	0.076	0.109	0.302	0.332	0.069	0.301	0.330	0.642
Log likelihood	-1157.0106	-297.91	-733.04	-871.54	-1374.28	-331.04	-153.13	-315.78	-320.84	-332.38
Observations	2529	2529	2529	2529	2529	568	568	568	568	568

Robust standard errors in parentheses. Marginal effects shown.For dummies the effect for a change from 0 to 1 is given. Manufacturing (discrete) is the basis category.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: Marginal effects from multinomial logit models on mutual exclusive outcomes of problem and coping

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firms with innovative activities				Firms with patent applications			
Dep. variable	PROBLEM, NO COPING	PROBLEM, COPING	NO PROBLEM, COPING	NO PROBLEM, NO COPING	PROBLEM, NO COPING	PROBLEM, COPING	NO PROBLEM, COPING	NO PROBLEM, NO COPING
Young (0/1)	-0.002	-0.008	0.049*	-0.039	0.056	-0.069	0.044	-0.031
	(0.011)	(0.013)	(0.021)	(0.025)	(0.039)	(0.054)	(0.050)	(0.048)
ln(employees)	-0.003	0.020***	0.036***	-0.054***	-0.002	0.060**	0.022	-0.080***
	(0.004)	(0.004)	(0.006)	(0.008)	(0.012)	(0.022)	(0.018)	(0.019)
Ln(R&D/sales)	0.024***	0.035***	0.024*	-0.083***	0.012	0.084**	0.001	-0.097***
	(0.005)	(0.006)	(0.010)	(0.012)	(0.016)	(0.030)	(0.025)	(0.023)
Application (0/1)	0.027	0.031	-0.016	-0.042				
	(0.019)	(0.019)	(0.031)	(0.042)				
ln(application stock)	0.010	0.038***	0.031*	-0.078***	-0.007	0.073***	-0.018	-0.048*
	(0.007)	(0.008)	(0.014)	(0.021)	(0.013)	(0.020)	(0.017)	(0.020)
Sales share main poduct	-0.000	-0.000	-0.000	0.001*	-0.000	-0.001	0.002*	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Process inno only (0/1)	-0.032*	-0.009	-0.013	0.055	0.000	-0.010	-0.067	0.077
	(0.015)	(0.021)	(0.026)	(0.032)	(0.068)	(0.110)	(0.089)	(0.093)
Product and process inno (0/1)	0.014	0.062***	0.025	-0.101***	-0.033	0.151***	-0.034	-0.083*
	(0.011)	(0.014)	(0.019)	(0.023)	(0.030)	(0.046)	(0.041)	(0.039)
Manufacturing (complex)	-0.002	0.005	-0.038	0.035	0.012	-0.007	-0.038	0.034
	(0.013)	(0.015)	(0.022)	(0.027)	(0.032)	(0.051)	(0.048)	(0.040)
Pharma	0.010	0.051	0.038	-0.100*				
	(0.022)	(0.030)	(0.042)	(0.051)				
Utilities, trade, transport	-0.057***	-0.063***	0.007	0.113**				
	(0.013)	(0.015)	(0.034)	(0.037)				

Technical services	-0.015	-0.026	-0.001	0.042				
	(0.014)	(0.018)	(0.028)	(0.033)				
Non-technical services	-0.028	0.005	0.074	-0.051				
	(0.018)	(0.031)	(0.041)	(0.049)				
Patent protection high imp. (0/1)					-0.053	0.108*	0.011	-0.067
					(0.034)	(0.050)	(0.044)	(0.042)
Concentration of IP ownership					-0.134	-0.708	0.893**	-0.051
					(0.306)	(0.406)	(0.340)	(0.371)
Conc. of product market sales					-0.004	-0.290	0.302	-0.008
					(0.220)	(0.376)	(0.301)	(0.304)
Discrete technology (0/1)					0.013	0.026	-0.061	0.022
					(0.036)	(0.054)	(0.047)	(0.045)
Baseline probability	0.067	0.094	0.204	0.634	0.116	0.386	0.258	0.241
Log likelihood		-2490.5				-663.6		
Observations		2529				568		

Robust standard errors in parentheses. Marginal effects of changes in the probability of a specific outcome category shown. The marginal effects of all four outcomes sum to zero. For dummies the effect for a change from 0 to 1 is given. Manufacturing (discrete) is the basis category.
* significant at 10%; ** significant at 5%; *** significant at 1%

Are Patent Subsidies for SMEs Effective?

Empirical evidence from Italy

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Abstract

Over the last decade, public patent subsidies have played an important role in several countries in enhancing international filings by domestic companies, expecially SMEs. In this paper, we first analyze the policy actions based on patent subsidies implemented in Italy from year 2002 to year 2011. We then use data from a sample of 222 subsidized and control patents, in order to assess the impact on patent value of the first and the largest of such programs. We conclude by discussing policy recommendations for the optimal design of patent subsidy schemes.

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Are Patent Subsidies for SMEs Effective?

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1. Introduction

Over the last decade, patent subsidies have played an important role in several countries in enhancing international filings by domestic companies, expecially SMEs. Patent subsidies refer to a series of policies, undertaken at the national or local level, aimed at financing the costs of firms' patent applications, examination and maintenance. They are intended to stimulate firms' patenting activities (in particular those undertaken at the international level), by lowering the financial burden which tend to be particularly relevant for SMEs. Significant policy actions centered on public subsidies for SMEs have been launched over the last decade in a wide variety of countries (i.e. Italy, Spain, Belgium, Japan, China, India, United Kingdom), with the aim to foster the innovation capabilities of domestic inventors. However, in spite of a rich literature addressing the rationale and effectiveness of R&D subsidies programs (Klette et al., 2000; Blanes, 2004; Gonzalez and Pazo, 2008; Colombo et al., 2011), no attention has been devoted yet to the mapping and assessment of patent subsidies policies. To our knowledge, no specific attention has been devoted on how to optimally design this type of schemes in order to encourage innovation and competition, and no empirical exercise has been undertaken in order to evaluate their impact.

As to this latter point, a critical issue surrounding this type of policy measure relates to patent quality. A debate involving both government insiders, legal experts and academic scholars (Jiachun et al., 2008; Zhou and Stembridge, 2010), and reflected in the financial press (Financial Times, 2008; The Economist, 2010), has raised concerns about the possibility that subsidization by public bodies leads to an increase in the number of patents with low quality. According to more critical views, in fact, by reducing or eliminating initial fees and costs to be paid by the applicants, such measures could lead to an inflation of patent filings that do not meet the statutory requirements (and whose legal validity can therefore be challenged) and that are characterized by a limited economic value for the applicants.

Building on such debate, our study intends therefore to fill a gap in the literature, by analyzing the policy actions based on patent subsidies implemented in Italy from year 2002 to year 2011, and assessing the impact on patent value of the first and the largest of such programs, the one promoted by the Chamber of Commerce of Milan, the Province of Milan and the Region Lombardia in Northern Italy. The case of Italy is particularly interesting given that numerous and diversified schemes centred on patent subsidies and specifically oriented to SMEs have been established over the last decade, promoted by both local, regional or national authorities. In particular, the measure promoted in the province of Milan in Northern Italy has funded, since its inception in year 2002, hundreds of SMEs by covering part of the expenses related to their international patent filings. Based on this empirical evidence, the paper addresses the following two research questions: *1) How are patent subsidies programs designed? 2) Which is the impact of such programs on the value of subsidized patents (as compared to a control group of non-subsidized ones)?*

The objective of the first part of the study is therefore that to investigate the characteristics of all the policy measure established in Italy at various levels (national, regional and local) in order to promote patent filings by domestic firms. In this stage, we first identify and map all 34 patent subsidies measures implemented in Italy since 2002 and analyze them along the following dimensions, which are relevant for the program design: main objectives, promoting institutions, geographical scope of the measure, eligible expenses, eligible companies, amount of funding, ex-ante and ex-post evaluation.

The second part of the study is aimed at assessing the impact of such policy actions on patent value, by analyzing, in a regression framework, differences in patent value between two groups of patents: a group of 111 patents that were subsidized over the period 2002-2007 in the province of Milan, and a control group of 111 non-subsidized patents. The control group was created using a matched-paired research design, identifying, for each subsidized patents, a corresponding patent, with the same priority year and filed by a SME located in the province of Milan. In order to measure patent value, we adopted measures based on patent-information, identified and validated in the literature, resorting in particular to the number of forward citations and the legal status of the patents (Munari and Sobrero, 2011; Reitzig, 2003, 2004).

We therefore aim to contribute to the empirical literature that evaluates the effects of public support to R&D and innovation activities (Klette et al., 2000; Blanes, 2004; Gonzalez and Pazo, 2008), by focusing for the first time on the design and impact of patent subsidies program, a topic that, despite its increasing relevance for policy-making, has not been directly addressed until now. We adopt in this specific case a research approach, focused on the analysis of patent value, that has been previously applied in other settings, for instance in the evaluation of the impact on academic patenting of the Bay-Dole Act in the United States (Henderson et al., 1998; Mowery and Ziedonis, 2002). In terms of policy implications, our study intends to shed light on the role of public intervention to foster SMEs patenting, in order to stimulate innovation, promote markets for new ideas and products, and enhance the economic development. Ultimately, we intend to provide policy guidelines for the design and implementation of effective patent policies for SMEs.

The rest of the paper is organized as follows. In the first section, we review the relevant literature and provide an overview of the different actions centred on patent subsidies implemented around the world. We then focus on the Italian experience, by mapping and analyzing the different actions realized at the national, regional and provincial level. We then describe in more detail our sample and variables, related to a group of patents by SMEs in the province of Milan. We finally report the results of our regression analyses and conclude by discussing policy implications

2. Literature Review

2.1. Patenting by SMEs: is there a market failure?

Endogenous-growth theory claims that technological change is a major factor driving economic growth and that governments can therefore enhance economic growth by influencing the pace of technological change through subsidizing firms' R&D expenditures (Grossman and Helpman, 1994; Davison and Segerstrom, 1998). Moreover, the growing body of literature on the importance of spillovers in R&D and innovative activities (Klette, Møen and Griliches, 2000), has recognized the existence of market failures as one of the main justifications for policy measures subsidizing R&D and innovation programs. Subsidies are thus intended to adjust market failures and to augment the supply of socially rewarding technologies. Such market failures tend to be particularly pronounced for small and medium-sized enterprises (SMEs), due to the limited financial resources to support R&D, patent and innovation expenditures (Gabriel and Florence, 1993) and to the absence of scale and scope economies in R&D (Ortega-Argilés et al.,2009). As a consequence, extensive innovation support programs across the European Union (and in other regions of the world) have been explicitly targeted towards SMEs over the last decades (Hoffman, Bessant and Perren, 1998).

For what concerns patent activity, the patent system itself is viewed as a policy instrument originally aimed at encouraging innovation generation and diffusion. Similarly with issues explored in the R&D subsidies literature, issues related to the design of appropriate patent systems and to the assessment of their impact on innovation activities, are some of the main concerns addressed in recent research on patent policies (Guellec and Van Pottelsberghe, 2007). Encaoua et al. (2006), in an overview of the economics of patents and patent policy, suggest that economic research should focus more on how to design effective policies in the patents field, in order to lever the innovation process.

In particular, SMEs represent a very important and specific target for patent policies, since it is well documented that they present a low propensity to file for and use patents, due to several reasons (Blind et al., 2006; Munari et al., 2011). A first explanation deals with the high costs involved in patent filings and maintenance, which can represent a significant financial burden for small enterprises. In addition to that, one should also calculate the honorary of the IP consultants who are generally involved in the registration process, given that such kind of companies typically do not maintain in-house IP professionals. Moreover, IP rights are costly to enforce. Consider for instance the type of costs that an innovator has to undertake in case of infringement disputes. On the one hand, there are direct legal costs. In addition to that, there are business costs of litigation that can take several forms, going from the time devoted by managers and researchers to prepare documents and depositions in the court, to the blockage of cooperative relations with suppliers and customers, to the shut-down of production and sales activities during the litigation period. SMEs may not have the financial resources to fund such dispute resolution procedures and face the related risks, therefore preferring to recur to informal protection mechanisms (such as trade secrets). Finally, an important organization resource to fully exploit IP strategies is represented by the availability of firm-level expertise in the area of IP law and IP management. Given the

financial and resource constraints which typically characterize SMEs, it is very difficult that they retain in-house the necessary expertise, either in formalized IP department, or in single IP professional.
Existing empirical evidence supports the view that firm's size is an important driving force of patenting and that SMEs tend to be disadvantaged in comparison to large companies (Blind et al.,2006). For all such reasons, it is likely that a specific market failure characterizes patent activity by SMEs. To address such issue, over the last decades, in several countries policy actions centred on patent subsidies have been established in many countries around the world.

2.2. Patent Subsidies for SMEs: international experiences

Over the last decade, an increasing number of countries and regions around the world have been establishing subsidies or funds to support R&D/innovation activities for national enterprises, research institutes and universities. Among such measures, the use of patent subsidies, in particular in favour of SMEs, has recently gained an increased attention by policy-makers. Table 1 summarizes some international experiences of patent subsidies over the past decade, identified through existing literature and Internet sources. Typically, such measures take the form of direct support to finance part of the expenses related to national and, more often, international patent filings. Generally such schemes are intended to cover part of the filing costs, with a few of them also subsidizing maintenance fees or enforcement expenses, as in the experience of the Chinese government and the region of Chongqing.
Such measures can be funded by the national government, through a ministry or a central bureau, as in the case of Italy, Spain and China, or through a specialised agency, as illustrated in cases of Canada and Ireland. Patent subsidies could also be awarded by regional authorities, through a department (as for measures activated in Lombardia, Scotland or Wallonia), or through a specialized institute (as in the case of Hongkong, Chongqing and Gujarat).
Domestic SMEs constitute the primary target of patent subsidies measures, even though other beneficiaries can be found, such as large enterprises, research institutes and universities.
Although the amount of patent subsidies conferred to beneficiary firms largely varies across countries, they are mostly executed through the reimbursement of a certain proportion of the costs incurred (typically with an upper limit), or through a fixed amount for each subsidized patents.

--- Include Table 1 around here ---

2.3. How to design and assess the effectiveness of patent subsidies? Insights from the literature on R&D subsidies

Despite the growing diffusion and relevance of patent subsidies measures around the world, that we have partially documented so far, to our knowledge no attempts have been made in the literature to assess their characteristics, optimal design and effectiveness. We therefore rely on the established literature on R&D subsidies to infer some useful indications for the appropriate design, implementation and assessment of patent subsidies measures.

Several efforts have been dedicated to evaluate the effects of R&D subsidies on firms' R&D behavior and growth. A key indication relates to the balance between public and private R&D, in terms of complementarity or substitution. On one hand, the positive impact of R&D subsidies on firms' R&D expenditures was suggested by works such as Leyden and Link(1991), Busom(2000), Almus and Czarnitzki(2003), Koga(2005), Hussinger (2008), Aerts and Schmidt(2008), Bérubé and Mohnen(2009), among others. On the other hand, the substitutive effect of public R&D crowding out private R&D was instead observed by studies of Lichtenberg (1984,1987,1988), Mamuneas and Nadiri(1999) and Wallsten(2000).

For what concern the design and implementation of the programs, previous studies have analyzed the allocation process of R&D subsidies. Blanes and Busom (2004), for instance, reveal the heterogeneity of projects and firms selection rules across different agencies and industries. They suggest that national and regional programs end-up supporting different types of firms and that each agency may use R&D subsidies with different policy goals in each industry. Giebe et al. (2006) identify two sources of inefficiency in the application rules for allocating R&D subsidies and propose an improved mechanism designed to correct the allocation inefficiency, which includes the form of auction whereby applicants bid for subsidies. A recent study of Colombo et al. (2011), based on a sample of new technology based firms in Italy, compare the effects of different types of subsidization schemes distinguishing between ''automatic'' and ''selective'' subsidies, where the latter provide financial support only to selected applicants. Their results suggest that the receipt of selective R&D subsidies tend to have a higher impact on firm's performance as compared to automatic subsidies, thus resulting more beneficiary for the success of target firms.

On a different level, Scherer and Harhoff (2000) suggest that technological policy should allocate government subsidies in order to support a sizeable array of projects with the emphasis placed on a relatively number of big successes, as a consequence of the highly skewed distribution of the value of innovations (i.e. the fact that a small minority of innovations yield the lion's share of all innovations' total economic value). This observation is particularly important in the case of the assessment of the effectiveness of patent subsidies, due to the high heterogeneity in the value of patents, which have been well documented in the literature (Gambardella et al., 2008).

To sum up, the rich literature on R&D subsidies provides several important indications on how to assess the effectiveness of patent subsidies for SMEs. First, as mentioned by Encaoua et al.(2006), more empirical testing of the economic effects of patent policies is required. Second, the debate on the additionality or crowding-out effects of R&D subsidies provides important methodological guidelines for the assessment of patent subsidies measures, in particular for what concern the application a matching estimations method (Berube and Mohnen, 2009). Third, the review highlights the necessity to assess the impact of policy measures not only in terms of number of additional patent filings undertaken by SMEs, but also in terms of value of subsidized patents.

This latter point appears of particular interest in the light of the recent debate involving both government insiders, legal experts and academic scholars (Jiachun et al., 2008; Zhou and Stembridge, 2010), and reflected in the financial press (Financial Times, 2008; The Economist, 2010), about the possibility that patent subsidization by public authorities leads to an increase in the number of patents with low quality. More critical voices have advanced that, by reducing or eliminating initial fees and costs to be paid by the applicants, such measures may lead to an inflation of weak patents, whose legal validity can be ultimately challenged or that can generate little or not economic value for their owners. Such debate has been particularly centred on the experience of China, whose impressive growth in the number patent filings over the last decade has been in part encouraged by a relevant program of patent subsidies administered by central, provincial and city governments (Zhou and Stembridge, 2010). The fact that most Chinese patents over the period 2001-2008 were related to new design appearances or new models, thus not requiring great technical innovation, has been interpreted as a signal that public subsidies to cover patent application costs can become a factor that artificially inflates the number of filings (Financial Times, 2008; The Economist, 2010).

The economic literature has convincingly questioned the assumption that "more patents is better", arguing that a surge in the number of low-value patents can have, on the contrary, a detrimental effect on innovation and competition (Guellec and Van Pottelsberghe, 2007). On the one hand, a more practical concern is related to the difficulties of patent offices to cope with an inflated workload, ultimately inducing a significant backlog that can raise delays in the procedures (Encaoua et al., 2006). On the other hand, and more importantly, an inflation in the volume of patents with low quality or even illegitimate patents (i.e. not novel or not sufficiently inventive) can rise the uncertainties about the enforceability of property rights and induce situations of overlapping patents (patent thickets), ultimately increasing patent disputes and discouraging innovation (Lemley and Shapiro, 2005; Bessen and Maurer, 2008).

As to this point, Encaoua et al. (2007) highlight that patent application and renewal fees can act as "self-selection mechanisms" to encourage high valuable inventions to be patented and discourage the least valuable ones.

Based on such arguments, it becomes therefore important to assess whether the provision of public subsidies to SMEs impacts or not the value of patents. In the empirical part of our work, we address such research question, by mapping first the characteristics of patent subsidy measures adopted in Italy, and assessing then their effectiveness in terms of patent value, by comparing a sample of subsidized and control patents. The analyses we perform are primarily oriented to derive lessons for policy makers that can be usefully applied in the design of patent policy measures, as discussed in the final part of our work.

3. Research design

We focus our analysis on the policy actions implemented in Italy to foster patenting by SMESs. The case of Italy is of particular interest for several reasons. First, the Italian economic system is characterized by a strong diffusion of SMEs, which account for the lion's share of persons employed and value added generated in the country, with value considerably above EU-average levels. As far as innovation is concerned, according to the European Innovation Scoreboard (2009), Italy lies behind its main European partners in many indicators of technology and innovation – and in particular in those indicators concerning EPO and USPTO patent applications – also as a consequence of the predominance of small and medium-sized enterprises affecting R&D expenditure, innovation enhancement and protection. For such reasons, several policy actions have been implemented over the last decade in Italy at different levels (national, regional and local) in order to promote patent applications by domestic firms, in particular by SMEs. For all such reasons, Italy represents an ideal context to address our research interests.

We performed our data collection and analyses in two steps. We were first interested in identifying the main characteristics in the design of patent subsidies measures implemented in Italy. Therefore, we initially conducted a detailed mapping of all such measures realized in Italy by national, regional or provincial authorities. We then focused our attention on the experience of the Chamber of Commerce of Milan, in the region Lombardia in Northern Italy, in order to assess the impact of subsidies on patent value. We analyzed the different measures established by the Chamber of Commerce of Milan, the Province of Milan and the Region Lombardia, in Northern Italy, in order to support European and International Patent filings by SMEs located in the province of Milan. Such measures started in year 2002, with a total available funding of 2 millions Euro for that year. The subsidy was assigned automatically, based on chronological order of the applications (after a check of formal requirements). It covered up to 50% of expenses incurred by an SME for an international patent filing (including drafting expenses), up to a maximum amount of 15.000 Euro). The measure has been repeated up to 2011 (with the exception of year 2004), funding hundreds of companies. Up to August 2011, it has been by far, the most important measure of this kind in Italy, in terms of amount of funding and number of companies involved[1].

In this section we first present the sources we used to collect the data, and describe than in more detail the sample and variables we adopted in our analyses focused on how subsidies affect patent value.

3.1. Data sources

In order to identify all the patent subsidies measures promoted in Italy over the last decade, we first analyzed the web-pages of all the Chambers of Commerce in Italy, since they responsible, through local competent offices, for patent filings registrations, in collaboration with the Italian Patent and Trademark Office (UIBM)[2]. In addition to this role, local Chamber of Commerce are typically responsible for a series of several activities aimed at promoting the diffusion of a patent culture. We then complemented this initial search, by performing a more general web search using key-words related to patent subsidies[3]. In order to complement such initial search, we then performed five further interviews, respectively with: representatives of the Patent Office of two major Italian Chambers of Commerce (Milan and Bologna); consultants of two leading IP consulting firms in Italy; a consultant of a major Italian consulting firm specialized in enterprise and public funding. The interviews were intended first to complete our knowledge and understanding of the main measures implemented in Italy to promote patenting, clarify their design and logics, and have a first feedback on their impact

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1 In August 2011 the Italian Ministry of Economic Development has launched an ambitious subsidy scheme with the objective to boost the number of patent filings by SMEs and their economic exploitation, allocating a budget of 40 milion Euro to such measure. This measure is however too recent to be included in our assessment exercise.

2 Patent applications for industrial inventions in Italy can be filed with the Chamber of Commerce or directly to the Italian patent and trademark office. In the first case, the Chamber sends the documents received to the central office.

3 We used the following keywords to perform the web search: “Brevetti” (Patents) + “Sussidio” (Subsidy), or “Incentivi” (Incentives), or “Contributo” (Aid), or “Bando” (Call).

and effectiveness.
Based on such effort of data collection, we were able to identify 34 patent subsidy actions implemented in Italy over the period 2002-2011: 25 actions have been promoted by local Chamber of Commerce, 3 by provincial authorities, 3 by regional authorities, and 2 at the national level by the Ministry of Economic Development (Ministero per lo Sviluppo Economico).
We then focused on the patent subsidy measures established, from year 2002, by the Chamber of Commerce of Milan, the Province of Milan and the Region Lombardia, in Northern Italy.

3.2. Sample

In our study on the different measures established by the Chamber of Commerce of Milan, the Province of Milan and the Region Lombardia, in Northern Italy, we decided to focus on the calls published in years 2002, 2003, 2005 and 2006 (in 2004 the measure was not implemented), in order to have a time period sufficient to assess the final outcome (i.e. grant) of the patent application process. We were able to identify all patents and companies receiving the subsidies in such years (as well as those companies which applied for a subsidy, but were not selected), using information from the website of the Chamber of Commerce of Milan.
Our data gathering was structured in three phases. In the first phase, we identified all SMEs, and their related patents, which obtained a subsidy over the year 2002, 2003, 2005 and 2006. This initial sample consisted of 146 SMEs in province of Milan operating in several industries, ranging from biotechnologies and healthcare, to electronics and ICT, as well as mechanics and materials.
In the second phase, we collected information on such patent applications, using Espacenet as data source. We retained from the initial sample only those SMEs for which information on the subsidized patents were available in the patent database. After whittling down the initial sample following these criteria, we were left with a sample of 136 SMEs, and 191 subsidized patents.
In the third and final phase of our data collection, we constructed a matched sample of SMEs (and related patents) located in the province of Milan which did not receive a patent subsidy over the period of analysis. In order to construct such a control group, for each subsidized patent, we identified a corresponding patent satisfying the following three conditions: 1) having a SME as applicant; 2) having Milan as the applicant's address; 3) having the same priority date of the subsidized patent. We applied the SME definition of the European Commission in order to filter the patents in the control group. We therefore checked whether the applicant's turnover (in the priority year of the subsidized patent) fell within the limits posed the the EC definition of SMEs, matching companies included in the same category of micro, small and medium-sized enterprises.[1] More precisely, a subsidized patent of micro enterprise was matched by a corresponding patent, with the closest priority date, filed by a micro enterprise located in the province of Milan. Following the same logic, we identified the control patents for small and medium-sized companies included in our sample. Information

[1] We use Recommendation 2003/361/EC adopted by European Commission as a criteria in this aspect, categorizing micro enterprise with a turnover not greater than 2 million euro, small enterprise not greater than 10 million euro, and medium-sized enterprise not greater than 50 million euro.

on firm's turnover and address for the initial and matched samples came from the commercial database AIDA, including accounting information on public and privately-held companies in Italy.

In this process, we were not able to find a corresponding match for some of the subsidized patents, since accounting information were not available on AIDA either for beneficiary or for target companies. For such reasons, we were left with the final sample of 111 subsidized patents - including 60 EP patents and 51 PCT patents - applied by SMEs in the province of Milan with the priority years ranging from 2000 to 2007. Such patents were matched to a corresponding group of 111 control patents (including 60 EPO patents and 51 PCT patents) which did not receive a subsidy, identified with the procedure described above.

3.3. Methods and variables

We employed two main regression models in order to evaluate the effects of subsidies on patent value. We first used as dependent variable the number of forward citations received by each patent, since it represents the most frequently used proxy for the value of patents in the literature (for a review of this literature see Munari and Sobrero, 2011 and Omland, 2011). As dependent variable in the second model, we used a dummy variable to capture whether the patent was granted or not up to May 2011. Because of the non-negative, discrete and highly skewed nature of the first dependent variable ("Number of forward citations"), we adopted a Poisson regression model in the first equation. In the second equation, we used a logit specification to analyse the impact of patent subsidies on the likelihood of grant.

Dependent variables. As a measure of *patent value* we used the number of forward citations received by each patent from patents subsequently issued. Forward citations were identified and collected through Espacenet. Citations from later patents to the patent under examination (forward citations) represent a significant indicator of value, which has been analyzed, validated and used in numerous scientific studies since several decades (Carpenter et al., 1981; Albert et al., 1991; Harhoff et al., 1999; Reitzig, 2003 and 2004; Trajtenberg, 1990). Several theoretical arguments explain this empirical fact (Omland, 2011). First, the existence of citations from later patents indicates that patents on similar technology have been applied for later, meaning that subsequent investments building on such invention have been made and that the technology is perceived as attractive. Second, it suggests that the cited patent contained a technical aspect that is used in later technology, thus revealing that the original invention contained a useful aspect. Third, citations indicate that the claims of the later patent may have been limited by what was already described in the earlier patents. This suggests that the newer invention might integrate aspects already protected by earlier patents. Hence, the 'old' patent claims appear to be still relevant in the newer technology space.

It is probably the most commonly used proxy in the literature for the value of patents, (Sapsalis et al.,2006). As an additional variable of patent quality, we used the legal status of the patent, constructing a dummy variable *Patent granted* which takes the value 1 if the patent has been granted as of May 2011. It serves as another empirical indicator widely used in the literature to approximate the value of a patent by indicating the probability of getting a patent granted (Guellec and van Pottelsberghe de la Potterie, 2000, 2002).

Independent variable. In our regression models, we included a dummy variable *Patent subsidies* taking the value 1 to indicate the beneficiary status for the subsidized patent in our sample, and 0 otherwise (for patents in the control group). We use this dummy of patent subsidies as a key explanatory variable in order to evaluate the effectiveness of the patent policy measures on patent value.

Control variables. The *number of inventors* for each patent was counted and collected as a potential determinant of patent value. It is established as an indicator of the number of researchers involved in the research project and a proxy reflecting the importance of the research for the company and the potential profits expected (Sapsalis et al., 2006). Another variable used to determine the value of a patent in our study is the number of *co-assignees*, which indicates the level of collaboration with other knowledge-generating institutions or individuals (Sapsalis et al., 2006). We then built a *patent scope* variable, counting the number of IPC classes to which the patents is assigned. As IPC classes encode and classify the technical content of patent documents which is positively correlated with the patent value (Lerner 1994, Harhoff and Reitzig 2004). We also counted the *number of backward citations* for each patent as another determinant of patent value. This measure could indicate the extent to which a patent is based on previous science or technological knowledge and it is theorized to operationalize the technical novelty of a patent (Sapsalis et al., 2006; Reitzig, 2004). Utility is a dummy variable taking the value 1 for the patent of a unility model when there is a kind code of U after the publication number, and 0 for all the other cases of invention patents. We also included a dummy variable *PCT* to separate PCT patents from others. The choice of the application route has been proposed as a potential value indicator (van Zeebroeck et al., 2008). The observed choice of the applicant to use the PCT system has been tested as a value indicator by Harhoff et al. (2004; 2007). We also constructed a dummy *Utility patent* to distinguish utility models from patents for technical inventions. The time effect of patents being cited or granted is taken into account through a set of time dummies (Sapsalis et al., 2006), corresponding to the priority year of each patent from 2000 to 2007. A variable *Firm's turnover* was adopted in order to capture size effects which might impact on the quality of the patent. For each firm, turnover levels were measured in the priority year of the patent, according to AIDA.

4. Analyses and results

4.1. The design of patent subsidies measures in Italy

In the first step of our research we have identified all patent subsidies measures established in Italy from 2002, for a total of 34 actions that we were able to map and analyze. Table 2 briefly analyze such different measures along a series of dimensions which are relevant in the design of the scheme: 1) promoting institutions and geographic coverage; 2) rationale and objectives; 3) target beneficiaries of the measure; 4) eligible costs; 5) maximum amount of funding; 6) overall budget; 7) selection and evaluation criteria.

--- Include Table 2 around here ---

From the analysis of Table 2, it is immediate to notice some critical issues which have characterized the design of patent subsidy schemes in Italy. First, it emerges a strong fragmentation of the different programs, due to the activation of several schemes which are often geographically bounded to single provinces, benefit of a limited available budget (in many cases inferior to Euro 50.000) and award to beneficiary firms only a small amount of funding to cover a minimum part of patent expenses. Therefore, such measures are often established with a mere signaling role, but it is unlikely that they can have a real impact as an incentive for SMEs to file additional patents, due to the limited funding available. Moreover, the emerging picture is that of a limited coordination between the different institutional actors involved in the process (Chambers of Commerce, Provinces, Regions, Foundations), which hinders the possibility to establish sizeable programs with the critical mass to provide a real contribution.

A second critical point relates to the definition of the objectives of the measures. The vast majority of the schemes have a strong focus on supporting an increase in the number of patents filed by SMEs, as a way to strengthen innovation and internationalization process. In other words, the measures are centred on augmenting the number of patents filed, with limited or no attention on improving the quality of patents filed or fostering the economic valorization of such intellectual property rights. However, it is well documented in the literature that the value of patents is extremely skewed, and the large majority of patents are of limited, if any, value for the applicants, since they are not subsequently exploited in downstream product developments or licensing agreements (Munari and Sobrero, 2011). The twin challenges of patent quantity and quality should therefore be encouraged by policy makers, also in the light of the explosion in both the number and the volume of patent filings for all patent offices in the last two decades (Guellec and Van Pottelsberghe, 2007). Despite that, no measure in our sample has been established with the declared objective to enhance the number of "high-quality" patents. Moreover, in only a limited number of cases the objective of favouring the economic exploitation of patents is mentioned.

A third critical issue, which directly stems from the previous one, is the lack of pre-defined criteria to guide the evaluation and selection of the patents to be subsidized. In the vast majority of the schemes under analysis, no ex-ante evaluation of the submitted patent was made, with the exception of a formal check on the satisfaction of eligibility criteria. Typically, the subsidies were automatically awarded based on the chronological order of the submission, up to the consumption of overall budget. In only four cases out of 32 the programs were managed as selective schemes providing financial support only to selected applicants. In such cases, a committee of experts was formed to perform a selection based on pre-defined criteria (including the geographic and technological scope of the patent; the degree of innovativeness; potential market size and scope; competences of the applicant; collaborations with universities and public research centres). As to this point, previous research on the impact of public R&D subsidies have highlighted that selective schemes, when competition among applicants is tough and the support program is administered by a reputable governmental, are likely to be more beneficial than automatic ones to foster SMEs value creation (Colombo et al., 2011). Moreover, as suggested by Lerner (1999), selective schemes may provide a certification of the quality of beneficiary firm (and the underlying patent) to uninformed third parties, such as external investors or potential licensees.

A direct consequence of such shortcomings in the design of policy measure is the risk of subsidizing patents characterized by low quality and limited exploitation potential, thus limiting the effectiveness of the measure. This is essentially what we wanted to test in our next analyses, based on data from patent subsidized in the province on Milan.

4.2. The impact of subsidies on patent value: descriptive analyses

In the following sections, we report the results of our analyses to test whether the receipt of subsidies impacts patent value, based on data related to patent subsidy schemes implemented in the province of Milan. Table 3 reports descriptive statistics on our sample of 222 patents of SMEs located in the province of Milan, including 111 subsidized and 111 control patents with priority years ranging from 2000 to 2007.

--- Include Table 3 around here ---

Table 3 shows that the average patent in the sample receives less than 1 forward citations by subsequent patents (0.91), with a maximum number of 10 citations per patent. About 40% patents in our sample were granted by May 2011, with the majority of applications still pending at that deadline as a consequence of the lengthy examination process of EPO and PCT procedures. The average breadth of patents, as measured by the number of four-digit IPC classes, is around 3. The average number of inventors and of applicants nearly reach to 2 per sample patent, with maximum levels of 8 and 9 respectively. The number of backward citations on average arrives at nearly 5. Such descriptive statistics related to different measures of patent quality - such as the number of forward citations, the likelihood of grant, the number of IPC classes, the number of inventors, the number of applicants, the number of backward citations – suggest a high skewness in the value distributions, which are consistent with findings of previous studies demonstrating a high heterogeneity in the value of patents (Munari and Sobrero, 2011).

The SMEs responsible for these international fillings have, on average, an annual turnover of 6 million Euro, corresponding to the EU definition of small enterprises. It is noteworthy that, as a consequence of the matching procedure we adopted in the construction of the control group of patents, average turnover levels are similar between beneficiary firms and control firms.

We then used a corrected t-test to compare the mean values of different indicators of patent quality between the two samples of subsidized patents and control (i.e. non-subsidized) patents. Table 4 reports the results of this comparison, showing in general terms that no statistically significant differences in patent quality seem to emerge between the two samples.

--- Include Table 4 around here ---

The number of forward citations received by subsidized patents is indeed slightly higher than the matched sample, with average values of 0.94 citations as compared to 0.87 citations, even though the difference is not statistically significant at conventional levels. Similarly, subsidized patents have a slightly higher likelihood to receive a final grant as compared to control patents (more precisely, 42% of them are granted as to May 2011, as compared to 34% of control patents), but the difference is not statistically significant either. Moreover, the number of backward citations in the sample of patents with subsidies is greater than in the matched sample, with the average value of 5.1351 compared to 4.7838, but the difference is not significant. On the other hand, the breadth, the number of inventors and the number of applicants are smaller for subsidized patents than the matched sample, but only in the case of the number of investors such difference is statistically significant at the 10% level[1].

4.3. The impact of subsidies on patent value: regression analyses

We then performed regression analyses in order to control for other factors which might influence patent value, in addition to the receipt of a subsidy. Table 5 first reports the correlation matrix for our main variables in the full sample. It shows that traditional patent value determinants, such as the patent breadth, the number of inventors, the number of applicants, the number of backward citations tend to be correlated with each other. However, no significant evidence of multi-collinearity seems to emerge from the data.

--- Include Table 5 around here ---

Turning to the regression models reported in Table 6, Model 1 adopts the total number of forward citations received by each patent as dependent variable. It includes the dummy *Patent Subsidy* as independent variable, and other value determinants as control variables. The subsequent Model 2 adopts the dummy *Patent grant* as dependent variable and the same explanatory variables than the previous model.

--- Include Table 6 around here ---

The results of running the regression models are in accordance with the t-test analysis. The evidence presented in both Model 1 and Model 2 shows that the fact of obtaining a patent subsidy does not have a significant effect on patent value, either in terms of subsequent forward citations, or the probability of getting the patent granted. In both cases, in fact, the coefficient of the dummy *Patent Subsidy* is positive, but not statistically significant at conventional levels[2]. We therefore do find support for the concerns that patent subsidy

[1] As a further robustness check, we replicated our analyses first in the sub-sample of EPO patents (including 60 subsidized and 60 control patents), and then in the sub-sample of PCT patents (including 51 subsidized and 51 control patents). Results were largely confirmed, both in terms of signs and magnitude of the differences. The only notable exception is represented by the likelihood of grant in the sub-sample of EPO patents, which is still higher in the case of subsidized patents (50% vs. 33%), with the difference now significant at the 5% level.

[2] This result is confirmed also when we replicate our regression analyses in the two different

measures may provide incentives for low-quality patents.

When examining the effect of traditional other value determinants, in Model 1 we notice that the coefficient of the number of IPC classes on the number of forward citations is positive and significant at 1% level, signaling that patent with a larger scope are more likely to be subsequently cited. Besides, the number of inventors has a positive and significant impact (at the 1% level) on patent value. Indeed, the size of the research team and the resource allocated to the research project can be linked to quality of the underlying invention and its expected profit. Therefore a larger inventors' team would suggest a better patent quality with a higher expected value. On the other hand, the number of applicants has a negative and significant influence on the number of forward citations (at the 5% level). These results might be explained that the number of co-assignees tends to raise the opportunistic behaviors, risks or other difficulties particularly for SMEs when collaborating with individuals or other institutions which in turn would have a negative effect on the quality of the patent. Furthermore, there seems a mixed impact of backward citations on patent value. On the one hand, the effect of the number of backward citations on the number of forward citations is positive and significant at 1% level, suggesting that the broad state of art upon which the patent is based is reflected in citations coming from later patents. On the other hand, the larger number of backward citation does not necessarily lead to a higher probability to get the patent granted, as evidenced by the negative and significant coefficient (at 10% level) shown in Model 2. Not surprisingly, the coefficient of the time dummies in both models suggest that more recent patents have a lower likelihood to receive subsequent citations and obtain a final grant, as compared to older ones. Finally, our results do not suggest a significant effect of firm's size on patent value or patent grant as well.

5. Conclusions and policy implications

This paper has investigated a series of issues related to the design and assessment of patent subsidies schemes to foster patent activities by SMEs. Such measures have gained increasing importance over the last years in a wide variety of countries as a way to address the market failures connected to innovation and patenting activities by small and medium enterprises. To our knowledge, this is the first attempt in the literature to empirically investigate the optimal design of such schemes and to evaluate their effectiveness. We were particularly interested in assessing the impact of public subsidies on the value of patents, inspired by a series of concerns related to a potential inflation of low quality patents following the adoption of this kind of measures (Jiachun et al., 2008; Financial Times, 2008; The Economist, 2010).

From an empirical standpoint, we first mapped and analyzed a series of 34 policy programs centred on patent subsidy schemes activated in Italy by local, regional or national authorities starting from 2002. We than studied a sample of 222 patents, including 111 subsidized and 111 control patents, from the province in Milan, in Northern Italy, to test whether the receipt of a subsidy was associated with low patent value.

Our results reflect some flaws which seem to characterize the majority of this type of schemes activated in Italy: a strong fragmentation of the measures, resulting often in a limited budget

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sub-samples of EPO patents and PCT patents.

and a small amount of funding provided to beneficiary firms; a lack of coordination between actions undertaken at different levels (local, regional, national); a prioritary focus on increasing the number of international patent fillings, but not on increasing the quality of patents; the predominant automatic assignment of the subsidies, and the consequent absence of ex-ante evaluation on the quality and economic potential of submitted patents. All such shortcomings may have negative consequences, such as providing inadequate incentives for SMEs, or funding patents with limited economic potential, thus generating inefficiencies in the distribution of public financial resources.

For what concerns the impact of patent quality, results from our regression analyses on a sample of subsidized and control patents, do not support the concerns that the receipt of a subsidy is associated to lower patent value (measured in our case in terms of both the number of forward citations and the probability of getting the patent granted). However, they do not support either the existence of a higher value of subsidized patents, given that no statistically significant differences emerge in these dimension with respect to the control sample of non-subsidized patents. This evidence can be a direct consequence of the design of the specific measure we have analyzed, based on the award of automatic subsidies to applicants, following a mere check of the formal requirements.

Our study, therefore, suggests some important lessons and implications that can be applied by policy-makers to design and implement effective patent policies for SMEs based on subsidies. A first issue concerns the size of the programs. Rather than fragmenting the financial resources in narrowly designed schemes (often with rigid geographical limits), with limited budgets available and providing small amount of money to beneficiary firms, the implementation of sizeable programs should be encouraged (Scherer and Haroff, 2000). A second issue relates to the importance of jointly boosting the quantity *and* the quality of patents filed. It is doubtful that the establishment of patent subsidy schemes assigned with an automatic procedure is able to reach this goal, as suggested by our results. Selective schemes providing financial support only to selected. applicants, based on an ex-ante evaluation of the quality of the patent and the economic potential of the invention, could be more appropriate to reach this goal. Our review of the measures implemented in Italy has suggested a series of criteria that can be used to perform this kind of selection by a committee of experts, including the geographic and technological scope of the patent; the degree of innovativeness; potential market size and scope; competences of the applicant; collaborations with universities and public research centres. Finally, and as a direct consequence of the previous point, from a policy perspective, it appears important to encourage not only domestic and international patent filings by SMEs, but also their actual use to generate economic value. There is ample evidence that often patents generate no or very little value for their owners, since they remain unexploited (Giuri et al., 2007; Munari and Sobrero, 2011). SMEs in particular can take advantage from their patents in a wide variety of ways, including the protection from imitation and of the freedom to operate, but also outward licensing, access to external financing and reputation building (de Rassenfosse, 2011). An ideal extension of patent subsidy measures, therefore, would be that to encourage also the economic exploitation of patents, by covering not only expenses related to patent drafting and filings, but also to services related to their use and commercialization (for instance, costs for services related to patent evaluation and due diligence, technology marketing, license drafting, feasibility studies and proof of concepts). In this sense, a recent and interesting initiative that we observed in our study is the scheme launched in August 2011 by the Italian Ministry for Economic Development, devoting a budget of 40 Euro million to two different calls oriented to SMEs. The first call aims to foster domestic and international patent applications, by covering part of the drafting and filing expenses (up to a maximum of 6000 Euro per patent). The second call aims to foster the economic valorization of patents, by covering expenses (up to a maximum of 70000 Euro) related to prototyping and engineering studies, feasibility studies, market analyses, technological due diligence, license agreements drafting.

In conclusions, the evidence we presented provides several implications which are worth some reflection by policy makers, due to the increasing diffusion of public patent subsidies measure around the world.

References

Aerts, K., Schmidt, T., 2008. Two for the Price of One?: Additionality Effects of R&D Subsidies: A Comparison between Flanders and Germany. Research Policy 37: 806-822.

Almus, M., Czarnitzki, D., 2003. The Effects of Public R&D Subsidies on Firms' Innovation Activities: The Case of Eastern Germany. Journal of Bussiness&Economic Statistics, 21: 226-236.

Bérubé, C., Mohnen, P., 2009. Are firms that receive R&D Subsidies More Innovative? Canadian Journal of Economics 42(1): 206-225.

Blanes, J.V., Busom, I., 2004. Who Participates in R&D Subsidies Programs? The Case of Spanish Manufacturing Firms. Research Policy 33: 1459-1476.

Busom,L., 2000. An Empirical Evaluation of the Effects of R&D Subsidies. Economics of Innovation and New Technology 9: 111-148.

Colombo, M. Grilli, L., Murtinu, S. 2011. R&D subsidies and the performance of high-tech start-ups. Economics Letters 112 (2011) 97–99.

David, P.A., Hall, B.H., Toole, A.A., 2000. Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence. Research Policy 29: 497-530.

Davidson, C., Segerstrom, P., 1998. R&D Subsidies and Economic Growth. The RAND Journal of Economics 29: 548-577.

de Rassenfosse, G. 2011. How SMEs exploit their intellectual property assets: evidence from survey data. Small Business Economics, forthcoming.

Encaoua, D., Guellec, D., Martínez, C., 2006. Patent Systems for Encouraging Innovation: Lessons from Economic Analysis. Research Policy 35: 1423-1440.

Financial Times "The value of branding becomes patent," Financial Times, July 2, 2008.

Gabriel, D., Florence, E. M., 1993. Technology Watch and the Small Firm. The OECD Observer 182: 31-34.

Giebe, T., Grebe, T., Wolfstetter E., 2006. How to Allocate R&D (and other) Subsidies: An Experimentally Tested Policy Recommendation. Research Policy 35: 1261-1272.

Griliches, Z., 1998. R&D and Productivity: The Econometric Evidence. The University of Chicago Press, Chicago.

Gonzalez, G., Pazo, G. 2008. Do public subsidies stimulate private R&D spending?. Research Policy. 37: 371-389,

Grossman, G.M., Helpman, E., 1994. Endogeous Innovation in the Theory of Growth. Journal of Economic Perspectives 8: 23-44.

Guellec, D., van Pottelsberghe de la Lotterie, B. 2000. Applications, grants and the value of patent. Economics Letters 69(1): 109.

Guellec, D. van Pottelsberghe de la Lotterie, B. 2001. The internationalization of Technology Analysed with Patent Data. Research Policy 30(8): 1256-1266.

Guellec, D. van Pottelsberghe de la Lotterie, B. 2007. The Economics of the European Patent System. IP Policy for Innovation and Competition. Oxford University Press. Oxford.

Harhoff, D. and F. Narin (1999). "Citation frequency and the value of Patented Inventions." Review of Economics & Statistics 81(3): 511-515.

Harhoff, D., F. M. Scherer, et al. (2003). "Citations, family size, opposition and the value of patent rights." Research Policy 32(8): 1343-1363.

Harhoff, D. and M. Reitzig (2004). "Determinants of Opposition Against EPO Patent Grants: The Case of Pharmaceuticals and Biotechnology." International Journal of Industrial Organization 22: 443-480.

Harhoff, D. and K. Hoisl (2007). "Institutionalized incentives for ingenuity--Patent value and the German Employees' Inventions Act." Research Policy 36(8).

Harhoff, D. ,Reitzig, M., 2004. Determinants of opposition against EPO patent grants – The case of biotechnology and pharmaceuticals. International Journal of Industrial Organization 22: 443–480.

Henderson, R., Jaffe, A.B., Trajtenberg, M., 1998. Universities as a source of commercial technology: a detailed analysis of university patenting, 1965–1988. Review of Economics & Statistics: 119–127.

Hoffman, K., Parejo, M., Bessant, J., Perren, L., 1998. Small Firms, R&D, Technology and Innovation in the UK: A Literature Review. Technovation 18(1): 39-55.

Hussinger, K., 2008. R&D and Subsidies at the Firm Level: An Application of Parametric and Semiparametric Two-step Selection Models. Journal of Applied Econometrics 23: 729-747.

Jiachun, W., Yongtao, Z., Xuezhong, Z. 2008. Research on Patent Fees Subsidised by Local Governments in China. Paper presented at the 2008 International Conference on Information Management, Innovation Management and Industrial Engineering.

Klette, T. J., Møen, J., Griliches, Z., 2000. Do Subsidies to Commercial R&D Reduce Market Failures? Microeconometric Evaluation Studies. Research Policy 29: 471-495.

Koga, T., 2005. R&D Subsidy and Self-Financed R&D: The Case of Japanese High-Technology Start-Ups. Small Business Economics 24: 53-62.

Lemley, M., Shapiro, C., 2005. Probabilistic Patents. Journal of Economic Perspectives, 19:2, Spring, 75-98.

Lerner, J., 1994. The importance of patent scope: an empirical analysis. RAND Journal of Economics 25 (2), 319– 333.

Leyden, D.P., Albert, L.N., 1991. Why Are Government R&D and Private R&D Complements? Applied Economics 23(10): 1673-1681.

Lichtenberg, F.R., 1984. The Relationship between Federal Contract R&D and Company R&D. American Economic Review 74(2):73-78.

Lichtenberg, F.R., 1987. The Effect of Government Funding on Private Industrial Research and Development: A Re-Assessment. Journal of Industrial Economics 36(1): 97-104.

Lichtenberg, F.R., 1988. The Private R&D Investment Response to Federal Design and Technical Competitions. American Economic Review 78(3): 550-559.

Manuneas, T.P., Nadiri, I.M., 1996. Public R&D Policies and Cost Behavior of the U.S. Manufacturing Industries. Journal of Public Economics 63(1): 57-81.

Mowery, D.C., Ziedonis, A.A. 2002. Academic patent quality and quantity before and after the Bayh-Dole act in the United States. Research Policy, Volume 31: 399-418.

Munari, F. Sobrero, M. Malipiero, A. 2011. Absorptive capacity and localized spillover. Focal firms as technological gatekeepers in industrial districts. Industrial and Corporate Change, forthcoming.

Munari, F., Sobrero, M. 2011. Economic and management perspectives on the value of patents. In Munari, F., Oriani, R. (eds.) The Economic Valuation of Patents. Methods and Applications. Edward Elgar, Cheltenham.

Ortega-Argilés, R., Vivarelli, M., Voigt, P., 2009. R&D in SMEs: A Paradox? Small Business Economics 33(1): 3-11.

Omland, N. 2011. Valuing patents through indicators, in Munari, F., Oriani, R. (Eds.) The Economic Valuation of Patents. Methods and Applications. Edward Elgar, Cheltenham, UK.

Narin, F., E. Noma, et al. (1987). "Patents as indicators of corporate technology strength." Research Policy 16(2): 143-155.

Reitzig, M., 2003. What determines patent value? Insights from the semiconductor industry. Research Policy 32: 12-26.

Reitzig, M., 2004. Improving patent valuations for Management purposes---validating new indicators by analyzing application rationales. Research Policy 33: 939-957.

Sapsalis, E., Van Pottelsberghe, B., Navon, R., 2006. Academic versus Industry Patenting: An in-depth Analysis of What Determines Patent Value. Research Policy 35: 1631-1645.

Scherer, F.M., Harhoff, D., 2000. Technology Policy for a World of Skew-distributed Outcomes. Research Policy 29: 559-566.

van Zeebroeck, N. and B. van Pottelsberghe, B. (2008). Filing strategies and patent value. CEPR Discussion Paper 6821.

Wallsten, S.J., 2000. The Effects of Government-Industry R&D Programs on Private R&D: The case of the Small Business Innovation Research Program. RAND Journal of Economics 31: 82-100.

Zhou, E.Y. and Stembridge, B. (2010). Patented in China: the Present and Future State of Innovation in China. Thomson Reuters.

Tables and Figures

Table 1 - An overview of international experiences of patent subsidies schemes over the past decade

County/ Region	Funding Scheme	Eligible Costs Relate to Patenting	Agency Responsible	Target Company	Amount
Spain	The Foreign Promotion Initiation Plan	Registration of patents and trademarks abroad, including the professional fees of an Industrial Property Agent.	The Spanish Institute for Foreign Trade, and the Higher Council of Chambers of Commerce	Spanish SMEs	The subsidy of up to 80% of the expenses, up to a maximum of €46,000
China	A Special Financial Subsidy Program for International Patent Filings	The official fees of out-going pantent applications and three years after the patent granted.	The Ministry of Finance, and the State Intellectual Property Office	Chinese SMEs	The amount of subsidy for each country/region (maxium 5 countries or regions per earch patent) not more than 10 million RMB, except for a significant innovation.
Canada	The Atlantic Innovation Fund	Patent searches and filing fees	The Atlantic Canada Opportunities Agency, a federal government agency in Canada	Private sector firms	Actual cost
Ireland	R&D Fund	Costs of research, development and innovation projects in preceding the granting of the patent or other industrial property rights in Ireland and aboard.	The government agency of Enterprise Ireland, coordinated by Department of Enterprise, Trade and Employment.	Irish based companies, particularly SMEs	The maxium R&D grant of a company is €450,000, with the Patent costs no more than 20% of the overall project cost.
Milan, Italy	Measure to Support European and International Patenting	Expenses incurred for an international patent filing.	The Chamber of Commerce of Milan	SMEs in Milan	Up to 50% of expenses incurred with a maximum amount of 15.000 Euro.

	Processes of SMEs of the Province of Milan				
Scotland, U.K.	The SMART, SPUR or SPUR ^{PLUS} Grants	Essential project costs such as: labour, overheads, materials, sub-contracting, consultancy and intellectual property.	Scottish Executive Enterprise,Transport and Lifelong Learning Department of the Scottish Government	SMEs based in Scotland	75%,35%,35% of eligible costs, with maximum grant of €35,000, €52,000, €351,000 for SMART, SPUR and SPRUR ^{PLUS}.
Wallonia, Belgium	Subsidy for Patent Registration and Extension	Patent application to national or European patent office with a search for previous patents; additional formalities and the extension to other territories.	The Directorate General Operational for Economy, Employment and Research (DGO6) of the Ministry of the Walloon Region.	Local SMEs	35% and 70% of the costs incurred of patenting an innovation and all cost incured for national validation.
Hong kong	Patent Application Grant	Patent application and the administration fee charged by HKPC	Innovation and Technology Commision, and Hong kong Productivity Council	Local companies	90%(maximum HK$150,000) of the sum of the total direct cost.
Chongqing, China	Special Patent Fund	Patent fling fees, substantive examination fees, and maintenance fees and the first annuity due in the year after the patent granted	The Chongqing Scientific and Technological Committee of the Municipal Government of Chongqing	Enterprises in Chongqing	A grant of RMB 1 million
Gujarat, India	Patent Registration Assistance	Patent registration in india and abroad.	Industries and Mines Department of the Government of Gujarat	Local small, medium and large company	50% (maximum Rs. 5.00 Lakhs) of necessary expenditure incurred for obtaining the patent.

Source: WIPO ducument at http://www.wipo.int/sme/en/documents/managing_patent_costs.htm#P108_27414, and own summarization.

Table 2 - The design of patent subsidies measures in Italy
(Data are related to 34 measures promoted by local Chambers of Commerce, Provincial, Regional or National Authorities in Italy over the period 2002-2010)

Promoting institutions and geographic coverage	The vast majority of patent subsidy measures (25 cases) have been promoted and managed by local Chambers of Commerce, often with the financial support of provincial or regional authorities (11 cases our of 25). In three cases (Venezia, Puglia, Lazio), the measure was promoted, funded and managed directly by a regional authority, in three cases by a provincial authority (Roma, Trento and Parma), and in one case by a foundation (Fondazione Cassa di Risparmio di Imola in the case of Imola). Two recent measures have been established at the national level in August 2011 by the Ministry for Economic Development. For measures promoted by Chamber of Commerce and Provincial Authorities, the scheme is oriented only to companies located in the relevant province. For measures managed by Regional Authorities, the action is oriented to companies localized within the region.
Rationale and objectives	All the calls we have analyzed present similar objectives oriented to encourage firms to protect their IPRs at an international level, so to foster innovation and internationalization activities, particularly by SMEs. Only three calls report the objective to promote the exploitation of patents (Italian Ministry for Economic Development, Regione Lazio, Provincia di Trento), and not only their grant.
Target beneficiaries	In most of the cases, the target beneficiaries of the measures are small and medium enterprises (typically defined according to the EU classification). In all of the cases, only companies satisfying the requirements of the “de minimis aid” rule are admitted in the calls, in order to comply with the state aid regulations of the European Community[1]. Submission presented by individual inventors are typically not admitted (with the exception of one measure). In some cases, also patents from universities and public research centres are admitted (the call of the Region Puglia is specifically reserved to such institutions).
Eligible costs	Typically subsidies for invention patents and utility patents are provided[2]. Coherently with this aim, the subsidies (awarded in the form of grant) cover all the costs incurred for submitting an application to the national office or the European Patent Office (including filing fees, costs for patent attorneys, costs for patentability search), and the costs for extensions of the patent in other territories[3].

[1] According to the “de minimis rule”, an aid of no more than EUR 200 000 granted over a period of three years is not regarded as state aid within the meaning of Article 87(1). The Regulation does not apply to aid for fisheries and aquaculture, the primary production of agricultural products, export-related activities, the coal sector, the acquisition of road freight transport vehicles or firms in difficulty, or to aid tied to the use of domestic over imported goods. It applies to aid granted to firms in all other sectors, including transport and, on certain conditions, for the processing and marketing of agricultural products.

[2] In a few cases such subsidies address also registered designs, whereas in only one case (Chamber of Commerce of Mantova) also layout designs for integrated circuit and plan variety rights are included. Generally, registered trademarks are not considered in such measures, with the exception of the measure implemented by the Chamber of Commerce of Avellino.

[3] Generally, maintenance fees of the patent are excluded from eligible costs in such actions. In two cases (Chambers of Commerce of Gorizia and Udine), the aids are also intended to cover legal expenses incurred for litigations of the patent.

Amount of funding awarded	The maximum amount of funding awarded significantly varies across measures, ranging from a minimum amount of 500 euro per applicant (Campobasso) up to 70.000 euro (Italian Ministry of Economic Development).
Overall available budget	There is high variation in the overall budget available for the measures, ranging from a minimum of Euro 5000 Euro of budget (Chamber of Commerce Campobasso) to a maximum of Euro 1.200.000 for provincial measures (Milano), Euro 3.000.000 for regional measures (Lombardia), Euro 40.000.000 for national measures (Italian Ministry of Economic Development).
Selection and evaluation criteria	In the vast majority of cases, no ex-ante evaluation of the submitted patent is made (except for a formal check of the satisfaction of eligibility criteria), but the subsidies are automatically awarded on chronological order of the submission, up to the consumption of overall budget. In only five cases out of 32 (Ravenna, Imola, Venezia, Roma and Region Lazio, Italian Ministry for Economic Development) the selection is made by a Selection Committee based on pre-defined criteria (including degree of innovativeness; potential market size and scope; competences of the applicant; collaborations with universities and public research centres).

Table 3 - Descriptive statistics of patent applications by SMEs in the province of Milan

Variable	*N*	*Mean*	*Std.*	*Min*	*Max*
Number of Forward Citations	222	0.91	1.59	0.00	10.00
Dummy Grant	222	0.38	0.49	0.00	1.00
Dummy of subsidies	222	0.50	0.50	0.00	1.00
Number of IPC class	222	3.07	3.34	1.00	39.00
Number of Inventors	222	1.72	1.20	1.00	8.00
Number of Applicants	222	1.97	1.49	1.00	9.00
Number of Backward Citations	222	4.96	2.82	0.00	20.00
Dummy PCT	222	0.46	0.50	0.00	1.00
Dummy Utility	222	0.06	0.24	0.00	1.00
Turnover (in million Euro)	222	6,0099	8,3133	0,001	35,564589

Source: AIDA database, Espacenet.

Table 4 - Comparison of patent value indicators between the sample of patents with subsidies and the control group

	Patents with subsidies (mean value)	*Control patents (mean value)*	*T-value*	*Sig. (2-tailed)*
Number of Forward Citations	0.9369	0.8739	0.319	0.750
Dummy of Grant	0.4234	0.3423	1.347	0.181
Number of IPC class	3.0360	3.1081	-0.171	0.865
Number of Inventors	1.5856	1.8468	-1.740	0.085
Number of Applicants	1.9640	1.9820	-0.129	0.898
Number of Backward Citations	5.1351	4.7838	0.890	0.375

Data refer to 111 patents with subsidies and 111 control patents.

Table 5 - Correlation matrix among main variables in the full sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)Forward citations	1.00							
(2)Dummy Grant	0.53	1.00						
(3)Dummy Subsidies	0.02	0.08	1.00					
(4)IPC class	0.30***	0.06	-0.11	1.00				
(5)Inventors	0.09	-0.12*	-0.11	0.14**	1.00			
(6)Applicants	0.05	-0.11*	-0.01	0.20***	0.76***	1.00		
(7)Backward citations	0.09	-0.05	0.06	0.21***	0.09	0.14**	1.00	
(8)Dummy PCT	0.03	-0.08	0.00	0.19***	0.24***	0.68***	0.07	1.00

*p<10%, **p<5%, ***p<1%

Table 6. Regression models on the impact of patent subsidies for SMEs on patent value (full sample)

	(1) Poisson regression model	(2) Logit regression model
	Dependent variable: Number of forward citations	Dependent variable: Dummy of granted patent
Dummy of patent subsidies	0.1268(0.1510)	0.4408 (0.3253)
Number of IPC class	0.0381 (0.0125)***	0.0195 (0.0527)
Number of inventors	0.3865 (0.1069)***	-0.1281(0.2706)
Number of applicants	-0.2446 (0.1118)**	0.0031 (0.2895)
Number of backward citation	0.0205(0.0258)	-0.1131(0.0638)*
Dummy of PCT	0.2781(0.2538)	-0.2218 (0.5636)
Log Turnover	-0.0320 (0.0386)	-0.0335 (0.0863)
Dummy utility patent	0.1485(0.2738)	-0.9814 (0.6657)
Dummy priority year		
2000	Reference case	Reference case
2001	-0.7727(0.3568)**	-0.2715(0.8744)
2002	-0.2618(0.2657)	-0.9517(0.7415)
2003	-0.7918(0.2768)***	-1.5386(0.7315)**
2004	-1.0023 (0.3496)***	-1.6489(0.8355)**
2005	-1.4873(0.3420)***	-3.6734(0.9251)***
2006	-1.9932(0.4340)***	-2.9055(0.8850)***
2007	-13.8314(526.4201)	(omitted)
Constant	0.4681 (0.7277)	2.2113 (1.6748)
Log likelihood	-298.0555	-120.2082
LR Chi^2	91.01	51.18
Prob>Chi^2	0.0000	0.0000
Number of observations	222	220

*p<10%, **p<5%, ***p<1%; standard errors are in parentheses.

Testing the Assumptions of Biotechnology Innovation in Australia

Key words

Patent licensing, biotechnology, Australia

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Introduction

Patents are widely assumed to be critical conduits to innovative product development in biotechnology (biotech) (OECD, 22-24). In this respect, biotech has much in common with the pharmaceutical industry (pharma) (Levin et al, 1987; Cohen et al, 2000). In contrast, empirical studies in other industry sectors suggest that at best, patents provide a small incentive for innovation (Arora et al, 2008). Despite positive attitudes towards patents within the biotech industry, there is ongoing theoretical debate that broad foundational patents could block innovation (Shapiro, 2001) and that if the patent landscape is too cluttered, multiple bargains must be negotiated (Heller and Eisenberg, 1998; Eisenberg, 2008). It remains unclear whether the net impact of patents on innovation in biotech is positive or negative. These issues have been examined in an extensive series of law reform inquiries. In Australia, for example, there have been three specific inquiries into the need to reform the law relating to gene patenting (ALRC, 2004; Australian Senate Community Affairs Reference Committee, 2010; Australian Senate Legal and Constitutional Affairs Committee, 2011) and two more general inquiries that were initiated largely in response to these issues (ACIP, 2005; 2010). To date, however, there have been few concrete changes to patent law, either in Australia or in other jurisdictions, resulting from these law reform inquiries (Nicol, 2011).

The aims of the study reported in this paper are twofold: first, to determine whether the biotech industry has developed a distinctive model for utilising patents in the development of biotech products and processes, taking into account the complex patent landscape and other unique features of the industry; and secondly, to analyse the extent to which strategies for utilising patents within the biotech industry are successful and sustainable. These questions were analysed using data from an Australian Inventor Survey undertaken in 2007 by the Intellectual Property Research Institute of Australia (IPRIA) (Webster and Jensen, 2011; Jensen et al 2011).[1] The ultimate aim of this study is to provide evidence to assist in policy debates relating to patent law reform.

According to Keith Pavitt's well-accepted taxonomy of technical change, the main sources of technological innovation for science-based firms are research and development activities, 'based on the rapid development of the underlying sciences in the universities and elsewhere' (Pavitt, 1984, at 362). In contrast, other industry sectors

[1] Anonymised data from the survey were provided by Webster and Jensen for the present study.

tend to be much more supply and production-focused. In many respects, biotech would seem to be the paradigm example of a science-based industry. The merging of basic science and applied technology has been well documented in biotech. Eisenberg and Nelson locate it in Donald Stokes' Pasteur's Quadrant, where basic science is used to solve practical problems (Eisenberg and Nelson, 2002). The result, they argue, is the a significant private biotech industry formed around pre-product development research. Research on the characteristics of biotech patents (particularly in the drug discovery sector) also indicates that early inventive activity is predominantly located in public research organizations (Narin et al, 1997).

Coriat et al (2003) argue that biotech does not fit neatly into Pavitt's classic science-based category. They to draw out some points of distinction between various sub-classes within this science-based regime, particularly focusing on the motivators for patenting. In pharma, for example, they note that, aside from preventing copying, key rationales for patenting include blocking competitors and enhancing reputation (as well as acquiring licensing revenues). In computer technology, on the other hand, they argue that the main objectives of patenting are facilitating negotiations and avoiding suits. This, they conclude, reflects a distinction in the nature of the technologies, pharma being more discrete, favouring large firms that block competitors, and computer technology being more complex and cumulative, favouring small firms that engage in rapid diffusion of technology. In biotech, it could be argued that a hybrid industry has emerged, comprising small firms that engage in rapid diffusion of scientific knowledge but that also utilize patents to block competitors, and enhance reputation. These firms are likely to have close relationships with scientific researchers, both in-house and in public research organisations, to facilitate transfer of the vast array of discoveries in this rapidly-emerging field (Zucker et al 1998; 2001).

The open innovation business model described by Chesbrough (2003) and others (reviewed by Ebersberger et al, 2011) seems particularly suited to small biotech firms spun out from the public sector, lacking many necessary skills, materials, equipment, intellectual property, financial and other resources as well as manufacturing and distribution expertise to take products down the long road from early-stage discovery to product delivery (Glick, 2008). Coincidentally, large, well established pharma and agricultural companies have also been looking to externalize early stage research and development in this rapidly developing high technology, high risk industry (Pisano, 2006, provides a detailed account of these changes). As such, one of the expected features of an efficient biotech industry is a dense network of collaborations between small firms, public sector organisations and larger downstream developers (see, e.g., Arora and Merges, 2004).

Many commentators, including Pisano (2006) and Coriat et al (2003) question the sustainability of this biotech business model. Coriat et al (2003) argue that reliance on venture capital funding for early stages of commercial development, vulnerability to fluctuations in the stock market, competition for the limited licensing opportunities with larger downstream companies and ongoing uncertainty about patent validity all make the biotech model particularly susceptible to failure. Added to these concerns, complexity of the patent landscape together with obligations to engage in multiple licensing and other technology transfer transactions could impede, rather than facilitate innovation, particularly if transactions are ultimately unsuccessful or if onerous terms are imposed (Heller and Eisenberg, 1998; Koo and Wright, 2010).

Despite these concerns, and recognizing that the longevity of individual firms is highly variable, the biotech industry continues to expand. Qualitative empirical studies suggest that in Australia (Nicol and Nielsen, 2003), as in other jurisdictions (e.g. Walsh et al, 2003; Thumm, 2004), biotech industry participants are capable of finding working solutions to fragmentation, hold-up and other risks (reviewed by Eisenberg, 2008). This research suggests that there continue to be rich research and development opportunities in biotech, and firms are able to find spaces within the complex patent landscape that are relatively free from clutter and even in more complex areas they are able to engage in successful collaborations, licensing and technology transfer. Despite this, Eisenberg concludes from these studies that 'the risk of an anticommons, although perhaps smaller than might have been feared a decade ago, is nonetheless quite real in the calculations of product-developing firms' (Eisenberg, 2008 at 180).

There have not been many opportunities for quantitative assessment of the positive and negative effects of patents on innovation in biotech, particularly in countries like Australia, which actively promote a biotech future, but provide few incentives for development of the industry. In the present study, we sought to test some of the assumptions about the nature and sustainability of the biotech business model in

Australia using data from the Australian Inventor Survey on outcomes of inventive activity in biotech and the other science-based industry sectors, including both pharma and information and communication technology (ICT), and non-science-based industry sectors (the remainder of the survey population).

1. Taxonomy of the biotech industry

First, we sought to validate the placement of biotech within the Pavitt science-based taxonomy by examining sources of knowledge and funding for inventive activity compared with other industries. We expected that biotech, pharma and ICT inventors would be more likely to be funded by government research programs and more informed by peer reviewed scientific knowledge than market orientated knowledge.

We also expected that there would be some differences in the nature of inventions between the science-based and non-science-based industries. However, we saw the precise nature of those differences as being difficult to predict. On the one hand, it might be expected that science-based inventors would tend to produce more cutting edge or 'radical' inventions, and the non-science-based inventors would produce more 'incremental' inventions because of their focus on supply and production. But on the other hand, because of the propensity for scientists to 'stand on the shoulders of giants' (Merton, 1965), innovation based on science may be more likely to be seen to be incremental rather than radical in nature by the inventors themselves.

2. Existence of a distinctive biotech business model

A major objective of this research was to determine whether a distinctive biotech business model could be identified, whereby inventors tend to focus on early stage discovery and leave it to others to engage in later state development and delivery. We sought to analyse differences in the rates of licensing and other forms of technology transfer (for example, forming a spin off company) between biotech and other industry sectors. We also sought to assess the efficacy of this business model by examining relative levels of success in licensing and transfer to spin offs. In accordance with predictions about the biotech model, we expected to see more attempts to license-out biotech inventions or to transfer them to a spin-off company, relative to the rest of the population. Moreover, we expected that a viable biotech industry would be reflected in greater success in attempting to license and spin off relative to other sectors.

3. Product development strategies and impediments

Given that we expected biotech, pharma and ICT inventions to be more intimately linked with basic science than other sectors, we hypothesised that it may take longer for them to reach the market, and that this may be reflected in sales revenue. As the Australian Inventor Survey includes inventions from 1986 onwards, we speculated that many science-based inventions may only have recently reached the marketplace and even more may still only be in the development phases when compared with non-science-based inventions. Conversely we expected that licensing revenue and the value inventors put on their patents should be less affected by the type of invention (science-based versus non-science-based).

We also expected that the assumption of greater reliance on open innovation in biotech would be reflected in increased propensity for product development to involve other organisations and scientists, and lower likelihood that products would be developed in-house. While relative success in the phases of product development might be reflective of a healthy biotech industry and a sustainable biotech business model, the long time and distance to market may confound this assumption. It may simply be to early for particular phases of development and manufacturing to have commenced and to know what problems might be encountered during those phases. As such, we did not speculate on how measures relating to development, manufacturing and mass production might differ across industry sectors, but sought to examine trends and perceived problems associated with each development phase.

4. The patent and product development landscape and viability of the biotech business model

We wanted to know whether differences in susceptibility to market success or failure could be attributed to factors such as number of products and processes that an invention feeds into and number of patents required for a particular invention to be developed. Given that open innovation and collaboration are assumed to be particular features of the biotech business model, we should expect to see some evidence that each biotech invention will feed into more product and processes and each biotech product or process will require access to more additional patents for its development than for other industries. A positive relationship between the number of products and processes that an invention feeds into and the number of patents required for an invention to be developed and successful licensing and spin off activity should be indicative of a well functioning innovation system with rich collaborative networks. Conversely, if an anticommons exists, we may see a negative relationship between number of products and processes and number of patents on the one hand and successful licensing and spin off activity on the other. The relationships between licensing and spin off activity, invention value and nature of the invention should also tell us something about the viability of this type of business model. We sought to analyse each of these relationships.

Methods

The Australian Inventor Survey included 3,789[2] responses from inventors reporting on one invention that was the subject of a patent application to the Australian Patent Office at IP Australia between 1986 and 2005. The total population of applications from one inventor was 31,313. Taking into account unopened returned surveys and an estimation of valid addresses, the response rate was 68.6% (see Webster and Jensen, 2011 for a detailed description of the recruitment process, response rates and population and sample characteristics). The inventors were asked a series of questions about the nature of the invention, its value, complexity, perceived problems and licensing activity.[3]

The OECD framework for statistics (OECD, 2005) was used to classify inventions based on their IPC code as biotech and ICT. The A61K IPC code of was used for pharma and the remainder were classified as non-science-based. All analyses were calculated using PASW for Windows (Version 18). As Table 1 shows, there were 127 inventions classified as biotech, 453 as ICT, 99 as pharma, and 3110 as non-science-based.

Table 1. Frequencies and percentages of cases across OECD patent classification groups.

OECD Classification	Frequency	Percentage
Biotech	127	3.4
ICT	453	12.0
Pharma	99	2.6
Non-science-based	3110	82.1
Total	3789	100

[2] The total number of responses used in this research differs from that used (3736) in the IPRIA analyses (Jensen et al, 2011; Webster and Jensen, 2011). In their analyses 53 responses that had missing values on a variable relating to technology were excluded (see Jensen at al, 2011). These responses were retained in the current analysis, giving an n of 3,789. As for the IPRIA analyses, 73 responses with missing IPC codes were not included in the current research.
[3] A detailed description of the measure used is available in Jensen et al (2011).

Results

1. Taxonomy of the biotech industry

Two questions from the Australian Inventor Survey were used as indicators of an association between inventions and basic scientific research. The first asked, 'What were the main sources of funding for this research?' Table 2 shows the number and percentage of respondents who indicated that they had received each of five types of funds across the four OECD classification groups. The second question asked, 'How important were the following sources of knowledge for this research'. Respondents were asked to rate the level of importance of eight sources of knowledge from 1 (Not important) to 7 (Very important). Figure 1 shows the mean importance rating for each source across the four groups.

Table 2. Source of funds across OECD patent classification groups.

	Biotech		Pharma		ICT		Non-science	
	n	%	n	%	n	%	n	%
Internal organisational	55	43.3	41	41.4	253	55.8	1363	43.8
Financial intermediaries	20	15.7	23	23.2	20	4.4	133	4.3
Government research programs	75	59.1	34	34.3	75	16.6	277	8.9
Other organisations	34	26.8	19	19.2	47	10.4	179	5.8
Personal funds	14	11.0	32	32.3	196	43.3	1803	58.0

Note. n = number and % = percentage of respondents in each group who indicated that they had received the type of funds. Percentages do not total 100% as respondents could select more than one type of funds.

Table 2 shows that the funding for inventions in the three science-based sectors was more likely to be sourced from the government and other organisations than for non-science inventions, and this was particularly the case for biotech inventions. Conversely, funding for non-science-based inventions was much more clearly sourced personally. To statistically assess these trends, five separate binomial logistic regression equations were calculated for each type of funds as the dependent variable and group as the independent variable. For all analyses, selecting the funding source was coded as 1 and not selecting the source was coded as 0. The reference category for the independent variable group in all analyses was the biotech group. As expected, biotech were significantly more likely than non-science-based inventors to receive funds from government programs (B = -2.691, S.E. = .19, Wald = 198.30, p<.001, Odds ratio = .07). Biotech were also more likely to receive government funding than pharma (B = -1.01, S.E. = .28, Wald = 13.30, p<.001, Odds ratio = .36) and ICT inventors (B = -1.98, S.E. = .22, Wald = 81.06, p<.001, Odds ratio = .14). The results also show that biotech inventors were significantly more likely than ICT (B = -1.40, S.E. = .33, Wald = 17.50, p<.001, Odds ratio = .247) and non-science-based inventors (B = -1.43, S.E. = .26, Wald = 30.48, p<.001, Odds ratio = .247) to receive funds from financial intermediaries, but were not significantly different from pharma (at p<.05). Biotech inventors were also significantly more likely than ICT (B = -1.15, S.E. = .25, Wald = 20.69, p<.001, Odds ratio = .32) and non-science-based inventors (B = -1.79, S.E. = .22, Wald = 69.47, p<.001, Odds ratio = .17) to receive funds from other organisations, but were not different from pharma (at p<.05). Finally, biotech inventors were significantly less likely to use personal funds than pharma (B = 1.35, S.E. = .36, Wald = 14.40, p<.001, Odds ratio = 3.86), ICT (B = 1.82, S.E. = .30, Wald = 37.00, p<.001, Odds ratio = 6.16), and especially non-science-based inventors (B = 2.41, S.E. = .29, Wald = 71.18, p<.001, Odds ratio = 11.13).

Figure 1. Mean importance of knowledge sources across OECD patent classification groups.

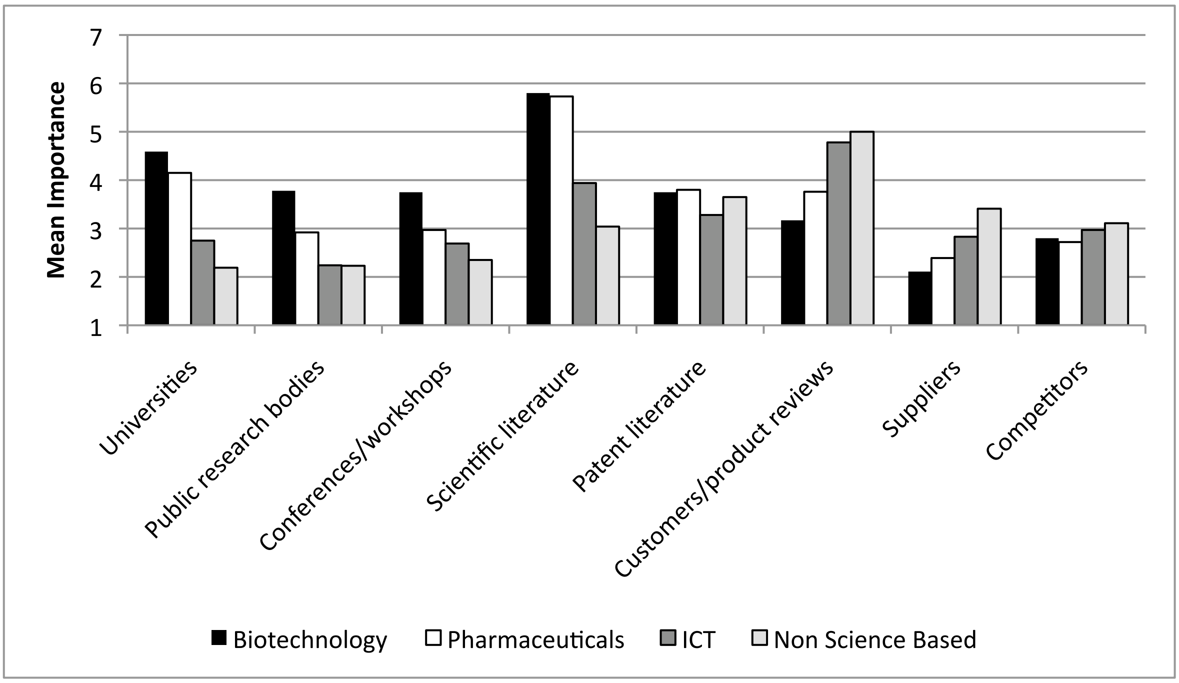


Figure 1 suggests that biotech and pharma inventors were far more reliant on scientific knowledge, particularly universities and the scientific literature than market sources including customer, suppliers and, to a lesser extent, competitors. A series of one-way analysis of variance (ANOVA) tests with post hoc comparisons (Student Newman Keuls) revealed that biotech inventors saw universities as a significantly[4] more important source of knowledge than all other groups, with pharma placing significantly higher importance on universities than ICT, who in turn placed significantly more importance on this source than non-science-based inventors. Biotech inventors also rated other public research bodies as a more important source than all other groups, with pharma placing more importance on this source than both ICT and other inventors (who did not differ from each other significantly). Conferences and workshops were also rated as significantly more important for biotech compared to all other groups, with pharma placing significantly more importance on this source than non-science-based inventors, but were similar to ICT (who did not differ significantly from non-science-based inventors). As expected, biotech and pharma (who did not differ from each other) also viewed scientific literature as a significantly more important source of knowledge than non-science-based inventors, and their importance ratings were also statistically higher than ICT, who in turn rated this source as significantly more important than non-science-based inventors. In contrast, the ANOVA revealed that ICT and non-science-based inventors (who did not differ from each other) placed significantly more importance on customers as a source of knowledge than both pharma and biotech. For ICT, this may reflect the importance of users on innovation in this particular sector (see, for example, von Hippel, 2005). Pharma saw this source as significantly more important than biotech inventors. In relation to suppliers, non-science-based inventors saw them as a more important source than all other groups, with ICT and pharma (who did not differ from each other) rating this source as significantly more important than biotech. There was no significant difference in the importance inventors place upon competitors as a source of knowledge, all groups seeing them as moderately important. Suppliers were also seen as being of moderate value as a source of knowledge, although as stated above, they were somewhat more important for the non-science-based sector. There was also no significant difference in views on the importance of the patent literature as a source of knowledge, all groups seeing this as more important than competitors and

[4] All comparisons were significant at $p<.05$.

suppliers. In sum, by far the most significant difference in sources of knowledge was for universities and the scientific literature (most important for biotech and pharma) and customers (most important for ICT and non-science).

To assess the radical/incremental nature of inventions across the science and non-science-based inventions we used the Australian Inventor Survey question, 'Relative to the "state of the art" at the time of patent application, was the invention…'. Table 3 shows frequencies and percentages of responses across the four groups.

Table 3. Nature of the invention across OECD patent classification groups.

	Biotech		Pharma		ICT		Non-science	
	n	%	n	%	n	%	n	%
Incremental improvement	48	38.1	27	27.3	144	32.0	968	31.4
Radical improvement	68	54.0	62	62.6	273	60.7	1864	60.4
Unsure	10	7.9	10	10.1	33	7.3	252	8.2

Table 3 shows that biotech inventions were slightly less likely to result in a radical compared to incremental improvement than non-biotech inventions. However, a binomial logistic regression (omitting unsure response and using biotech as the reference category) revealed that there were no significant differences between biotech and the other three categories in terms of the proportion of inventions that were incremental compared to radical. A total of five binomial logistic regressions were computed to assess the relationship between the nature of the invention and the five sources of funding described above. The frequencies for each category are shown in Table 4 for the sample as a whole. Since the frequencies were too small to obtain confident results for separate analyses within each of the OECD categories, the relationships between these variables were completed for the whole sample only.

Table 4. Nature of the invention across funding sources for all inventions

		Incremental improvement		Radical improvement		Unsure		Total
		n	%	n	%	n	%	
Internal	No	552	26.2	1324	62.9	228	10.8	2104
	Yes	653	37.8	989	57.3	85	4.9	1727
Financial intermediaries	No	1150	31.6	2184	60.1	300	8.3	3634
	Yes	55	27.9	129	65.5	13	6.6	197
Government	No	1069	31.7	2015	59.8	284	8.4	3368
	Yes	136	29.4	298	64.4	29	6.3	463
Other organisations	No	1113	31.3	2132	60.0	306	8.6	3551
	Yes	92	32.9	181	64.6	7	2.5	280
Personal	No	702	39.9	965	54.9	92	5.2	1759
	Yes	503	24.3	1348	65.1	221	10.7	2072

The results of the logistic regression revealed that government and personal funding were significantly associated with the nature of the invention. If the inventor received government funding (B = -.32, S.E. = .12, Wald = 7.41, $p<.01$, Odds ratio = .72) or used their personal funds (B = -.74, S.E. = .10, Wald = 53.40, $p<.001$, Odds ratio = .48) they were more likely (28% and 52% respectively) to develop a radical than an incremental invention. Receiving funding from all other sources was not associated with the nature of the invention. To assess the relationship between the nature of the invention and sources of knowledge, the eight sources of knowledge questions described above were subjected to a series of independent samples t-tests using the nature of the invention as the independent variable. The mean importance scores across incremental and radical inventions are displayed in Figure 2. Again, the frequencies were too small to obtain confident results for separate analyses within each of the OECD categories. Thus, relationships between these variables were completed for the whole sample only.

Figure 2. Mean importance of each knowledge source across incremental and radical inventions.

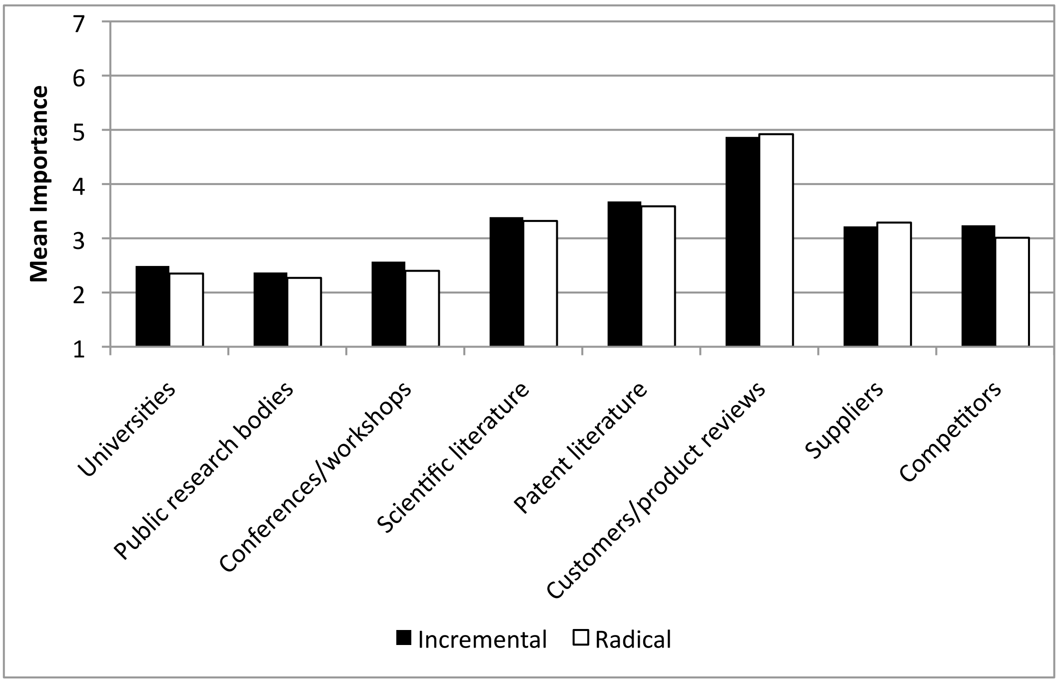


Figure 2 illustrates that there was little difference in the perceived importance of each source of knowledge across the nature of the invention categories. The results of the t-tests did however reveal two significant differences. Respondents whose inventions were incremental placed greater importance on conferences/workshops and competitors than those with radical inventions (both were significant at $p<.01$).

2. Existence of a distinctive biotech business model

Responses to two Australian Inventor Survey questions were used to assess whether biotech inventors are more or less likely than others to attempt to license and attempt to tranfer to a spin off company. The first asked, 'Has there been any attempt to license or sell this patent to a third party?' The second asked, 'Has there been any attempt to transfer this patent to a spin-off company?' A series of logistic regressions were computed to assess whether the responses to each of these questions significantly differed across the four OECD groups. In all analyses, the reference category for the independent variable was biotech. The frequencies for licensing across OECD groups are shown in Table 5 and those for the transferring to a spin-off are in Table 6.

Table 5. Attempts to license across OECD patent classification groups

	Biotech		Pharma		ICT		Non-science	
	n	%	n	%	n	%	n	%
Yes, but not successfully	30	23.6	23	23.2	96	21.3	786	25.5
Yes, successfully	48	37.8	42	42.4	83	18.4	441	14.3
Total Yes	78	61.4	65	65.7	179	39.8	1227	39.9
No	37	29.1	32	32.3	233	51.8	1697	55.1
Unsure	12	9.4	2	2.0	38	8.4	154	5.0

Note. 'Total Yes' is the sum of 'Yes, but not successfully' and 'Yes, successfully'.

Table 5 shows that biotech and pharma inventors were more likely to attempt to license than not (i.e. Total Yes compared to No), and that ICT and non-science inventors were less likely to attempt to license. Of those who did attempt to license, both biotech and pharma were more likely to do so successfully, while ICT and non-science-based inventors were more likely to be unsuccessful. To test the significance of these differences, a binomial logistic regression compared the proportion of Total Yes responses to No across all groups, and a second compared the Yes successfully response with the Unsuccessful response. The results of the first analysis show that biotech inventors were significantly more likely to license than all groups except pharma (which was not significant at $p<.05$). Biotech were 64% more likely to license than ICT inventors (B = -1.01, S.E. = .22, Wald = 20.49, $p<.001$, Odds ratio = .36) and 66% more likely to license (compared to no attempt to license) than non-science-based inventors (B = -1.07, S.E. = .20, Wald = 27.76, $p<.001$, Odds ratio = .34). The results of the second binomial logistic regression analysis, using only the Yes successfully responses, reveals that biotech inventors who attempted to license their inventions were more likely than ICT (B = -.62, S.E. = .28, Wald = 4.94, $p<.05$, Odds ratio = .54) and non-science-based inventors (B = -1.05, S.E. = .24, Wald = 19.03, $p<.001$, Odds ratio = .35) to be successful (relative to unsuccessful), but were not statistically different from pharma.

Table 6. Attempts to transfer to a spin-off across OECD patent classification groups

	Biotech		Pharma		ICT		Non-science	
	n	%	n	%	n	%	n	%
Yes, but not successfully	10	8.0	9	9.3	19	4.2	182	5.9
Yes, to a failed spin-off	3	2.4	6	6.2	10	2.2	38	1.2
Yes, successfully	27	21.6	16	16.5	32	7.1	200	6.5
Total yes	40	32.0	31	32.0	61	13.6	420	13.7
No	78	62.4	61	62.9	346	77.2	2493	81.3
Unsure	7	5.6	5	5.2	41	9.2	153	5.0

Note. 'Total Yes' is the sum of 'Yes, but not successfully', 'Yes to a spin-off that failed' and 'Yes, successfully'.

Table 6 shows that across all groups inventors were less likely to transfer to a spin off than not. Those who did attempt to transfer to a spin off in biotech appeared to be much more likely to do so successfully than not successfully and than transferring to a spin off that failed. Multinomial logistic regression analyses were undertaken to compare the three attempt to transfer to a spin-off company responses (i.e., successful, unsuccessful, and transferred to a spin off company that failed) across OECD classification groups (using successful and biotech as the reference categories), revealed that biotech inventors who did attempt to transfer to a spin-off company were more likely to do so successfully than not successfully compared to non-science-based inventors (B = -.62, S.E. = .28, Wald = 4.94, $p<.001$, Odds ratio = .54), but were not significantly more likely to do so than pharma or ICT. There was no significant difference in the proportion of inventors who were successful compared to those who transferred to a spin-off company that failed across the groups. A second multinomial logistic regression revealed that biotech inventors were significantly more likely to attempt to transfer successfully than to make no attempt than ICT (B = -1.32, S.E. = .29, Wald = 20.74, $p<.001$, Odds ratio = .27) and non-science-based inventors (B = -1.46, S.E. = .24, Wald = 38.68, $p<.05$, Odds ratio = .23) but not pharma.

3. Product development strategies and impediments

The extent to which inventions were producing commercially viable outcomes by OECD patent classification group was assessed using responses to the following Australian Inventor Survey questions: 'To date what is your estimate of sales revenue from products and processes', 'If you were selling this patent or invention today, what price would you be willing to accept for it?', and 'If this patent had been licensed, what is your best estimate of the licensing revenues to date?' To put a useful measure on invention value, a numeric was allocated for each response option to all three questions: 1 = 0<$100,000, 2 = $100,000 to 500,000, 3 = $500,000 to 1 million, 4 = $1 million to $2 million, 5 = $2 million to 10 million, 6 = >$10 million. Means by OECD group are shown in Figure 3.

Figure 3. Invention value across OECD patent classification groups.

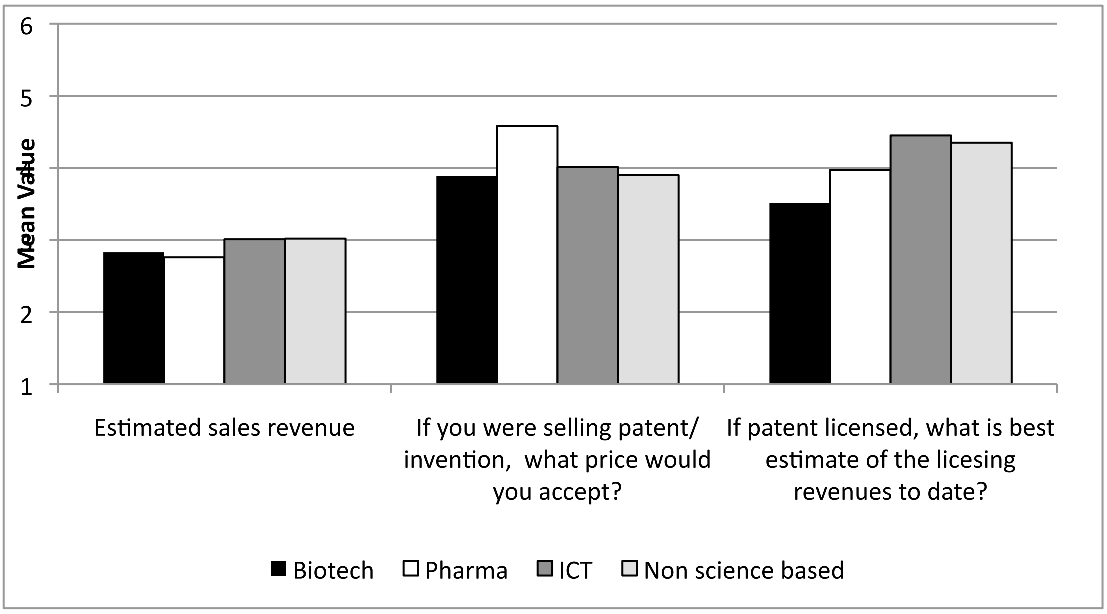


Figure 3 illustrates that the mean responses were fairly uniform across groups. Given that a large number of responses were in the 0 to <$100,000 category, and in order to simplify the analyses, the categories were collapsed into 0 to < $100,000 and over $100,000. The numbers of responses and relative percentages are shown in Table 7.

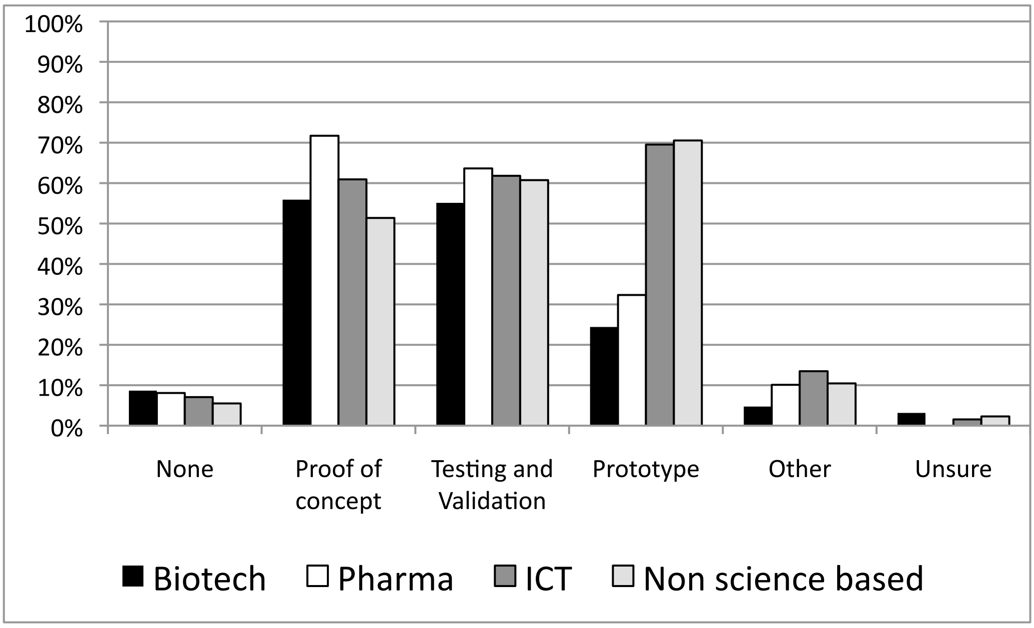
Table 7. Sales revenue to date, expected sale value and licensing revenue across OECD patent classification groups

		Biotech		Pharma		ICT		Non-science	
		n	%	n	%	n	%	n	%
Estimated sales revenue to date	0 to <$100,000	76	74.5	55	64.7	205	53.0	1357	52.9
	Over $100,000	26	25.5	30	35.3	182	47.0	1209	47.1
Acceptable price	0 to <$100,000	32	32.9	9	12.9	87	25.9	689	31.0
	Over $100,000	65	67.1	61	87.1	248	74.1	1534	69.0
Estimated licensing revenue to date	0 to <$100,000	50	70.4	26	54.2	92	53.5	701	57.4
	Over $100,000	21	29.6	22	45.8	80	46.5	521	42.6

Table 7 shows that the estimated sales revenue for products and processes developed from over fifty percent of the inventions in each OECD group was below $100,000, with lowest percentages of revenue above $100,000 being in biotech and pharma. This is illustrative of the point that many products and processes across all groups have not yet, or have only just, reached the market. It is noteworthy, though, that the second highest percentage of responses to the estimated sales category question was >10 million across all group (12.7% for biotech, 15.3% for pharma, 13.4% for ICT and 11.9% for non-science), indicating that if products do make it to market they can return significant revenue, irrespective of the sector of invention. There is no clear differential in acceptable price between groups, except for pharma. Estimated licensing revenue to date also tended to be at the lower end for over half of the inventions in each group, with no great difference in percentages between the science-based and non-science-based groups of inventions, except biotech (despite biotech having the highest propensity to license successfully). The results of a binomial logistic regression reveal that biotech inventors were significantly less likely to report estimated sales revenue over $100,000 than ICT (B = .95, S.E. = .25, Wald = 14.67, p<.001, Odds ratio = 2.60) and non-science-based inventors (B = .96, S.E. = .23, Wald = 17.23, p<.001, Odds ratio = 2.60) but not pharma. The results for the estimated acceptable price showed that biotech were less likely to estimate over $100,000 than pharma inventors (B = 1.21, S.E. = .42, Wald = 8.34, p<.005, Odds ratio = 3.34), but were not significantly different from ICT and non science based inventors. Finally for estimated licensing revenue to date, biotech inventors were slightly less likely to estimate over $100,000 than ICT (B = .73, S.E. = .30, Wald = 5.82, p<.05, Odds ratio = 2.07) and non-science-based inventors (B = .57, S.E. = .27, Wald = 4.59, p<.05, Odds ratio = 1.77), but not pharma.

To assess relative levels of involvement in product development, responses to the following two Australian Inventor Survey question were analysed: 'Which development stages were attempted in relation to this invention?' and 'Once the invention had been conceived, was it developed…?' were also analysed. The percentages of development stages completed are shown in Figure 4, and the percentages of responses for where the invention was developed are shown in Figure 5.

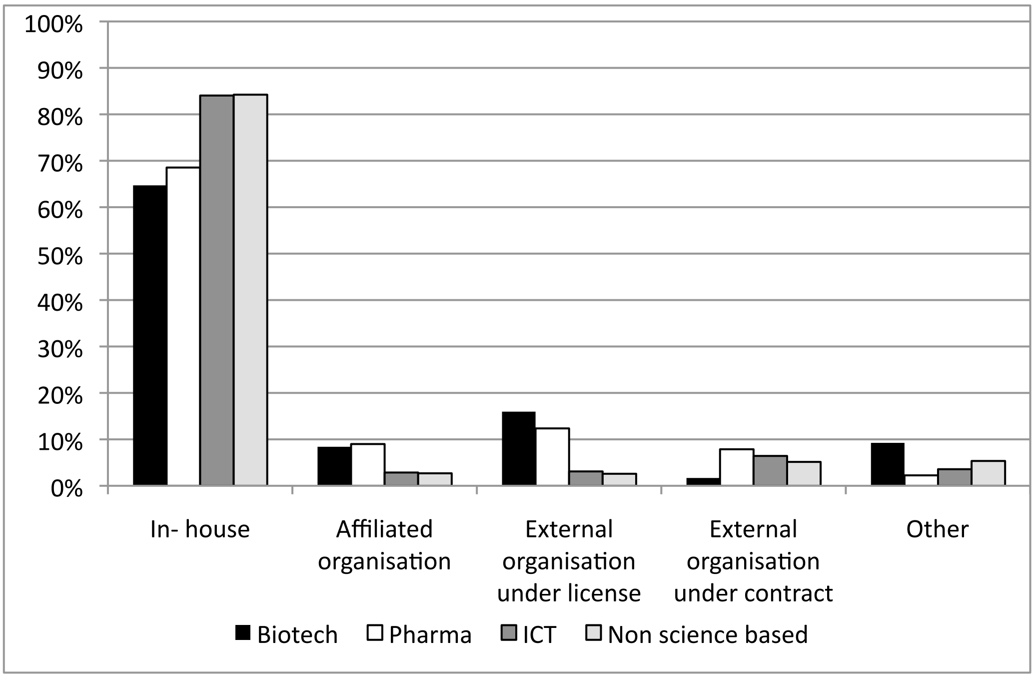
Figure 4. Percentage of developmental stages completed across OECD patent classification groups.



Note. Respondents could select more than one response. Percentages represent the proportion of respondents within each group selecting each option.

The results in Figure 4 suggest that some product development was attempted for most inventions, with the number of responses to 'None' and 'Unsure' being under 10% for all groups. A series of binomial logistic regressions (using biotech as the reference category) comparing the proportion of responses selected to not selected across groups suggests that biotech inventors were significantly less likely to have attempted proof of concept than pharma (B = .69, S.E. = .29, Wald = 5.88, p<.05, Odds ratio = 2.00), but were not significantly different from ICT or non-science-based inventions. The odds ratio suggests that biotech inventors were 100% less likely to attempt proof of concept (than not) compared to pharma inventors. Biotech inventors were also significantly less likely to attempt a prototype than ICT (B = 1.96, S.E. = .23, Wald = 72.03, p<.001, Odds ratio = 7.07) and non-science-based inventors (B = 2.004, S.E. = .21, Wald = 90.80, p<.001, Odds ratio = 7.42). ICT and non-science-based inventors were both approximately 6 times more likely than biotech (and pharma who were not significantly different to biotech) to develop a prototype. Biotech were also less likely to participate in another stage of development than ICT (B = 1.14, S.E. = .44, Wald = 6.74, p<.01, Odds ratio = 2.27) and non-science-based inventors (B = .86, S.E. = .42, Wald = 4.11, p<.05, Odds ratio = 2.35), but were statistically similar to pharma in their tendency to select the 'other' category. There were no significant differences between biotech and the other groups across the responses 'none', 'testing and validation', and 'unsure'.

Figure 5. Percentage of responses relating to where the invention was developed across OECD patent classification groups.

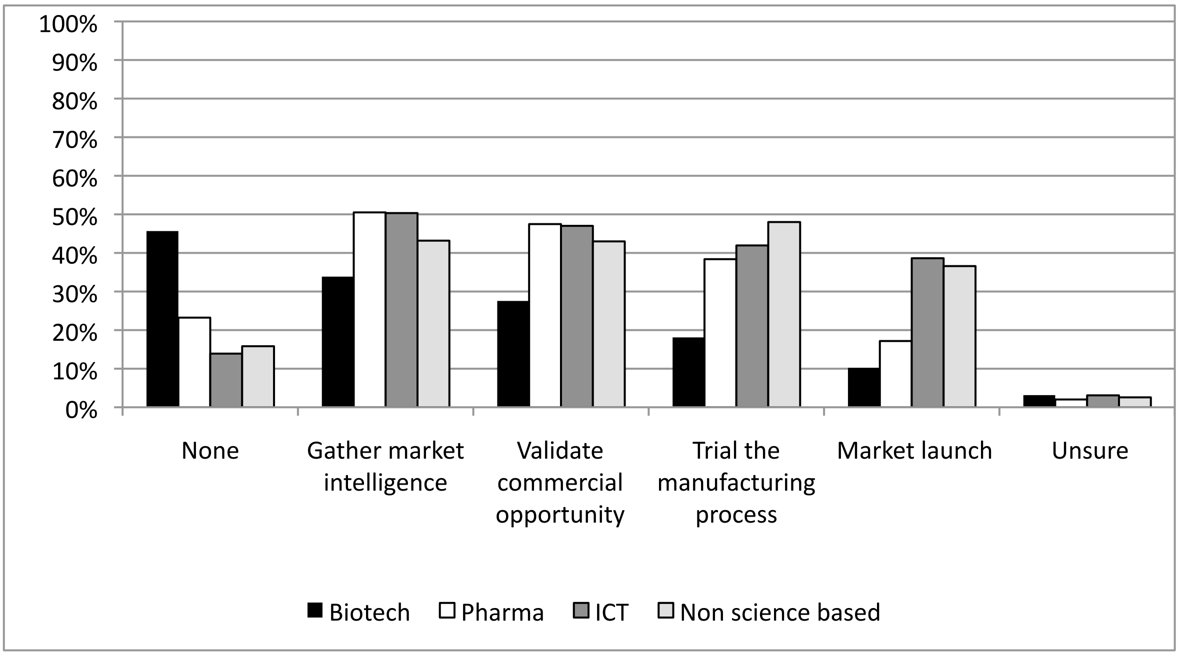


Note. Biotech n = 119, Pharma n = 89, ICT n = 420, Non-science-based n = 2936.

Figure 5 shows that most inventions were developed in-house for all four groups, though biotech and pharma inventions appear to be less likely to be developed in-house than ICT and non-science-based inventions. A multinomial logistic regression (using biotech and in-house as the reference categories), revealed that biotech inventions were significantly less likely to be developed in-house than in an affiliated organisation compared with ICT (B = -1.34, S.E. = .45, Wald = 9.02, p<.005, Odds ratio = .26) and non-science-based inventors (B = -1.40, S.E. = .36, Wald = 15.61, p<.001, Odds ratio = .25), but not pharma. Biotech were again less likely to develop inventions in-house than in an external organisation under licence compared with ICT (B = -1.90, S.E. = .38, Wald = 24.89, p<.001, Odds ratio = .15) and non-science-based inventors (B = -2.08, S.E. = .28, Wald = 54.80, p<.001, Odds ratio = .13), but not pharma. Biotech inventors were also more likely to indicate that another source was involved in developing their invention than in-house development, compared with ICT (B = -1.21, S.E. = .42, Wald = 8.45, p<.005, Odds ratio = .30) and non-science-based inventors (B = -.81, S.E. = .33, Wald = 5.94, p<.05, Odds ratio = .44), but again they were similar to pharma. Finally there were no significant differences between biotech and the other groups in terms of the tendency to have their invention developed by an external organisation under contract.

Analyses were also undertaken of responses to two further questions from the Australian Inventor Survey to assess relative levels of involvement in manufacture and mass production. The first asked, 'Which of the following manufacture stages were attempted?' Relative percentages of responses are shown in Figure 6. The second question asked, 'Were attempts made to mass produce the invention?' Relative percentages of responses are shown in Figure 7.

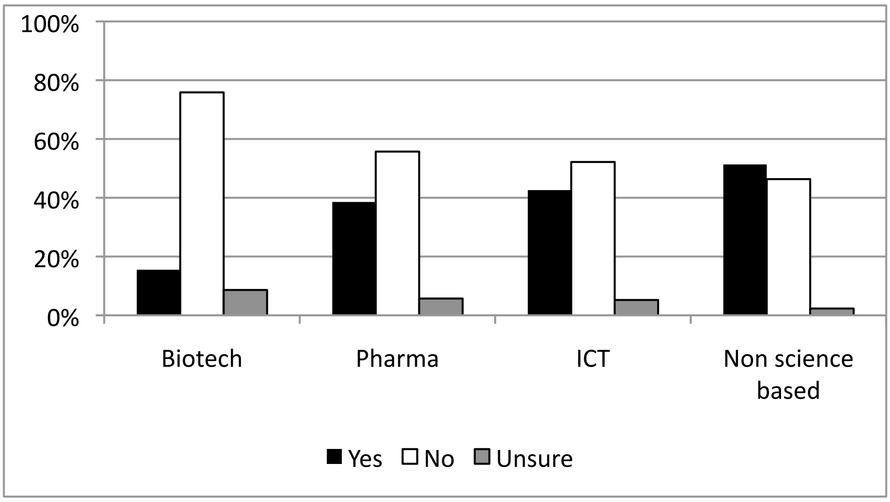
Figure 6. Percentage of manufacturing stages attempted across OECD patent classification groups.



Note. More than one response could be selected. Percentages represent the proportion of respondents in each group selecting each option. There were no missing responses.

Figure 6 suggests that overall around half of the respondents across all groups had attempted at least one manufacturing stage. Biotech inventors, however, appear to have attempted less than the other groups, with a higher percentage indicating that no manufacturing stages had been attempted and a lower proportion selecting all four stages. To test this pattern statistically, a series of binomial logistic regressions (using biotech as the reference category) comparing the proportion of selected responses to not selected across groups were computed. They suggest that biotech inventions were significantly more likely to select no manufacturing stages attempted than pharma (B = -1.02, S.E. = .30, Wald = 11.81, $p<.01$, Odds ratio = .36), and especially compared with ICT (B = -1.65, S.E. = .22, Wald = 54.22, $p<.001$, Odds ratio = .19) and non-science-based inventors (B = -1.65, S.E. = .22, Wald = 54.22, $p<.001$, Odds ratio = .19). They were also slightly less likely than pharma (B = .69, S.E. = .28, Wald = 6.30, $p<.05$, Odds ratio = 1.99), ICT (B = .68, S.E. = .21, Wald = 10.60, $p<.01$, Odds ratio = 1.98) and non-science-based inventors (B = .40, S.E. = .19, Wald = 4.28, $p<.05$, Odds ratio = 1.49) to have gathered market intelligence. Biotech were also significantly less likely than all other groups to validate the commercial opportunity of their inventions (all comparisons were significant at $p<.01$) and trial the manufacturing process (all comparisons were significant at $p<.001$). Biotech inventors were also significantly less likely than ICT and non-science-based inventors (but not pharma) to attempt a market launch of their invention (all comparisons were significant at $p<.001$). There were no significant differences across the groups in terms of their tendency to select unsure.

Figure 7. Percentage of responses relating to attempts to mass produce across OECD patent classification groups.

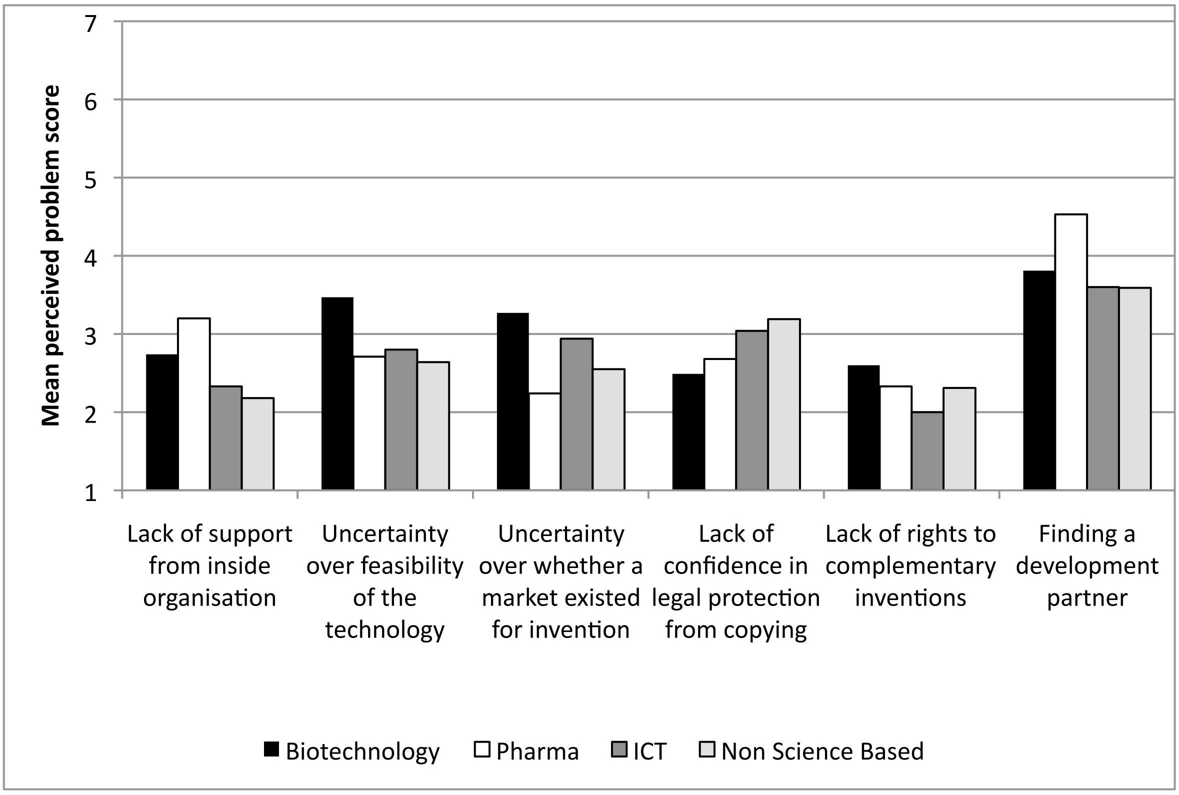


Note. Biotech n = 58, Pharma n = 70, ICT n = 345, Non-science-based n = 2380 (i.e., there were many missing responses on this variable for all categories).

Figure 7 shows that biotech inventors were much less likely to attempt mass production than all other groups. This was confirmed by a binomial logistic regression (using biotech as the reference category), which compared the OECD groups across the yes and no responses (omitting unsure responses). Biotech were 70% less likely to attempt to mass produce than pharma, 75% less likely than ICT, and 81% less likely than non-science-based inventors.

A series of questions from the Australian Inventor Survey were used to assess the types of problems encountered in the development, manufacturing and mass market phases. Respondents were asked to rate, 'How severe were the following problems in this development phase?' (see Figure 7 for the six problems), 'How severe were the following problems at the 'make and sell' phase? (see Figure 8), and 'How severe were the following problems at the mass market phase?' (see Figure 9). All problems were rated on a 7-point scale where 1 corresponds to not a problem and 7 to a severe problem (8 = not applicable). The means (omitting 'not applicable' responses) for each problem at each phase are shown in Figures 8 to 10.

Figure 8. Mean perceived problems in the development phase across OECD patent classification groups.



To statistically compare the groups, each mean perceived problem score was compared across OECD groups via six one-way ANOVAs using Student-Newman-Keuls post hoc comparisons. The results show that the level of perceived problems differed significantly across the groups for all six areas (i.e., all F statistics were significant at $p<.01$). Post hoc contrasts reveal that pharma inventors perceived lack of support from inside the organisation as being more of a problem than all other categories, and biotech inventors perceived this as more of a problem than non-science-based and ICT inventors (who did not differ significantly from each other). The results for uncertainty over feasibility suggest that biotech inventors perceived this as being more of a problem than all other groups (which were all not significantly different from each other). Biotech inventors also viewed uncertainty over whether a market existed as significantly more of a problem than non-science-based and pharma inventors, but were statistically similar to ICT inventors. Lack of confidence in legal protection was perceived to be less of a problem for biotech than ICT and non-science-based inventors (which were similar to each other). Biotech inventors were not significantly different from pharma in their perception of problems relating to confidence in legal protection. Lack of rights to complimentary inventions was perceived to be a significantly greater problem for biotech inventors than ICT, but pharma and non-science-based inventors viewed this a similar level of problem as biotech. Finally, finding a development partner was perceived to be more of a problem for pharma inventors compared to all other categories (which were all statistically similar).

Figure 9. Mean perceived problems in the make and sell phase across OECD patent classification groups.

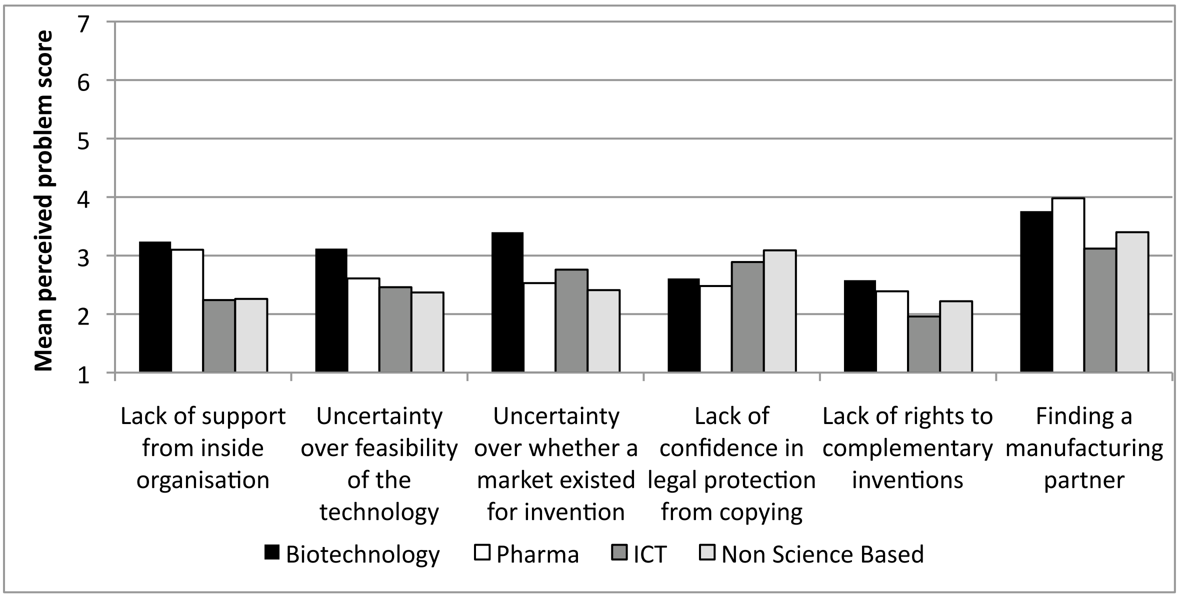


Figure 9 suggests that biotech inventors, and in some instances pharma, perceived all problems (with the exception of lack of confidence in legal protection) to be more severe than ICT and the non-science-based inventors. A series of ANOVAs reveals, however, that there were no significant differences across the groups for lack of rights to complimentary inventions and finding a manufacturing partner. Biotech and pharma (who did not differ from each other) viewed lack of support from inside the organisation as significantly more of a problem than ICT and non-science-based inventors (who were statistically similar). Biotech also viewed uncertainty of the technology and whether a market existed as significantly greater problems than all other groups (who were statistically similar to each other on both of these variables).

Figure 10. Mean perceived problems in the mass market phase across OECD patent classification groups.

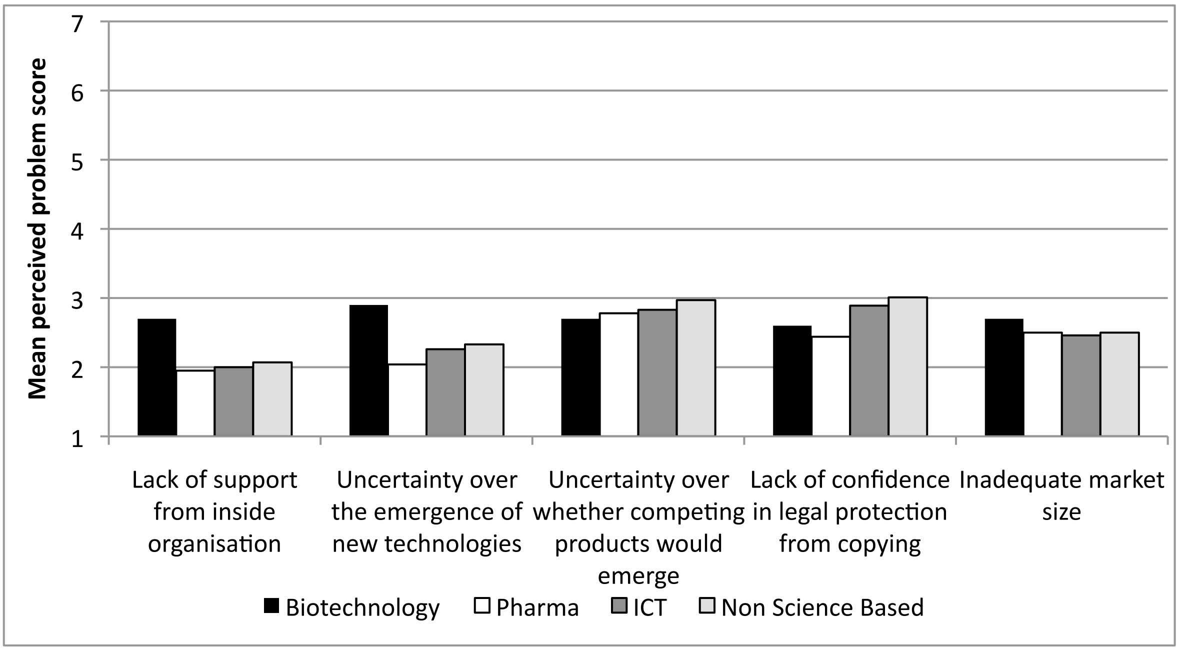
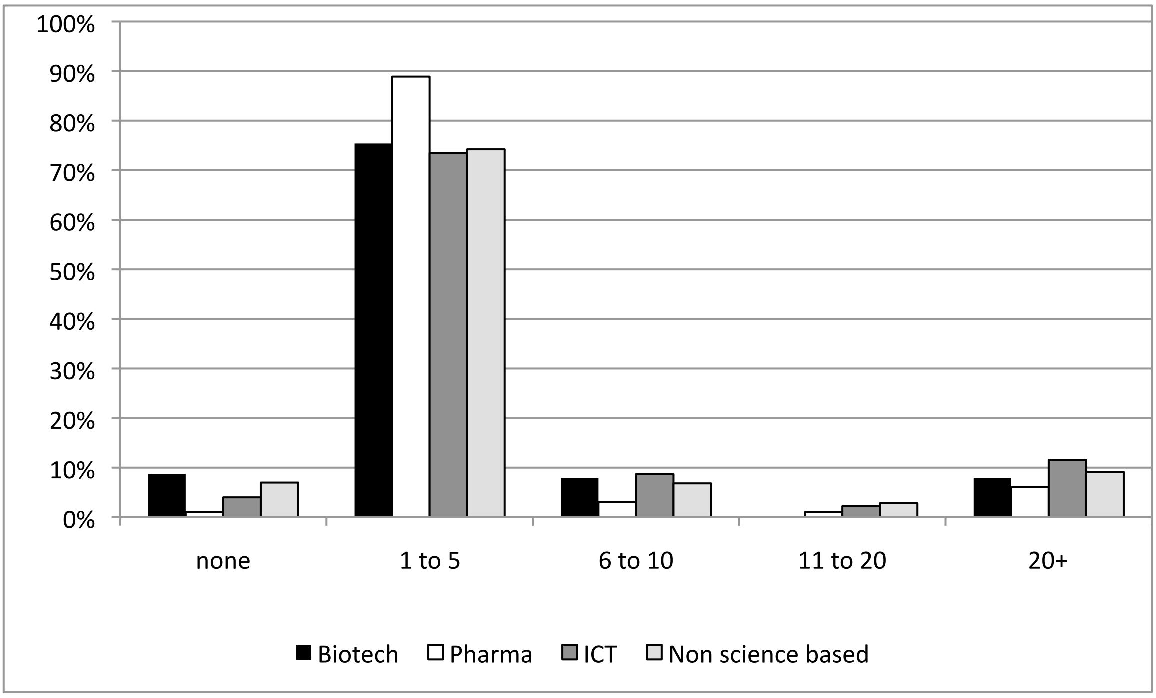


Figure 10 suggests that problems in the mass market phase were relatively minor for all groups. Biotech appeared to rate lack of support from inside the organisation and uncertainty over the emergence of new technologies as more of a problem than the other groups. However a series of ANOVAs comparing mean scores across groups did not find any significance differences between any of the OECD groups for all variables.

4. The patent and product development landscape and viability of the biotech business model

The expectation that biotechnology inventors tend use their inventions in the development of more products and processes and use more patents in the development of their inventions than other fields was tested using two questions from the Australian Inventor Survey. The first asked respondents, 'In how many different products or processes was this patent to be used' and 'How many other patents were also used, or intended to be used, to develop this (these) product(s) or process(es)?' The response options for both these questions, along with the percentage of respondents selecting each category are shown in Figure 11 and Figure 12.

Figure 11. Percentage of how many different products/processes the invention was to be used in across OECD patent classification groups.

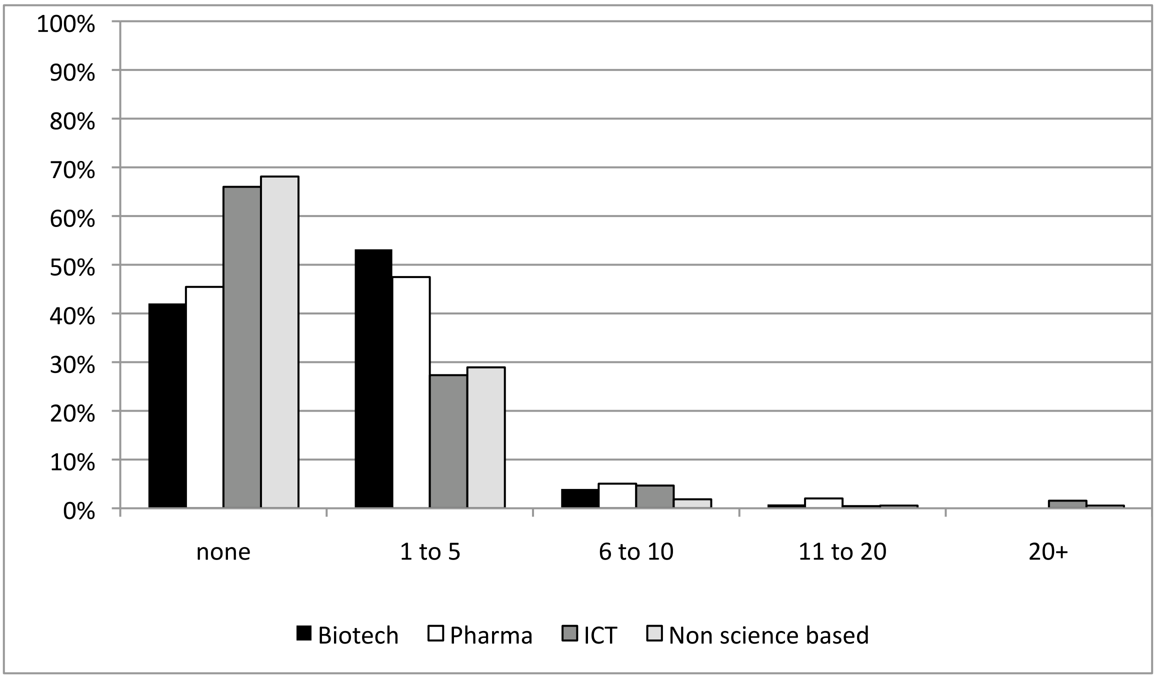


Note. Biotech n = 126, Pharma n = 99, ICT n = 449, Non-science-based n = 3076.

Figure 11 shows that the most common number of products or processes that would use the invention once developed was between 1 to 5, and this pattern was relatively consistent across all groups. An ANOVA[5] comparing the mean number of products or processes groups across groups was not significant, suggesting that biotech and science-based inventions were not more likely than non-science-based areas to be used in more product and processes once developed.

[5] The cell sizes were too small to compute an ordinal comparison of categories across OECD groups.

Figure 12. Percentage of how many different patents the invention used in its development across OECD patent classification groups.



Note. Biotech n = 126, Pharma n = 99, ICT n = 450, Non-science-based n = 3086.

Figure 12 shows that biotech and pharma inventors were more likely to use between 1 to 5 patents, and less likely to use none than ICT and non-science-based inventors. The results of an ANOVA across the four groups confirm this suggesting that the number of other patents used was significantly different across the four groups ($F = 14.22$, $p<.001$). The post hoc comparisons reveal that the mean number used was significantly higher for biotech and pharma (which do not differ from each other significantly) than for ICT and non-science-based inventions (which do not differ from each other). Thus, although there were no significant differences between categories in respect of the number of products and processes that a particular invention feeds into, there was some support for the notion that biotech inventions require more other patents for product development than other categories, aside from pharma.

To examine success of the licensing/spin off model that seems to be particularly prevalent in biotech (see Tables 5 and 6), two logistic regressions were computed. The aim was to test extent to which numbers of products and processes per invention, numbers of patents required for the development of each invention, radicalness of the invention and invention value are associated with licensing and transfer to a spin-off.

The dependent variable for the first analysis consisted of the attempt to license variable, and the second consisted of the attempt to transfer to a spin-off company, both of which are described above. Since attempt to license or transfer to a spin-off compared to no attempt was of interest, all yes responses (see Tables 5 and 6) for both variables were collapsed into one overall 'attempt to license' and 'attempt to transfer to a spin-off'. These categories were then compared to 'no attempt' (unsure responses were omitted from both analyses). The independent variables were identical across both analyses. They were: nature of the invention (Table 3), invention value (Figure 3), number of patents (Figure 11) and number of products and processes (Figure 12). Given restrictions with small cell sizes, the number and value variables were treated as continuous rather than ordinal variables and the analyses were computed for the total sample rather than across OECD groups. Descriptive information for all variables in the analyses are shown below in Table 8, and the parameter estimated for the logistic regressions are shown in Table 9.

Table 8. Descriptive statistics for all variables in the predicting licensing and spin-off analyses.

	Mean	SD	n
Number			
How many different products/processes was invention to be used in	2.34	.99	3823
How many other patents were also used to develop product	1.39	.63	3833
Value			
Estimated sales revenue to date from product/processes using invention?	2.41	1.86	3196
If you were selling patent/invention, what price would you accept?	2.91	1.76	2780
If patent licensed, what is best estimate of the licensing revenues to date?	2.08	1.60	1544
		%	n
License/Spin-off			
Attempt to license		43.6	1577
No attempt to license		56.4	2040
Attempt to spin-off		15.6	562
No attempt to spin-off		84.4	3039
Nature of invention			
Incremental		34.3	1205
Radical		65.7	2313

Table 9. Parameter estimates for the logistic regression models predicting attempts to license and transfer to a spin-off.

	B		S.E.		Wald		Odds ratio	
	License	Spin-off	License	Spin-off	License	Spin-off	License	Spin-off
Radical	.09	.06	.11	.10	.77	.34	1.10	1.06
No. products/ processes used in	.14	.13	.06	.06	4.96*	4.79*	1.15	1.14
No. patents used to develop	.36	.40	.10	.10	12.36***	17.10***	1.43	1.49
Estimated sales revenue	.03	.01	.04	.04	.49	.07	1.03	1.01
Price willing to accept	.20	.20	.04	.04	24.15***	25.85***	1.23	1.22
Estimate of license revenue	-.13	-.15	.05	.05	7.09**	10.45**	.88	.87
Constant	-1.14	-.99	.27	.25	17.92***	15.04***	.32	.37

Note. * = p<.05, ** = p<.01, *** = p<.001. n for the license analyses = 1199, n for the spin-off analysis = 1190. Attempt to license and Attempt to transfer to a spin-off were both coded as 1 and no attempt was coded as 0. Radical was coded as 1 and incremental invention was coded as 0.

The results in Table 9 show that all variables, except for nature of the invention and estimated of sales revenue, were significantly associated with attempts to license and to transfer to a spin-off company. In relation to licensing, if an invention was to be involved in more products or processes, the chance of licensing the patent increased by 15% for every one unit increase in the number category (i.e. from none to 1 to 5, or from 1 to 5 to 6 to 10 and so on). If the invention used more patents in its development, there was also a greater tendency to license. According to the odds ratio, the tendency to license increased by 43% for every one unit increase in the number of patents used. The perceived value of the invention was also significantly associated with attempts to license. As the price the inventor was willing to accept rose, so did the chance of an attempt to license (by 23% for every one unit increase in price). Interestingly, as estimated sales of the patent had been licensed rose by one unit, the odds of attempting to license decreased by 12%.

In relation to attempt to transfer to a spin-off company, if an invention was to be involved in more products or processes the chance of transferring to a spin-off company increased by 14% for every one unit increase in the number of products and processes. If the invention used more patents in its development, there was also a greater tendency to license. According to the odds ratio, the tendency to license increased by 49% for every one unit increase in the number of patents used. The perceived value of the invention was also significantly associated with attempts to license. As the price the inventor was willing to accept rose, so did the chance of an attempt to spin off (by 22% for every one unit increase in price). Interestingly and similarly to the attempt to license analysis, as estimated sales of the patent rose by one unit, the odds of attempting to license decreased by 13%.

Discussion

The analysis presented in this paper provides strong support for the assumption that biotech, pharma and ICT inventions are more strongly linked to basic scientific research than other types of inventions. Hence, it seems justifiable to refer to these inventions as science-based, in accordance with the Pavitt taxonomy. The results also show that biotech inventions (and, to a lesser extent, the other science-based inventions) are firmly grounded in government-supported research or research supported from other non-financial sources, for example industry partners. While it would be expected that the development of science-based inventions would ultimately require funding from other sources, particularly financial intermediaries like venture capitalists, these results suggest that such funding is ex-post rather than ex-ante the early invention process.

Perhaps the finding that biotech inventions are slightly less likely than the other groups to result in more radical compared to incremental inventions emphasises the fact that biotech is substantially built on academic literature, with sweeping advancements being fewer than for other industries because of the 'standing on the shoulders of giants' philosophy. Overall, though, there seems to be a consistent tendency for all groups to view their inventions as being more radical than incremental. This may reflect an overly positive view from inventors of the contribution made to the field by their inventions, or it may illustrate the ambiguous nature of what it means to be incremental or radical. Given the lack of clear relationship between the nature of the invention and the OECD patent classification group within which the invention is located, together with the high percentage of inventions that are identified as being radical in nature, little can be made of these results.

This analysis also provides strong support for the assumption that biotech inventors are more likely to attempt to license and to transfer to spin-offs than non-biotech inventors (apart from pharma), and that these attempts are much more successful than for non-biotech sectors (again, aside from pharma). The results also clearly demonstrate that there are significant similarities in the business models of biotech and pharma inventors, particularly that both are highly reliant on licensing out their inventions. There do not seem to be sufficient differences between the biotech and pharma models to place them in separate categories in the Pavitt taxonomy. Rather, there appears to be a more clear distinction between biotech and pharma inventions on the one hand and ICT on the other. The analysis reported here suggests that this open innovation-type licensing strategy appears to be utilized with a reasonable level of success by both sectors. This result is not unexpected in the new pharma business model, where drug discovery is externalised (Pisano, 2006).

This analysis also shows that, as expected, measures of invention value do not vary greatly between OECD groups. Licensing revenue is slightly lower for biotech than the other sectors, but the most compelling difference between the categories is with regard to sales revenue to date, which is lower for biotech and pharma than ICT and non-science-based inventions. This may be reflective of the long time interval for downstream developers between in-licensing and product launch in industries like biotech and pharma due to the requirement to undertake more testing and validation than other sectors to satisfy stringent regulatory requirements. This suggestion is supported by the finding that there is somewhat less product development, manufacture and mass production for biotech and pharma than for the other categories. In addition to regulatory hurdles, in part this may also be more due to the nature of the product than impediments to development. Prototypes will not always be a recognised step in development of biotech and pharma products. Rather than a distinct prototype phase, product development in these fields is more likely to involve extended clinical trials and other testing and validation prior to entry onto the market. Despite this, the percentage of biotech inventions progressing to testing and validation was somewhat lower than for other inventions. While may be reflective of greater impediments to product development in biotech than in other industries, in the alternative it may simply indicate that the biotech cohort of inventions is younger because of the emerging nature of the technology, and hence that proportionally fewer have been in product development long enough to be at the testing and validation phase.

Interestingly, these analyses show that a considerable portion of product development is undertaken in house across all categories, albeit slightly lower for biotech and pharma. Given the high levels of licensing of biotech and pharma inventions, it might have been expected that there would be much less in house development in these industries. But probably what it does reflect is the well-recognised need in both industries for inventors to undertake some in-house product development prior to engaging with licensing partners. In previous interviews involving Australian medical biotech industry participants it was consistently reported that it was necessary to undertake proof of concept and preliminary testing and validation before being able to attract downstream partners (Nicol and Nielsen, 2003). The fact that development by external organisations under licence is higher for biotech and pharma than other categories affirms that product development and licensing are intimately connected.

Problems in product development, manufacture and mass production appear to be uniformly perceived as being relatively minor. Uncertainty over feasibility and market and finding development partners are the biggest problem areas for biotech inventors, and finding development partners is the most severe problem for pharma. Again, there is nothing particularly new about these results. Previous studies have shown that the road to product development in biotech is long and tortuous and products fail for a whole range of reasons, but finding partners and technological impediments are routinely identified as being particularly problematic (Nicol and Nielsen, 2003).

One of our aims in the analysis reported in this paper was to provide quantitative data that might assist in determining the relationship between patenting and innovation in Australian biotech. While the size of the dataset did not allow an analysis within each OECD patent classification group, an increased tendency to attempt to license was associated both with involvement of the invention in more products and processes and more patents being involved in the development of the invention. Attempts to license were also positively linked with estimates of current licensing revenue and invention value. These are precisely the relationships that would be expected in any well-functioning open innovation system. The fact that attempts to license were inversely related to product sales is perhaps more a function of the distance of such inventions to market rather than actual detrimental impact on sales as such. While the data on transfer to spin offs show strong associations between number of patents and transfer, as well as invention value and transfer, the numbers are too small to make firm conclusions.

In summary, this analysis suggests that biotech inventions have a greater tendency to be developed outside the inventor's organisation and seem to be more clearly distant from the market than inventions in other OECD patent classification groups, and biotech inventors perceive more problems on the road to market. There is much less difference between biotech and pharma than the other groups. These findings support many of the assumptions that biotech has been perceived to operate under and therefore validates much of the research in this sphere. This analysis needs to be contextualised against the backdrop of the complicated legal and economic issues surrounding management of intellectual property in the biotech industry. In their review of the recent literature on technology markets, Arora and Gambardella (2010) recognize that licensing plays a vital role for technology specialist firms with limited downstream capabilities, including biotech research and development specialists. They find that the level of available patent protection has a marked effect on the propensity to license for such firms, which lack complementarity between research and development and manufacturing. Firm size is also a relevant consideration, with licensing activity in small firms being more responsive to increase in patent effectiveness than for larger firms. Indeed, analysis of the PatVal-EU dataset by Gambardella et al (2007) indicates that firm size is the most important determinant of patent licensing (see also Gay and Dousset, 2005).

Like other commentators, Arora and Gambardella (2010) express some doubts about the longevity of technology specialist firms (including biotech), even those that have been successful in diffusing their technology downstream. Engaging in more extensive product development in house does not seem to be a viable option for biotech. Rather, empirical research suggests that in drug development, compounds taken through clinical trials by biotech companies are more likely to fail than compounds developed by large pharma companies (Guedj and Scharfstein, 2004; Arora et al, 2009). Thus, the ongoing survival of biotech companies that have successfully licensed-out their core technology depends on their ability to develop new ideas (where the chance of failure is high) or provide add-on services (which is not straight-forward either). It seems, then, that small, research-intensive biotech firms have a high likelihood of failure at some stage, whether before or after successful dissemination of their core technology.

Looking holistically at innovation in biotech, does it matter that individual firms are likely to fail, provided that the standard biotech business model of value-adding and on-licensing technology developed in the public sector is reasonably likely to succeed? As noted by Arora and Gambardella (2010 at 798):

> At the industry-level the licensing business model can be strong and active. While the individual technology suppliers may die after some time, new ones will enter. ... The continuous entry of new firms seeds a division of innovative labor, although individual licensors will likely have a short life-span. Put differently, a [market for technology] and the division of innovative labor can survive individual technology specialist firms.

Taking this holistic view, if biotech inventions do tend to be successfully licensed-out from small, science-based biotech firms to larger firms that are more product-development focused, we should not be too worried about high levels of attrition within the industry. Rather, government policy should be directed towards supporting early stage development and particularly the provision of an appropriate level of patent protection to facilitate effective transfer of technology, but not at the cost of creating unnecessary hold ups or fragmentation of rights. The patent policy conundrum in areas of cumulative innovation is thus: on the one hand, broad foundational patents are necessary to provide the incentive for early stage innovation and make licensing feasible and efficient, but on the other hand, onerous obligations on second stage innovators to in-license could disincentivise innovation at this level. The challenge is to find an appropriate balance.

This analysis suggests that that biotech does appear to be somewhat behind other sectors in terms of product development, manufacturing and mass marketing. Does this mean that there is something deeply wrong with biotech, that the biotech revolution is simply a myth, as posited by Hopkins et al (2007)? Or is it the case that product development in biotech (and pharma) just takes time? This analysis does not reveal huge difference in the pace of downstream product development between biotech and pharma, and it is probably no coincidence that both industries are exposed to significant regulatory hurdles before their products can reach the market. If it is desirable on the broader social and economic level for the biotech and pharma industries to succeed, perhaps we need to examine regulatory hurdles outside patent system, for example the clinical trials system. But this regulatory balance is also a difficult one – facilitating entry of products onto the market in a timely fashion, but not at the cost of decreasing protection for human health and welfare and the environment.

This study does not provide compelling evidence for a radical overhaul of the standards for granting patents. There also seems to be no compelling evidence for the creation of new regulatory requirements for patent licensing. Some protective measures do already exist to guard against overly aggressive or unfair licensing practices. These include: exemptions from infringement for experimental and regulatory purposes, licensing and government use without the authorisation of the patent holder, licensing guidelines for inventions developed from publicly funded research, and competition law guidelines (for a broad overview of the applicability of many of these protective measures in Australia see ALRC, 2004). Refinements are already being made to these protective measures to ensure that they meet contemporary needs. In Australia, for example, the Intellectual Property (Raising the Bar) Bill 2011, currently before Parliament, will introduce a statutory experimental use exemption and expand the existing regulatory approval exemption. The fact we are seeing a reasonable level of success in licensing in the biotech and pharma sectors further suggests that there is not yet a need to introduce more formalised structures like clearinghouses and patent pools currently being mooted as means for dealing with patent complexity in these fields (van Zimmeren et al, 2011). It is acknowledged, however, that it may be useful to explore these options for specific sub-sectors within biotech and pharma.

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References

ACIP. *Report on Review of Patentable Subject Matter.* Canberra: Advisory Council on Intellectual Property (2010). Available at: http://www.acip.gov.au/reviews_completed.html#psm

ACIP. *Consideration of Patents and Experimental Use.* Canberra: Advisory Council on Intellectual Property (2005). Available at: http://www.acip.gov.au/reviews_completed.html#peu

ALRC, *Genes and Ingenuity.* Sydney: Australian Law Reform Commission (2004)

A. Arora, M. Ceccagnoli and W.M. Cohen. R&D and the patent premium. *International Journal of Industrial Organization* 26: 1153-1179 (2008)

A. Arora and R.P. Merges. Specialized supply firms, property rights and firm boundaries. *Industrial and Corporate Change* 13: 451-475 (2004)

A. Arora and A. Gambardella. Ideas for rent: an overview of markets for technology. *Industrial and Corporate Change* 19: 775-803 (2010)

A. Arora, A. Gambardella, L. Magazzini and F. Pammolli. A breath of fresh air? Firm types, scale, scope and selection effects in drug development. *Management Science* 5510: 1638-1653 (2009)

Australian Senate Community Affairs Reference Committee. *Report on Gene Patents*. Canberra: Parliament of Australia (2010). Available at: http://www.aph.gov.au/senate/committee/clac_ctte/gene_patents_43/report/index.htm

Australian Senate Legal and Constitutional Affairs Committee. *Inquiry into the Patent Amendment (Human Genes and Biological Materials) Bill 2010* (2011). Available at: http://www.aph.gov.au/senate/committee/legcon_ctte/patent_amendment/index.htm

H.W. Chesbrough. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Cambridge, US: Harvard Business School Press (2003)

W.M. Cohen, R.R. Nelson and J.P. Walsh. Protecting their intellectual assets: appropriability conditions and why US manufacturing firms patent or not. *NBER Working Paper* 7552 (2000)

B. Coriat, F. Orsi and O. Weinstein. Does biotech reflect a new science-based innovation regime? *Industry & Innovation* 10: 231-253 (2003)

B. Ebersberger, S.J. Herstad, E. Iversen, O. Som and E. Kirner. *Open Innovation in Europe.* PRO INNO Europe: INNO-Grips II report, Brussels: European Commission, DG Enterprise and Industry (2011)

R.S. Eisenberg. Noncompliance, nonenforcement, nonproblem? Rethinking the anticommons in biomedical research. *Houston Law Review* 45: 1059-1099 (2008)

R.S. Eisenberg and R. Nelson. Public vs. proprietary science: a fruitful tension? *Academic Medicine 77*: 1392–1399 (2002)

A. Gambardella, P. Giuri and A. Luzzi. The market for patents in Europe. *Research Policy* 36: 1163-1183 (2007)

B. Gay and B. Dousett. Innovation and network structure dynamics: study of the alliance network of a major sector of the biotechnology industry. *Research Policy* 34: 1457-1475

I. Guedj and D. Scharfstein. Organizational scope and investment: evidence from the drug development strategies and performance of biopharmaceutical firms. *NBER Working Paper 10933* (2004)

J.L. Glick. Biotechnology business models work: Evidence from the pharmaceutical marketplace. Journal of Commercial Biotechnology 14: 106-117 (2008)

M.A. Heller and R.S. Eisenberg. Can patents deter innovation? The anticommons in biomedical research. *Science* 280:698-701 (1998)

M.M. Hopkins, P.A. Martin, P. Nightingale, A. Kraft and S. Mahdi. The myth of the biotechnology revolution: an assessment of technological, clinical and organisational change. *Research Policy* 36: 566-589 (2007)

P.H. Jensen, R. Thomson and J. Yong. Estimating the patent premium: evidence from the Australian Inventor Survey. *Strategic Management Journal* 32: 1128-1138 (2011)

B. Koo and B.D. Wright. Dynamic effects of patent policy on sequential innovation. Journal of Economics Management Strategy 19: 489-512 (2010)

R.C. Levin, A.K. Klevorick, R.R. Nelson and S.G. Winter. Appropriating the returns from industrial R&D. *Brookings Papers on Economic Activity* 783-820 (1987)

R.K. Merton. *On The Shoulders of Giants: A Shandean Postscript,* Free Press (1965)

F. Narin, K.S. Hamilton and D. Olivastro. The increasing linkage between US technology and public science. *Research Policy* 26: 317-330 (1997)

D Nicol, 'DNA Patenting: Can We Leave It To the Market?' unpublished manuscript on file with the author (2011)

D. Nicol and J. Nielsen. *Patents and Medical Biotechnology: An Empirical Analysis of Issues Facing the Australian Industry,* Hobart: Centre for Law and Genetics Occasional Paper No. 6 (2003). Available at: http://www.lawgenecentre.org/pub.php

OECD. *Patents and Innovation: Trends and Policy Challenges* (2004). Available at: www.oecd.org/dataoecd/48/12/24508541.pdf

OECD. *A Framework for Biotechnology Statistics* (2005). Available at: www.oecd.org/dataoecd/5/48/34935605.pdf

K. Pavitt. Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy* 13: 343-373 (1984)

G. Pisano. *Science Business: the Promise, the Reality and the Future of Biotech.* Cambridge, US: Harvard Business School Press (2006)

C. Shapiro. Navigating the patent thicket: cross licenses, patent pools and standard setting. In A. Jaffe, J. Lerner, and S. Stern (eds) *Innovation Policy and the Economy.* Vol 1. Cambridge, MA: MIT Press, 119-150 (2001)

N. Thumm. Strategic patenting in biotechnology. *Technology, Analysis & Strategic Management* 16: 529-538 (2004)

E. van Zimmeren, S. Vanneste, G. Matthijs, W. Vanhaverbeke, G. Van Overwalle. Patent pools and clearing houses in the life sciences. *Trends in Biotechnology,* in press (2011)

E. von Hippel. *Democratizing Innovation.* Cambridge, MA: MIT Press (2005).

J.P. Walsh, A. Arora and W.M. Cohen. Effects of research tool patents and licensing on biomedical innovation. In W. M. Cohen & S. A. Merrill (Eds.) *Patents in the Knowledge-based Economy.* Washington, DC: The National Academies Press, 285-340 (2001)

E. Webster and P.H. Jensen. Do patents matter for commercialization? *Journal of Law and Economics* in press

L.G. Zucker, M.R. Darby and M.B. Brewer. Intellectual human capital and the birth of US biotechnology enterprises. *American Economic Review* 88: 290-306 (1998)

L.G. Zucker, M.R. Darby and J.S. Armstrong. Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology. *NBER Working Paper Series* 8499 (2001)

Competition and growth: reinterpreting their relationship*

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Abstract

In this paper we modify a standard quality ladder model by assuming that R&D is driven by outsider firms and the winners of the race sell licenses over their patents, instead of entering directly the intermediate good sector. As a reward they get the aggregate profit of the industry. Moreover, in the intermediate good sector firms compete à la Cournot and it is assumed that there are spillovers represented by strategic complementarities on costs. We prove that there exists an interval of values of the spillover parameter such that the relationship between competition and growth is an inverted-U-shape.

Keywords: quality ladder; Cournot oligopoly; strategic complementarities; competition.

JEL Classification: L13, L16, O31, O52.

1 Introduction

Empirical analysis has recently provided evidence in favor of an inverted U-shaped relationship between competition and growth (see Aghion *et al.* 2005); nonetheless, only few theoretical models of growth and innovation are capable of explaining such empirical evidence. This paper proposes a novel rationale for the inverted U-shaped relationship, stemming from a modified quality ladder model in which we assume that firms compete à la Cournot in the intermediate good sector, where positive externalities or spillovers on costs are present. It is just the presence of a spillover effect which justifies the fact that a higher product market competition may enhance growth, because it can influence positively the profits that reward innovators.

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Standard Industrial Organization theory (Salop 1977, Dixit and Stiglitz 1977) and the first generation of Schumpeterian growth models (Grossman and Helpman 1991; Aghion and Howitt 1992; Barro and Sala-i-Martin 2004) predict that innovation and hence growth should decline with competition, because more competition reduces the rents that reward successful innovators. This discourages firms from investing in R&D, thus reducing the innovation rate and as a consequence the long run growth rate of the economy. However, the empirical literature, as Gerosky (1995), Nickell (1996) and Blundell *et al.* (1999), suggests a positive correlation between competition and growth. The theoretical literature tried to solve this dilemma by modifying radically the assumptions of the basic Neoschumpeterian model.

For example Aghion *et al.* (1999) introduce agency considerations in the decision-making problem of innovating firms. In particular they embed the agency model of Hart (1983) in an endogenous growth framework and show that competition has a positive effect on growth because, combined with the threat of bankruptcy, it can act as a discipline device, capable of fostering technology adoption and growth. However empirical evidence of these effects is mixed, as shown, for instance, by Grosfeld and Tressel (2001) and Nickell *et al.* (1997).

Another approach (see Aghion *et al.* 1997; Aghion *et al.* 2001) extends the basic Schumpeterian model by allowing incumbent firms to innovate. This is obtained by assuming a technological progress which is more "gradualist" ("step-by-step") than the standard models, where the leap-frogging of the previous incumbent is possible: innovation allows a firm to move one step ahead, with the lagging firm remaining active and eventually capable to catch up. In this models it is assumed that each intermediate good sector is characterized by a duopoly in which firms compete both in production and in R&D. Hence, since in this framework R&D is undertaken by the incumbents, the incentive to innovate depends not so much upon post-innovation rents per se, but more upon the difference between post-innovation and pre-innovation rents (the latter are equal to zero in the basic Schumpeterian model). In this case product market competition may act by reducing firms' pre-innovation rents more than it reduces their post-innovation rents. In other words, competition may increase the incremental profits from innovating and thereby encourage R&D investments aimed at escaping competition. This happens in those industries where both firms are technological par (leveled or neck-and-neck sectors), while in unleveled sectors the Schumpeterian effect of business stealing always prevails. The effect of an increase in product market competition on growth is ambiguous and depends on the size of innovation. If the latter is sufficiently large, the Shumpeterian effect always dominates; if it is sufficiently close to its lower bound , the escape competition effect prevails; finally for intermediate values the predicted relationship between competition and growth is an inverted-U-shape: the escape competition effect tends to dominate for low initial levels of competition, whereas the Schumpeterian effect tends to dominate at higher levels of competition. This prediction is in line with earlier findings of Scherer (1967), Levin *et al.* (1985) and others[1] and has also been tested by Aghion *et al.* (2005) using data from a panel of U. K. firms (the data run from 1973 to 1994). The same result is obtained by d'Aspremont *et al.* (2010) in a model in which there is the possibility of multiple winners[2]of the patent race, asymmetric firms in the product market and imperfect patent protection.

Another attempt to show the existence of a nonmonotonic relationship between competition and growth can be found in Denicolò and Zanchettin[3] (2004). They build a Neoschumpeterian model in which they allow for several firms to be simultaneously active in each industry (because the innovation is non drastic) and identify circumstances (a large size of innovation or a high intensity of competition, or both) in which the productive efficiency effect (the reduction of total industry costs due to the fact that low-cost firms have a large portion of the market) dominates the business stealing effect. This and the presence of a front loading effect (in more competitive markets, a larger fraction of innovation rents accrues in the early stages of the innovative firm's life cycle) imply that the equilibrium rate of growth tends to increase with the intensity of competition.

Recently also Acemoglu *et al.* (2010) provided a new explanation of the inverted-U shaped relationship between competition and growth based on the standardization process of the new technologies. Standardization is a costly process which is undertaken by newcomers: the lower is this cost, the higher is the intensity of competition. When standardization is very costly, growth is low because the new product does not enter the standardization process and so it is produced by employing skilled workers and this reduces the scale of production and the profitability. On the other hand, when standardization is cheap, the growth rate is still low because innovators enjoy ex post profits only for a short while.

In our paper we modify a standard quality ladder model and differently from Aghion *et al.* (2001) we assume that R&D is driven by outsider firms and the winners of the race sell licenses over their patents, instead of entering directly the intermediate good sector. As a reward they get the aggregate profit of the industry. Moreover, we depart from Aghion *et al.* (2001) models because, instead of assuming a duopoly in which firms compete à la Bertrand, we suppose that in the intermediate good sector an unspecified number of firms compete à la Cournot and we assume that there are spillovers on costs in the form of strategic complementarities. The latter constitutes our key assumption. In fact our goal is to prove that there exists an interval of values of the spillover parameter such that

[1] See Cohen and Levin (1989) for a brief survey of the empirical literature.

[2] The number of firms is endogenously determined and the set of successful ones is drawn by a Bernoullian random process.

[3] They measure competition as a switch from Cournot to Bertrand competition, so as a switch of the equilibrium price under the different regimes of competition.

the relationship between competition and growth is an inverted-U-shape, giving thus another theoretical foundation to the empirical evidence. In such case, when competition is low the spillover effect dominates the Schumpeterian business stealing effect and an increase in product market competition fosters growth. This is justified by the fact that incumbents firms may benefit from more competition as it increases the positive externality by a reduction of costs. When, instead, competition is high, the business stealing effect prevails over the spillover effect. We use the number of firms in each sector as a measure of competition, thus an increase in competition is expressed by an increase in the number of competitors. We think that this is the most natural measure of competition in a Cournotian framework[4]. It is customary in macroeconomic literature to study the effect of competition by comparing economies with the same market structure, but different degrees of substitutability between differentiated goods (see Grossman and Helpman 1991; Aghion and Howitt 1992; Aghion *et al.* 2001; Barro and Sala-i-Martin 2004). In these types of models the inverse of the degree of substitutability coincides with the mark up. In our setup the mark up depends on both the degree of substitutability and the number of firms in each industry. Hence if the number of competitors increases then the mark up decreases, so that firms' market power reduces[5]. However we show in section 5 that our result is robust if we use the degree of substitutability as measure of competition. Moreover, the same applies when we endogenize the number of firms in the intermediate sector.

We think that this novel theoretical mechanism can actually provide an alternative, innovative and realistic explanation of the inverted-U-shaped relationship between competition and growth[6]. Furthermore, we show that there exists a maximum number of firms that can survive in the market: this can be done by imposing a long run restriction on the positivity of the balanced growth rate.

Our explanation hinges upon the presence of spillover effects in the intermediate sector, and there is a wide empirical literature which offers a substantial support to the idea that economies of scale are an important phenomenon both at aggregate and at sectorial level. For example, Basu and Fernald (1997), Sbordone (1997), Jimenez and

[4] See for example Motta (2004).

[5] The use of the degree of substitutability may also have undesirable effect: as stressed by Koeniger and Licandro (2006), a change in the elasticity of substitution modifies a fundamental parameter, which in turn may lead to different equilibrium allocations that cannot be straightforwardly compared across economies. In particular an increase in the degree of substitutability has only a reallocation effect which moves resources to the most efficient sector, without modifying relative prices. Hence this may lead to an overestimation of the impact of competition on the economy's growth rate.

[6] The presence of spillovers in manufacturing industries is well known and it is also proved empirically (see, e.g., the literature we report below).

Marchetti (2002) show that, for the U. S. economy, the overall level of returns to scale (in a Cobb- Douglas production function) should be placed in the interval $[1; 1.2]$, so that external increasing returns to scale should affect the economy's dynamics in the long run as well as in the short run. Increasing returns and economies of scale can give rise to (favorable) spillover effects in the firms cost functions. Moreover also the literature on knowledge spillover is abundant. For example there are many works about knowledge spillovers both at regional and international level[7]. Keller (2002) analyzes whether the scope of technological knowledge spillovers is global or local (the dataset encompasses the world's innovative activity between 1970 and 1995). He finds that the diffusion of technology is geographically localized, in accordance with the conclusions of Adams *et al.* (1993), Jaffe and Trajtenberg (1999) and Eaton and Kortum (1996; 1999). However this literature does not distinguish between inter and intra-sectoral spillovers. Our model supposes the existence of intra-sectoral spillovers and this assumption is also supported by empirical findings offered by the literature. Rouvinen (2002) analyzes Finland manufacturing firms over the period 1985-1997 and finds evidence about the existence of intra and inter-sectoral spillovers by estimating the variable cost function. On the other hand, Malerba *et al.* (2004), by means of a panel data analysis of six OECD countries in the 1981-1995 time interval, show that the effect of intra-sectoral knowledge spillovers is 70% higher than the effect of national inter-sectoral spillovers. Brandt (2007) estimates the cost function using data on manufacturing industries of six OECD countries over the period 1980-1998. His main findings are that knowledge spillovers explain some of the productivity growth observed and are identified as an external source of economies of scale. Moreover, international intra-industry spillovers are the most important source of externalities in the investigated industries: they turn out to be more significant than R&D spillovers. Finally, Badinger and Egger (2008), by considering 13 OECD countries and 15 manufacturing industries in the year 1995, find that knowledge spillovers occur both horizontally and vertically, whereas other types of productivity spillovers are primarily of the intra-industry type.

Also the empirical urban economic literature supports the presence of spillovers: it shows the importance for productivity and growth of localization economies[8] (economies of scale arising from spatial concentration economies) and urbanization economies[9] (economies of scale arising from city size itself). Rosenthal and Strange (2001), for example, test the microfoundation of agglomerations economies for U.S. four-digit SIC codes manufacturing industries in the fourth quarter of 2000 at different levels of geographic aggregation and find that there is evidence

[7] See, among the others, Coe and Helpman (1995), Van Stel and Nieuwenhuijsen (2004).

[8] See, e.g., Moomaw (1981), Sveikauskas (1975), Nakamura (1985), Henderson (1986) and Ciccone and Hall (1996).

[9] See, e.g., Glaeser *et al.* (1992) and Henderson *et al.* (1995).

of the importance of all sources of localization economies (the Marshall's three theories of industry agglomeration); in particular knowledge spillovers are relevant at the zipcode level, input sharing at state level and labor market pooling is important at all levels[10].

The paper is structured as follows. Section 2 describes the overall framework of the model and contains an interpretation of the consequences of the introduction of Cournot oligopoly (with spillover effects) in the intermediate sector. In Section 3 the steady-state expressions for the growth rate, the interest rate and the probability of innovation are derived. Section 4 discusses our main result: there exists an interval of values of the spillover parameter such that the relationship between competition and growth is an inverted-U-shape. Section 5 presents a numerical analysis for the UK economy, which is based on the calibration of the degree of substitutability between intermediate goods, the spillover intensity and the size of the leading-edge innovation. Moreover we show that the relationship between competition and growth is bell-shaped both if we consider the degree of substitutability between intermediates as a measure of competition and if we endogenize the number of firms. Finally, Section 6 concludes.

2 The model

2.1 The agents

Our starting point is the standard version of the Schumpeterian growth scheme as exposed in Barro, Sala-i-Martin (2004), Ch. 7 (a quality ladder model). In this scheme there are four types of agents in the economy. Producers of final good that use labor and intermediate goods input to produce output which is sold at a unit price and it is used for consumption, for the production of the intermediate goods and, finally, it is invested in R&D. The final good sector is perfectly competitive. R&D firms devote resources to discover a new quality of the existing intermediate good: once this one has been invented, the winner of the race obtains a perpetual patent. We modify this framework by considering the case in which R&D is undertaken by outsider firms. Moreover, the winning one can sell a given number of licenses for each sector to allow other firms to produce the quality-improved good. Thus the last one is an oligopolistic market and we assume that firms compete in quantity (Cournot competition). In particular we suppose that there exist m intermediate sectors (with m large) and in each sector there are n firms producing the same good; finally there are households who consume the final good and their saving finances R&D.

[10] Also Ellison *et al.* (2010) assess the importance of all the Marshallian theories of industry agglomeration in U.S. three-digit SIC codes manufacturing industries from 1972 to 1997.

The behavior of these agents will be detailed in the following sections.

2.2 Final good sector

The production function of the representative final good firm i is given by

$$Y_i = L_i^{1-\alpha} \sum_{h=1}^{m} \tilde{x}_{ih}^{\alpha}$$

where $0 < \alpha < 1$, Y_i is output, L_i is labor input, $\tilde{x}_{ih} = \sum_{j=1}^{n} \tilde{x}_{ihj} = \sum_{k=0}^{k_h} q^k x_{ihk}, q > 1$ represents the quality-adjusted amount employed of the hth type of intermediate good, h refers to the generic intermediate sector $h = 1, .., m$. The potential grades of each intermediate good are arrayed along a quality ladder with rungs spaced proportionately at interval $q > 1$. Fixing at 1 the beginning quality, the subsequent rungs are at the levels q, q^2 and so on. Thus, if k_h improvements in quality have occurred in sector h, the available grades in the sector are $1, q, q^2, ..., q^{k_h}$. Increases in k_h are possible thanks to the successful application of the research effort.

Hence the production function becomes:

$$Y_i = L_i^{1-\alpha} \sum_{h=1}^{m} \left(\sum_{k=0}^{k_h} q^k x_{ihk} \right)^{\alpha}$$

Assuming that $\forall h$ only the best quality is produced[11], the production function becomes:

$$Y_i = L_i^{1-\alpha} \sum_{h=1}^{m} q^{\alpha k_h} x_{ihk_h}^{\alpha}$$

Each firm seeks to maximize profit[12]:

$$\underset{\{L_i, x_{ihk_h}\}}{Max} \pi_i = Y_i - wL_i - \sum_{h=1}^{m} p_{hk_h} x_{ihk_h} = L_i^{1-\alpha} \sum_{h=1}^{m} q^{\alpha k_h} x_{ihk_h}^{\alpha} - wL_i - \sum_{h=1}^{m} p_{hk_h} x_{ihk_h}$$

The first order conditions are:

$$L_i = \left(\frac{1-\alpha}{w} \right)^{\frac{1}{\alpha}} \left(\sum_{h=1}^{m} q^{\alpha k_h} x_{ihk_h}^{\alpha} \right)^{\frac{1}{\alpha}}$$

$$p_{hk_h} = \alpha q^{\alpha k_h} x_{ihk_h}^{\alpha-1} L_i^{1-\alpha}$$

[11] This will be proved in the following.

[12] We set the price of the final good equal to one.

From the latter we get the demand function from firm i to sector h:

$$x_{ihk_h} = L_i q^{\frac{\alpha k_h}{1-\alpha}} \left(\frac{\alpha}{p_{hk_h}}\right)^{\frac{1}{1-\alpha}}$$

To find the total demand in sector h we have to aggregate for all i:

$$x_{hk_h} = \sum_i x_{ihk_h} = Lq^{\frac{\alpha k_h}{1-\alpha}} \left(\frac{\alpha}{p_{hk_h}}\right)^{\frac{1}{1-\alpha}} \tag{2.1}$$

where $L = \sum_i L_i$ represents the aggregate labor force, assumed to be constant. The demand function for good produced in sector h is a decreasing function of the price.

To solve the Cournot problem in the intermediate goods sector, we need the aggregate inverse demand function:

$$p_{hk_h} = \alpha q^{\alpha k_h} x_{hk_h}^{\alpha-1} L^{1-\alpha} \tag{2.2}$$

2.3 Intermediate good sector

We assume that the winner of the R&D race does not produce directly the invention but sells the right to produce the new good to a given number of firms in each sector.

We suppose that there are m sectors and n firms in each one competing à la Cournot. We assume that in each sector h there are positive externalities or spillovers which are modeled as strategic complementarities: $\frac{\partial^2 \pi_{hj}}{\partial x_{hjk_h} \partial x_{hlk_h}} > 0, \forall i, l$. This means that the marginal profit of firm j increases as another competitor, say l, rises its produced quantity. This implies that firm j will find rising its quantity convenient.

A profit function satisfying this property is:

$\pi_{hj} = p_{hk_h} x_{hjk_h} - c\left(\frac{x_{hjk_h}}{\left(\sum_{l \neq j} x_{hlk_h}\right)^{\gamma}}\right), \gamma > 0$ where γ represents the spillover coefficient and $c(.)$ is a cost function. This assumption means that when a firm $l \neq j$ increases its production of the intermediate good, the production cost of firm j reduces. This implies that the marginal revenue of j increases, so that the firm find it convenient to increase production.

We now specify the cost function. In the benchmark model the marginal cost of intermediate firms is one unit of final good[13]. In order to introduce spillovers In the present case, strategic complementarity implies that the marginal cost equals $\frac{1}{\left(\sum_{l \neq j} x_{hlk_h}\right)^{\gamma}}$. Defining $\sum_{l \neq j} x_{hlk_h} = x_{-j}$, the profit function of j is:

[13] The final good is taken as the numeraire.

$$\pi_{hj} = p_{hk_h} x_{hjk_h} - \frac{x_{hjk_h}}{(x_{-j})^{\gamma}} \tag{2.3}$$

The cost function deserves some explanation, because, due to the hypothsis on the technology, the only way to include spillovers in this industry is to modify the marginal cost. In the benchmark model shown in Barro and Sala-i-Martin (2004), Ch. 7, each producer uses the same technology: one unit of the final good is needed to produce one unit of intermediate good, so that the marginal cost is equal to one. In order to include the spillover effect we need to divide the cost function by the quantity produced by competitors. Actually there is no other way to represent a spillover effect in this simple technological framewok, but to directly create a link with the quantities produced by rival firms. Nevertheless, several reasons may justify such cost-reduction effect as, for example, technological and intellectual spillovers between companies which are related to exchanges of information, skilled labor, etc. (an example of spillovers on the cost function which is similar to the one adpted here can be found in d'Aspremont and Jaquemin 1988). Moreover, in an industry populated by many firms producing an homogeneous good it is easy to find the presence of common infrastructural services which can certainly reduce the production cost of each single producer (this is an example of Marshallian externality). In our model the spillover effect is represented by the other firms' choice variables, and we excluded the quantity produced by the representative firm. This assumption is commonly used in the empirical literature on intra-industry spillovers on the cost function (see for example Bernstein and Nadiri 1989, Suzuki 1993, Rouvinen 2002). Nevertheless, empirical works estimating this type of cost function are rare, and this is due to the lack of high quality data and to the difficulty of estimating this specific functional form. In general, the empirical literature on spillovers can be splitted in two subgroups: the first one is the primal approach or technology flow, and the second one is the cost function or dual approach, which is intimately connected to advances in flexible functional forms. Actually, the estimations focus on these generalised functional forms, without any particular theory behind.

In a Cournot oligopoly, each firm chooses the quantity to be produced in order to maximize (2.3), where p_{hk_h} characterizes the inverse demand by the final good sector.

The resulting optimal price and quantity (we provide the derivations in the Appendix) are given by[14]

$$p^*_{hk_h} = \left\{ (n + \alpha - 1) \frac{1}{n} \left[\left(\frac{n-1}{n} \right) L q^{\frac{\alpha k_h}{1-\alpha}} \alpha^{\frac{1}{1-\alpha}} \right]^{\gamma} \right\}^{\frac{1-\alpha}{\alpha+\gamma-1}} \tag{2.4}$$

[14] The second order conditions for a maximum are satisfied. In fact

$$SOC = \alpha (\alpha - 1) q^{\alpha k_h} x^{*(\alpha-2)}_{hjk_h} L^{1-\alpha} [(\alpha - 2) + 2n] < 0$$

and

$$x^*(h) = x^*_{hjk_h} = \frac{1}{n} L^{\frac{\alpha-1}{\alpha+\gamma-1}} q^{-\frac{\alpha}{(\alpha+\gamma-1)} k_h} \alpha^{-\frac{1}{(\alpha+\gamma-1)}} \left\{ (n+\alpha-1) \frac{1}{n} \left(\frac{n-1}{n} \right)^{\gamma} \right\}^{-\frac{1}{\alpha+\gamma-1}} \quad (2.5)$$

2.3.1 Comparative statics

Now we pass to examine the influence of the spillover parameter over the optimal quantity and price. The results are contained in the following Proposition.

Proposition 1. *If* $(L^{1-\alpha} q^{\alpha k_h} \alpha \frac{n+\alpha-1}{n}) > \left(\frac{n-1}{n}\right)^{\alpha-1}$*, then the equilibrium quantity* (2.5) *is an increasing function of the spillover coefficient* γ *and the optimal price, which is given by* (2.4)*, is a decreasing function of* γ*.*

Proof. Consider the expression of the optimal quantity (2.5) and derive it with respect to γ so to obtain:

$$\begin{aligned} \frac{\partial x^*(h)}{\partial \gamma} = {} & \frac{1}{n} \left[L^{1-\alpha} q^{\alpha k_h} \frac{n+\alpha-1}{n} \right]^{\frac{1}{1-\alpha-\gamma}} \left(\frac{n-1}{n} \right)^{\frac{\gamma}{1-\alpha-\gamma}} \\ & \left[\frac{1}{(1-\alpha-\gamma)^2} Log \left(L^{1-\alpha} q^{\alpha k_h} \alpha \frac{n+\alpha-1}{n} \right) + \frac{1-\alpha}{(1-\alpha-\gamma)^2} Log \left(\frac{n-1}{n} \right) \right] \end{aligned}$$

The second term in the square bracket is negative. Hence if $(L^{1-\alpha} q^{\alpha k_h} \alpha \frac{n+\alpha-1}{n}) > \left(\frac{n-1}{n}\right)^{\alpha-1}$, then $\frac{\partial x^*(h)}{\partial \gamma}$ is positive.

We also know that the price is decreasing in x_{hk_h}. If each oligopolist is rising its own output, then also the total quantity produced in sector h will increase, determining a fall in the price.

□

The economic intuition is the following: if the spillover coefficient rises, this causes a reduction of costs for each firm, so that the output that equals marginal revenue to marginal cost must increase.

2.3.2 The MARK UP

Given that the optimal quantity and price are influenced by the spillover coefficient, we may expect that the mark up is also affected by γ. In this section we show that this does not happen.

We adopt the following definition of the mark up:

$$MU = \frac{P - MC}{MC} = \frac{P}{MC} - 1$$

where

$$MC = \frac{1}{(n-1)^{\gamma} x(h)^{*\gamma}}$$

is the marginal cost.

By using the expressions of the optimal quantity and price, we can rewrite MU in this way:

$$MU = \frac{1-\alpha}{n+\alpha-1}$$

Hence the mark up does not depend on the spillover parameter. In particular, it is equal to the mark up that we would obtain if strategic complementarities were absent[15].

Hence, the effects of γ on price and marginal cost must have the same magnitude, and this is due to the symmetry among the oligopolists. At a first glance, it may seem that the introduction of the spillover parameter in our model is irrelevant, but this is not the case: γ has nonetheless a sizable effect on both equilibrium price and quantity, as shown in the previous section. The fact is simply that, on one hand, γ has a negative impact on the equilibrium price and this implies a reduction of the mark up. But on the other hand, an increase in the spillover parameter reduces marginal costs MC, and this would imply an increase of the mark-up. The two effects are exactly balanced.

Taking the limit for n which tends to infinity, we find the usual property of the mark up:

$$\lim_{n \to +\infty} \frac{1-\alpha}{n+\alpha-1} = 0$$

Finally, the mark up depends negatively on α, that is the degree of substitutability between the differentiated products, as in the standard quality-ladder model it is: $\frac{\partial MU}{\partial \alpha} = -\frac{n}{(n+\alpha-1)^2} < 0$.

2.3.3 The optimal profit

Given the optimal quantity and price, we are able to compute the maximum profit for firm j in industry h:

$$\pi_{hj}^{*OLIG} = \bar{\pi} q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma} k_h} \tag{2.6}$$

where

$\bar{\pi} = \left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} \left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} \left[\frac{1-\alpha}{n^2}\right]$. The optimal profit is positive for all $0 < \alpha < 1, n \geq 2, \gamma > 0$. Moreover, we can note that $\lim_{n \to \infty} \pi_{hj}^{*OLIG} = 0$.

[15] This can be proved by redoing the previous calculations with $\gamma = 0$.

2.3.4 The engine of growth

If we substitute (2.5) into the aggregate production function we obtain:

$$Y = L^{\frac{(1-\alpha)(\gamma-1)}{\gamma+\alpha-1}} \alpha^{-\frac{\alpha}{\alpha+\gamma-1}} \left(\frac{1}{n}\right)^{\alpha} \left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} \sum_{h=1}^{m} q^{\frac{\alpha(\gamma-1)}{\alpha+\gamma-1}k_h}$$

We define $Q(\gamma) \equiv \sum_{h=1}^{m} q^{\frac{\alpha(\gamma-1)}{\alpha+\gamma-1}k_h}$ as the *Adjusted* aggregate quality index[16], so that the last equation can be rewritten in this way:

$$Y = L^{\frac{(1-\alpha)(\gamma-1)}{\gamma+\alpha-1}} \alpha^{-\frac{\alpha}{\alpha+\gamma-1}} \left(\frac{1}{n}\right)^{\alpha} \left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} Q(\gamma)$$

The key element in fostering the growth of aggregate output turns out to be the dynamics of the quality-ladder positions, k_h, in the various sectors. The impact of $Q(\gamma)$ is amplified by the spillover effect represented by γ, as the exponent of q in $Q(\gamma)$ is an increasing function of γ. We should expect this effect because of the influence of the externality on the optimal quantities of intermediate goods.

2.4 The R&D sector

2.4.1 Modeling destruction

In the previous sections we assumed that only the best quality k_h of the intermediate good h would be produced and used in each intermediate industry: this implies that the innovation process is drastic.

We now pass to investigate under which condition a drastic innovation occurs.

The different intermediate goods are perfect substitutes but are weighted by their respective grades, and each unit of the leading-edge good is equivalent to q units of the good of the previous quality. Thus, if the state of the art is sold at a price given by(2.4), the next best quality will be sold, at most, at the price $\frac{p_{hk_h}}{q}$. As a consequence, the following relationship holds: $p_{hk_h-1} \leq \frac{p_{hk_h}}{q} = MC = \frac{1}{x_{-j}^{\gamma}}$, and when a drastic innovation occurs, it must be: $\frac{p_{hk_h}}{q} < \frac{1}{x_{-j}^{\gamma}}$.

By substituting (2.4) and (2.5), we obtain:

[16] The term "adjusted" is justified by the fact that with respect to the basic model in this case the spillover parameter appears.

$$\frac{n}{n+\alpha-1} < q$$

Note that it is: $q^{-1} < 1$, while it is $\frac{n}{n+\alpha-1} > 1$; furthermore, the term $\frac{n}{n+\alpha-1}$ is decreasing in n. Thus for a high enough n, the inequality $\frac{n}{n+\alpha-1} < q$ is satisfied and the right-hand-side is also decreasing in α.

We finally note that the fact of having drastic innovation or not does not depend on the degree of spillover[17].

2.4.2 Modeling creation

We consider an endogenous Poisson process. This means that the time which should be waited for innovation to occur is a random variable which is distributed as an exponential. The parameter of this distribution constitutes the arrival rate of the Poisson process. We assume that it depends positively on the R&D aggregate expenditure in sector h, z_{hk_h}, and negatively on k_h for a given z_{hk_h}: the negative impact of z_{hk_h} is due to the increasing difficulty in innovation after the initial and easier stages. The flow probability to move from k_h to k_{h+1} is equal to:

$$p(k_h) = z_{hk_h} \varphi(k_h)$$

Hence probability p is an endogenous variable, because the level of R&D effort is chosen by the R&D firms.

2.4.3 Determination of R&D effort (steady-state analysis)

We assume that R&D is undertaken by outsiders, and in order to obtain the research arbitrage condition (and to determine p), the cost of R&D activity must be equated to respective benefits. A successful innovation grants an infinitely lived patent, hence the benefits of innovation are given by the flow of profits starting from the moment of innovation and discounted by the cumulative interest factor and the probability to be replaced by another innovation. By equating costs and benefits we obtain:

$$z_{hk_h} = p(k_h)\, nE(\pi_{hjk_h+1})$$

Actually, once an outsider R&D firm succeeds in innovating, it obtains a perpetual patent, whose expected value is equal to: $E(\pi_{hjk_h+1})$, which is subsequently sold as license to the n firms in the intermediate sector h. Thus, as a reward, the innovator obtains the entire aggregate profit of the industry h**:**

[17] The same justification we gave for the mark up independence from the spillover parameter applies.

$$z_{hk_h} = z_{hk_h}\varphi(k_h)\int_t^{+\infty} n\pi^{*OLIG}_{hjk_h+1}e^{-r(\tau-t)}e^{-p(k_h+1)(\tau-t)}d\tau$$

If we assume that the economy grows along a steady state path, then the interest rate is constant and the former equation can be recast in this way:

$$1 = \varphi(k_h)\, n\frac{\bar{\pi}q^{\frac{\alpha(1-\gamma)(k_h+1)}{1-\alpha-\gamma}}}{r+p(k_h+1)}$$

$$r + p(k_h+1) = \varphi(k_h)\, n\bar{\pi}q^{\frac{\alpha(1-\gamma)(k_h+1)}{1-\alpha-\gamma}}$$

We need now to specify the functional form of $\varphi(k_h)$. We assume constant returns to scale in the relationship between the rate of return of R&D ($r+p(k_h+1)$) and the demand-driven effect (coming from final good producers) which is represented by the term $q^{\frac{\alpha(1-\gamma)(k_h+1)}{1-\alpha-\gamma}}$ (recall that aggregate output is proportional to the latter factor). Thus we adopt the following specification: $\varphi(k_h) = \frac{q^{-\frac{\alpha(1-\gamma)(k_h+1)}{1-\alpha-\gamma}}}{\eta}$, where η is a parameter representing the cost of doing research. In other words, a successful innovation becomes more difficult the greater the output that would be produced at the newly attained ladder position $k_h + 1$[18].

Given this assumption, the research arbitrage condition turns out to be equal to:

$$r + p(k_h+1) = n\frac{\bar{\pi}}{\eta}$$

or also

$$p = n\frac{\bar{\pi}}{\eta} - r \tag{2.7}$$

So that if r is constant over time, then p also is constant.

3 The growth process

We assume Ramsey consumers, so that the growth rate of consumption is equal to

$$g = \frac{\dot{c}}{c} = \frac{1}{\sigma}(r-\rho) \tag{3.1}$$

[18] This is a commonly used function (see Barro and Sala-i-Martin 2004, p. 327).

where $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution and $\rho > 0$ is the discount rate[19].

Given that this is a lab-equipment model, the market clearing condition, $Y = C + X + Z$, implies that all the terms are proportional to $Q(\gamma)$ and so $g_C = g_Y = g_X = g_Z = g_Q = g$.

To compute the growth rate of $Q(\gamma)$, we first consider what happens in each sector h, then, by applying the law of large number, we describe the economy in the aggregate.

The proportional increase in quality in each sector is: $\frac{q^{\frac{\alpha(1-\gamma)(k_h+1)}{1-\alpha-\gamma}} - q^{\frac{\alpha(1-\gamma)k_h}{1-\alpha-\gamma}}}{q^{\frac{\alpha(1-\gamma)k_h}{1-\alpha-\gamma}}} = q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1$. In aggregate terms, the expected proportional increase of quality is:

$$g = \frac{\dot{Q}(\gamma)}{Q(\gamma)} = p\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right) \tag{3.2}$$

We assume that $q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1 > 0$, so it must be that $\frac{1-\gamma}{1-\alpha-\gamma} > 0$. We thus obtain a system of three equations, (2.7), (3.1) and (3.2) in three unknowns, r, g and p.

By solving the system composed by (2.7), (3.1) and (3.2) , we obtain the steady-state expressions for g, r and p as a function of the model's parameters:

$$g = \frac{n\frac{\bar{\pi}}{\eta} - \rho}{1 + \sigma\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right)}\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right) \tag{3.3}$$

where $\bar{\pi} = \left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}}\left[\frac{1-\alpha}{n^2}\right]$,

$$r = \frac{n\frac{\bar{\pi}}{\eta}\sigma\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right) + \rho}{1 + \sigma\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right)}$$

$$p = \frac{n\frac{\bar{\pi}}{\eta} - \rho}{1 + \sigma\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right)}$$

The growth rate, as given by (3.3), depends negatively on the households' preference parameters, ρ and σ, and on the R&D cost. On the other hand, it is an increasing function of $\bar{\pi}$ and q.

Before discussing the conditions required for having a positive growth rate g, recall that it must be: $q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1 > 0$ and, as consequence, $\frac{1-\gamma}{1-\alpha-\gamma} > 0$; this inequality provides a first constraint on the parameters' values and determines

[19] We assume that the population growth rate is equal to zero.

also the presence of the usual scale effect.

4 Analysis of the BGP growth rate: the relationship between competition and growth and the feasibility of the BGP

In order to analyze the relationship between competition and growth, we must however check that the balanced growth path is feasible: this in turns implies that some sufficient conditions on the model's parameters have to be satisfied for having a positive g.

We first derive the steady-state growth rate with respect to the number of firms n in the intermediate good sector, which is the chosen measure of competition. Our results are summarized in the following proposition:

Proposition 2. *Suppose that the number of firms is a continuous variable. If $\gamma > 1, n \geq 2$, the balanced growth rate g in equation* (3.3) *is a decreasing function of the level of competition in each intermediate sector, as measured by n. If $\gamma < 1-\alpha$, the steady state growth rate is an inverted-U-shape function of n for $\gamma \in \left(\frac{1-\alpha}{(1+\alpha)^2}, 1-\alpha\right)$, while for $\gamma \in \left(0, \frac{1-\alpha}{(1+\alpha)^2}\right)$, the balanced growth rate is still a decreasing function of n.*

Proof. In order to analyze the sign of the derivative of the growth rate with respect to the degree of competition, it is sufficient to compute the derivative of $n\bar{\pi}(n)$ with respect to n, since this is the unique term of g which depends on n. Hence:

$$sign\left(\frac{\partial g}{\partial n}\right) = sign\left(\frac{\partial\left(n\bar{\pi}(n)\right)}{\partial n}\right)$$

Differentiating $n\bar{\pi}(n) = \left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} \left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} \left[\frac{1-\alpha}{n}\right]$ with respect to n yields

$$\begin{aligned} \frac{\partial\left(n\bar{\pi}\right)}{\partial n} &= \frac{1-\alpha}{n^2}\left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[\frac{n+\alpha-1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} \\ &\cdot\left\{-\frac{\alpha}{\alpha+\gamma-1}\left[\frac{1-\alpha}{n+\alpha-1}+\gamma\frac{1}{n-1}\right]-1\right\} \end{aligned} \tag{4.1}$$

The sign of this derivative depends on the sign of the curly bracket, which in turn depends on the term $-\frac{\alpha}{\alpha+\gamma-1}$. We must distinguish two cases:

- If $\gamma > 1-\alpha$, i.e.: the spillovers are sufficiently high, then $\left\{ -\frac{\alpha}{\alpha+\gamma-1} \left[\frac{1-\alpha}{n+\alpha-1} + \gamma \frac{1}{n-1} \right] - 1 \right\} < 0$, thus $\frac{\partial g}{\partial n} < 0$. However, we should exclude the values of the spillover parameter in the interval: $\gamma \in (1-\alpha, 1)$, otherwise the BGP will not be feasible.

- If $\gamma < 1-\alpha$, that is the degree of spillover is relatively low, then the sign of $\left\{ -\frac{\alpha}{\alpha+\gamma-1} \left[\frac{1-\alpha}{n+\alpha-1} + \gamma \frac{1}{n-1} \right] - 1 \right\}$ is ambiguous. In order to make it clearer, we analyze the sign of this derivative in correspondence of the lower bound of the number of firms: $n = 2$. In particular

$$\begin{aligned} \frac{\partial (n\bar{\pi})}{\partial n} |_{n=2} &= \frac{1-\alpha}{4} \left(\alpha L^{1-\alpha} \right)^{\frac{1-\gamma}{1-\alpha-\gamma}} \left[\frac{1+\alpha}{2} \left(\frac{1}{2} \right)^{\gamma} \right]^{-\frac{\alpha}{\alpha+\gamma-1}} \\ &\cdot \left\{ -\frac{\alpha}{\alpha+\gamma-1} \left[\frac{1-\alpha}{1+\alpha} + \gamma \right] - 1 \right\} > 0 \end{aligned}$$

if and only if $\left\{ -\frac{\alpha}{\alpha+\gamma-1} \left[\frac{1-\alpha}{1+\alpha} + \gamma \right] - 1 \right\} > 0$. This occurs when $\gamma > \frac{1-\alpha}{(1+\alpha)^2} \equiv \tilde{\gamma}$. Note that $\tilde{\gamma} \in (0, 1-\alpha)$. Moreover $\lim_{n\to\infty} (n\bar{\pi}) = 0$. Thus if $\gamma \in (\tilde{\gamma}, 1-\alpha)$ the relationship between competition and growth is nonmonotonic: it is increasing for small values of n and decreasing for large values of n. When instead it is $\gamma \in (0, \tilde{\gamma})$, the function $n\bar{\pi}(n)$ is decreasing in a neighborhood of $n = 2$ and for $n \to \infty$.

It remains to understand the behavior of this function in the interval $n \in (2, +\infty)$. To this aim we propose the following argument. The derivative (4.1) is equal to zero if and only if $-\frac{\alpha}{\alpha+\gamma-1} \left[\frac{1-\alpha}{n+\alpha-1} + \gamma \frac{1}{n-1} \right] - 1 = 0$ which is a second order equation in n:

$$(1-\alpha-\gamma) n^2 - 2(\alpha\gamma - \alpha - \gamma + 1) n + (1-\alpha)(1-\gamma-\alpha\gamma) = 0$$

This equation admits two real roots. In fact, by computing the discriminant we found that it is equal to $\alpha^2 (1-\alpha)\gamma > 0, \forall 0 < \alpha < 1, \gamma > 0$. We should now check whether these roots are greater or smaller than 2.

In order to do this, we study the product and the sum of the solutions, which are given by $n_1 n_2 = \frac{(1-\alpha)(1-\gamma+\alpha\gamma)}{1-\alpha-\gamma}$ and $n_1 + n_2 = \frac{2(\alpha\gamma-\alpha-\gamma+1)}{1-\alpha-\gamma}$. They are both positive as we are in the region where $\gamma < 1-\alpha$, so that the roots are greater than zero. Moreover, it can be shown that in our case

$$n_1 + n_2 > 2 \text{ and } 1 < n_1 n_2 < 2 \tag{4.2}$$

We now have to distinguish between two cases:

1- If $\gamma \in (\tilde{\gamma}, 1-\alpha)$, we know that the function $n\bar{\pi}(n)$ is increasing in a neighborhood of $n = 2$ and $\lim_{n\to+\infty} n\bar{\pi}(n) = 0$. Thus we can find a unique global maximum in the interval $(2, +\infty)$, while the other stationary point must be smaller than 2, in order to satisfy (4.2). We can conclude that the shape of the balanced growth rate as a function of competition is an inverted U in the relevant interval.

2- If $\gamma \in (0, \tilde{\gamma})$, we can immediately note that the function can not attain a minimum and then a maximum in the interval $(2, +\infty)$, otherwise conditions (4.2) would not be satisfied; in particular it would be that $n_1 n_2 > 2$ and if conditions (4.2)must be satisfied, the case in which it is $n_1 > 2$ and $n_2 > 2$ must be excluded. Hence, we are left with only two possibilities: i) one of the two stationary points is greater than 2 and in this case it must be a flex with an horizontal tangent; ii) both n_1 and n_2 are smaller than 2.

In both cases the function turns out to be monotonically decreasing in the interval $(2, +\infty)$, and under ii) it is strictly decreasing.

These considerations conclude the proof.

□

The economic intuition of this result is the following. There are two ways of fostering spillovers: an increase in γ, which represents the intensity of the external economies of scale and an increase of the number of firms in each industries, which determines an increase in the aggregate quantity produced by the whole industry and so a reduction of each firm's marginal cost. Here, for a fixed γ, we study the effect of a change in the number of firms. Suppose that the spillovers are high. Then existing firms in the intermediate good sector would not be favored by an increase in strategic complementarities due to the entrance of new firms, as the incumbents are already big: the unique consequence would be a reduction of profits.

On the other hand, if spillovers are relatively low, then it can be possible that for a low number of firms the spillover effect dominates the business stealing effect because the few existing firms would benefit from more competition as it increases the strategic complementarities. But when n rises beyond a certain threshold, the business stealing effect prevails again, inducing a decline of the steady state growth rate. In this case, the relationship between competition and growth is an inverted-U-shape. Hence for low values of the spillovers parameters, when the number of firms is small enough, the spillover effect is greater than the business stealing effect. This interpretation can be supported by the following considerations. Consider the model without strategic complementarities, i. e. $\gamma = 0$. In this case $\bar{\pi}$ becomes

$$\bar{\pi}_{\gamma=0} = \left(\alpha L^{1-\alpha}\right)^{\frac{1}{1-\alpha}} \left[(n + \alpha - 1)\frac{1}{n}\right]^{-\frac{\alpha}{\alpha-1}} \left[\frac{1-\alpha}{n^2}\right]$$

As a consequence

$$\frac{\partial \bar{\pi}_{\gamma=0}}{\partial n} = \left(\alpha L^{1-\alpha}\right)^{\frac{1}{1-\alpha}} \left[(n + \alpha - 1)\frac{1}{n}\right]^{-\frac{\alpha}{\alpha-1}} \left[\frac{1-\alpha}{n^4}\right] \left[\frac{\alpha n}{n+\alpha-1} - 1\right] < 0$$
$$\forall 0 < \alpha < 1, n \geq 2$$

and

$$\frac{\partial (n\bar{\pi})_{\gamma=0}}{\partial n} = \left(\alpha L^{1-\alpha}\right)^{\frac{1}{1-\alpha}} \left[(n+\alpha-1)\,\tfrac{1}{n}\right]^{-\frac{\alpha}{\alpha-1}} \left[\tfrac{1-\alpha}{n^2}\right] \left[\tfrac{\alpha}{n+\alpha-1}-1\right] < 0$$

$$\forall 0<\alpha<1, n\geq 2$$

Thus if there were no spillovers in the intermediate good sector, then the relationship between competition and growth would be negative.

We now introduce the remaining conditions which guarantee the positivity of the balanced growth rate.

Proposition 3. *The balanced growth rate g, which is given by expression* (3.3), *is positive if $\frac{1-\alpha}{2}\left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[\frac{1+\alpha}{2}\left(\frac{1}{2}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}}$ $\eta\rho$. If this condition is satisfied, then it is possible to identify a closed, compact set of admissible values for the firms' number in the intermediate good sector, which are also sustainable in the long run.*

Proof. We previously assumed that $q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}}-1>0$. So, in order to have a positive long run growth rate, it must be: $\bar{\pi}>\frac{\eta\rho}{n}$, i.e.: $n\bar{\pi}>\eta\rho$. Define $n\bar{\pi}=h(n)$ and $\eta\rho\equiv i(n)=i$, which is a constant function with respect to n. Function $h(n)$ is continuous in n for $n>1$[20] and it is monotonically decreasing if $\gamma>1$. When instead it is $\gamma<1-\alpha$, $h(n)$ is increasing (w.r.t. n) and then decreasing if γ is in the interval $\gamma\in\left(\frac{1-\alpha}{(1+\alpha)^2},1-\alpha\right)$; finally, for $\gamma\in\left(0,\frac{1-\alpha}{(1+\alpha)^2}\right)$, $h(n)$ is decreasing , as shown in the previous proposition.

We now provide a sufficient condition on the parameters ensuring that i lies below $h(n)$ for $n=2$: $h(2)>i$. This imply that, by continuity, the two functions must cross at least once, let us say in $\bar{\bar{n}}$.

The sufficient condition for having a positive BGP growth rate and a compact, closed set of firms that can survive in the long run $\left([2,\bar{\bar{n}}]\right)$ is:

$$\begin{aligned} h(2) &= \left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[\tfrac{1+\alpha}{2}\left(\tfrac{1}{2}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}}\left[1-\tfrac{1+\alpha}{2}\right] \\ &= \left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[\tfrac{1+\alpha}{2}\left(\tfrac{1}{2}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}}\tfrac{1-\alpha}{2} > \eta\rho\equiv i \end{aligned}$$

that is

$$\frac{1-\alpha}{2}\left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[\frac{1+\alpha}{2}\left(\frac{1}{2}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} > \eta\rho$$

This concludes the proof.

□

[20] We remark that we are interested in $n\geq 2$.

This proposition identifies an upper bound for the sustainable number of firms in the long run, which includes the scale effect of endogenous growth models: the larger is L, the greater is the growth rate and the upper bound of the sustainable interval of n. Furthermore, the lower are η or ρ, the larger is the admissible number of firms, and these two parameters also have a negative impact on the growth rate.

4.1 The discrete case

In the previous analysis we considered the number of firms as a continuous variable. Actually $n \in \mathbb{N}$, thus both the domain and the codomain of $g(n)$ are numerable. In the following proposition we show that our main result is preserved in this case.

Proposition 4. *If the number of firms in each intermediate sector is such that $n \in \mathbb{N}, n \geq 2$, then when $\gamma > 1$, the steady state growth rate g in equation (3.3) is a decreasing function of n, while when $\gamma < 1 - \alpha$, the relationship between competition and growth is an inverted-U-shape function if $\gamma \in \left(\frac{1-\alpha \frac{[\log(2+\alpha)-\log(1+\alpha)]}{\log 3 - \log 2}}{1+\alpha\left(\frac{\log \frac{4}{3}}{\log \frac{3}{2}}\right)}, 1-\alpha \right)$, while it is monotonically decreasing if*
$$\gamma \in \left(0, \frac{1-\alpha \frac{[\log(2+\alpha)-\log(1+\alpha)]}{\log 3 - \log 2}}{1+\alpha\left(\frac{\log \frac{4}{3}}{\log \frac{3}{2}}\right)} \right).$$

Moreover, there exists the following link between the sufficient conditions in the continuous and discrete case that guarantee the non monotonicity of the above relationship:
$$\left(\frac{1-\alpha \frac{[\log(2+\alpha)-\log(1+\alpha)]}{\log 3 - \log 2}}{1+\alpha\left(\frac{\log \frac{4}{3}}{\log \frac{3}{2}}\right)}, 1-\alpha \right) \subset \left(\frac{1-\alpha}{(1+\alpha)^2}, 1-\alpha \right).$$

Proof. We have proved before that, if n is a continuous variable, when $\gamma > 1$, the growth rate is monotonically decreasing in the number of firms. For this values of γ, the monotonicity is thus preserved when $n \in \mathbb{N}$.

We now focus on the case in which is $\gamma < 1-\alpha$. Consider again the function $n\bar{\pi}(n) = \left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} \left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}}$ and compute the first difference

$$(n+1)\bar{\pi}(n+1) - n\bar{\pi}(n) =$$
$$(1-\alpha)\left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} \left\{ \left[(n+\alpha)\frac{1}{n+1}\left(\frac{(n+1)-1}{n+1}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} \frac{1}{n+1} \right.$$
$$\left. - \left[(n+\alpha-1)\frac{1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}} \frac{1}{n} \right\}$$

We now compute it for $n = 2$ and determine the (sufficient) condition on γ as a function of α for which it is: $3\pi(3) - 2\bar{\pi}(2) > 0$:

$$\frac{2}{3} > \left[\frac{2+\alpha}{3}\left(\frac{2}{1+\alpha}\right)\left(\frac{4}{3}\right)^{\gamma}\right]^{\frac{\alpha}{\alpha+\gamma-1}}$$

By solving for γ we obtain:

$$\gamma > \frac{1 - \alpha\frac{[\log(2+\alpha)-\log(1+\alpha)]}{\log 3 - \log 2}}{1+\alpha\left(\frac{\log\frac{4}{3}}{\log\frac{3}{2}}\right)} \equiv \hat{\gamma}$$

The value $\hat{\gamma}$ is lower than $1-\alpha$, as it can be shown by inspecting the graph of the function $f(\alpha) = \hat{\gamma} + \alpha$ when $0 < \alpha < 1$:

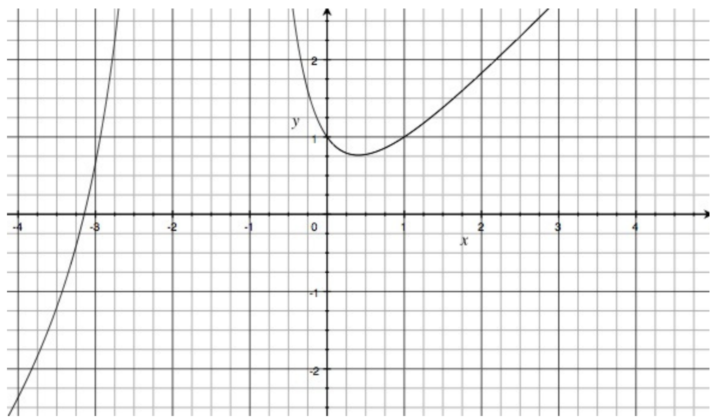

Figure 4.1: $f(\alpha)$

On the other hand, the lower bound of $\hat{\gamma}$ is $\frac{1-\alpha}{(1+\alpha)^2}$, as it can be checked from the graph of $g(\alpha) = \hat{\gamma} - \frac{1-\alpha}{(1+\alpha)^2}$ (for $0 < \alpha < 1$):

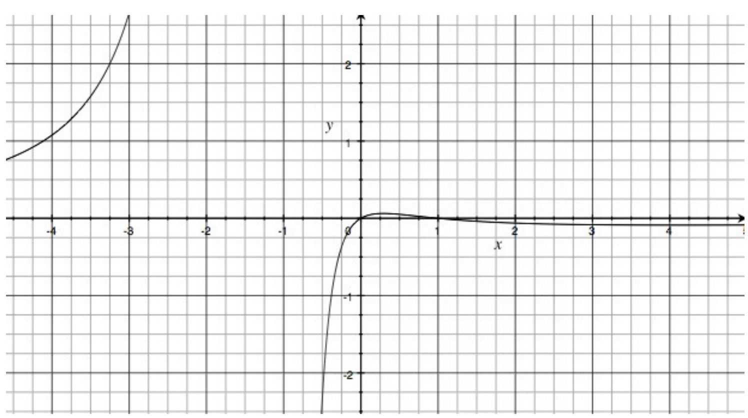

Figure 4.2: $g(\alpha)$

Thus we showed that $\left(\frac{1-\alpha\frac{[\log(2+\alpha)-\log(1+\alpha)]}{\log 3-\log 2}}{1+\alpha\left(\frac{\log\frac{4}{3}}{\log\frac{3}{2}}\right)}, 1-\alpha\right) \subset \left(\frac{1-\alpha}{(1+\alpha)^2}, 1-\alpha\right)$.

Furthermore, we know that $n\overline{\pi}(n)$ in the continuous case becomes decreasing after a certain n. This behavior is preserved in the discrete case, confirming the inverted-U-shape feature of the relationship between the growth rate and the number of firms.

On the other hand, if $\gamma \in (0, \hat{\gamma})$, the quantity $3\overline{\pi}(3) - 2\overline{\pi}(2)$ is negative. In the continuous case we showed that for very small values for γ the function $n\overline{\pi}(n)$ is decreasing for $n \in (2, +\infty)$. This implies that when γ lies in this interval, our function is decreasing in the discrete case too.

This concludes the proof.

□

We should remark that in the proof of Proposition 3 we made use of the fact that the growth rate is a continuous function of n. Actually both the functions $n\overline{\pi} \equiv h(n)$ and $\eta\rho \equiv i(n) \equiv i$ are discrete in n. However, for the growth rate to be positive, an inequality is needed, so that we can disregard the intersection between the two functions.

5 Calibration

5.1 The spillover parameter

We now adopt our framework for calibrating the values of the spillover parameter and the parameter representing the size of the leading-edge innovation for the UK economy. We have chosen this methodology taking into account the fact that it is difficult to get high quality data on firms' costs because the same firms has an incentive to keep this information private. Anyways our numerical analysis is sufficient to prove the existence and the importance in terms of relationship between competition and growth of intra-industry spillovers.

We use UK data, so to be consistent with Aghion *et al.* (2005) seminal paper[21]. We also need to calibrate the income share of intermediate goods α, because estimations of a production function with only labor and intermediates are not present in the literature. To this aim, we use the equation of the mark up, $MU = \frac{1-\alpha}{n+\alpha-1}$,

[21] Most of the empirical works on the relationship between competition and growth are based on UK data because the United Kingdom experienced a large number of policy changes that led to exogenous variation in the nature and magnitude of competition.

along the lines of Aghion *et al.* (2005); they use the price-cost margin[22] as a measure of product market competition, which is an approximation of the Lerner index. As the quantification of marginal costs is notoriously difficult, Aghion *et al.* (2005) approximate the price-cost margin with the ratio between operating profits (net of the financial costs) and sales. To compute this quantity, they use a panel of 311 firms of seventeen two-digit SIC codes industries over the period 1973-1994. The average Lerner index is 4%, which yields a mark up of 4.2%. Finally, by using the average number of firms of these sectors, we obtain $\alpha = 0.263$.

We calibrate the steady state interest rate r through equation (3.1). To this end we set $g = 2.18\%$ (source: World Bank, 1973-1994), $\rho = -\log\beta = -\log 0.99 = 0.01$ (source: DSGE literature; see for example King and Rebelo 2000), $\sigma = 1$[23], so to obtain $r = 3.18\%$.

Finally, we use the remaining steady state equations:

$$\begin{cases} g = p\left(q^{\frac{\alpha(1-\gamma)}{1-\alpha-\gamma}} - 1\right) \\ p = n\frac{\pi}{\eta} - r \end{cases}$$

calibrate γ and q.

In order to measure η we choose the average Industry R&D expenditures (by performer) over GDP, which is equal to 0.0143 (source: National Science Foundation, 1975-1992). We then set $L = 1$ and $p = 0.04$, consistently with the estimation performed by Caballero and Jaffe (2002).

Hence the resulting calibrated parameters are equal to:

1. $\gamma = 0.5782 \in (0.462, 0.737) \equiv \left(\frac{1-\alpha}{(1+\alpha)^2}, 1-\alpha\right)$;

2. $q = 1.8652$.

These results support our theoretical model: since $\gamma \in \left(\frac{1-\alpha}{(1+\alpha)^2}, 1-\alpha\right)$, the relationship between competition and growth is inverted-U shape for the UK economy.

[22] Price-cost margin is defined as the difference between price and marginal cost divided by price.

[23] If we consider a greater value for the inverse of the intertemporal elasticity of substitution, this does not change the conclusion on the spillover parameter. The same applies if we consider a different discount rate, for example $\rho = 0.03$. Thus our analysis is robust to changes in parameter values.

5.2 The degree of substitability as a measure of competition

Earlier studies consider the degree of substitability α between the intermediates in order to analyze the relationship between competition and growth (see Grossman and Helpman 1991; Aghion and Howitt 1992; Aghion et al. 2001; Barro and Sala-i-Martin 2004). Given the complexity of expression (3.3), we can not provide an analytical result, but a numerical example can show that the analytical result of proposition 2 is robust. In order to plot equation (3.3) as a function of α we use the calibration of section 5.1:

n	$311/17$
ρ	0.01
σ	1
L	1
η	0.0143
γ	0.5782
q	1.8652

Table 1: Baseline calibration

Figure 5.1 shows that the relationship between competition and growth, as measured by an increase of the degree of substitability between the intermediates , and growth is bell-shaped:

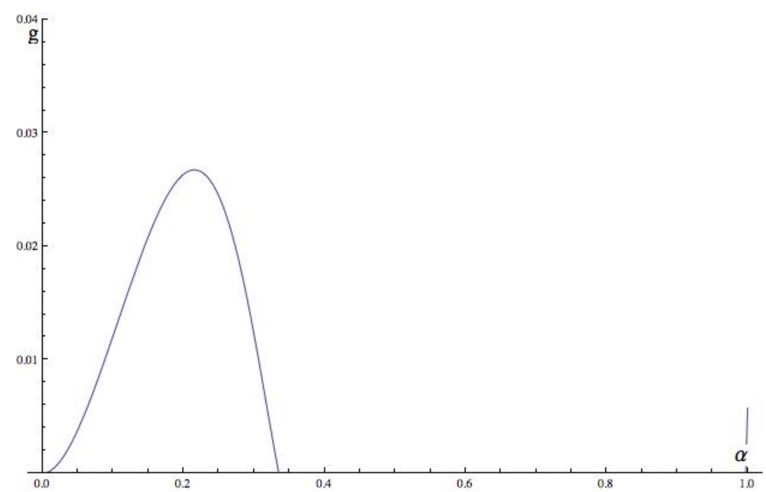

Figure 5.1: The degree of substitutability as a measure of competition

5.3 Endogenizing the number of firms

Up to now we assumed that the number of firms in the intermediate sector is exogenous. It may be natural to think that an inventor decides how many firms to license her innovation to in order to maximize her profit. Hence the R&D firm solves the following problem:

$$\max_n \quad z_{hk_h}\varphi\left(k_h\right)\int_t^{+\infty} n\pi^{*OLIG}_{hjk_h+1}e^{-r(\tau-t)}e^{-p(k_h+1)(\tau-t)}d\tau$$

which is equivalent to

$$\max_n \quad n\pi^{*OLIG}_{hjk_h+1}$$

where $\pi^{*OLIG}_{hjk_h+1}$ is given by (2.6). Since the only element related to n is $n\bar{\pi}\left(n\right)$, the first order condition is given by[24]

$$\frac{\partial\left(n\bar{\pi}\right)}{\partial n}=\frac{1-\alpha}{n^2}\left(\alpha L^{1-\alpha}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}}\left[\frac{n+\alpha-1}{n}\left(\frac{n-1}{n}\right)^{\gamma}\right]^{-\frac{\alpha}{\alpha+\gamma-1}}\left\{-\frac{\alpha}{\alpha+\gamma-1}\left[\frac{1-\alpha}{n+\alpha-1}+\gamma\frac{1}{n-1}\right]-1\right\}=0$$

We know from proposition 2 that

- if $\gamma>1$ or $\gamma\in\left(0,\frac{1-\alpha}{(1+\alpha)^2}\right)$, function $n\bar{\pi}\left(n\right)$ is decreasing for $n\in[2,+\infty)$. The optimal number of firms is therefore 2;
- if $\gamma\in\left(\frac{1-\alpha}{(1+\alpha)^2},1-\alpha\right)$, function $n\bar{\pi}\left(n\right)$ is bell-shaped for $n\in[2,+\infty)$. In this case $\arg\max\left\{n\bar{\pi}\left(n\right)\right\}$ solves

$$\left(1-\alpha-\gamma\right)n^2-2\left(\alpha\gamma-\alpha-\gamma+1\right)n+\left(1-\alpha\right)\left(1-\gamma-\alpha\gamma\right)=0$$

  and the optimal number of firms turns out to be[25]:

$$n^*=\frac{\left(\alpha\gamma-\alpha-\gamma+1\right)+\sqrt{\left(\alpha\gamma-\alpha-\gamma+1\right)^2-\left(1-\alpha\right)\left(1-\alpha-\gamma\right)\left(1-\gamma-\alpha\gamma\right)}}{\left(1-\alpha-\gamma\right)}$$

When n is endogenous comparative statics on competition should therefore be done by varying the degree of substitability between the intermediate goods. By using the baseline calibration of table 5.1 we find that in both cases the relationship between competition and growth is an inverted-U shape:

[24] See the proof of proposition 2.

[25] See the proof of proposition 2 for futher details.

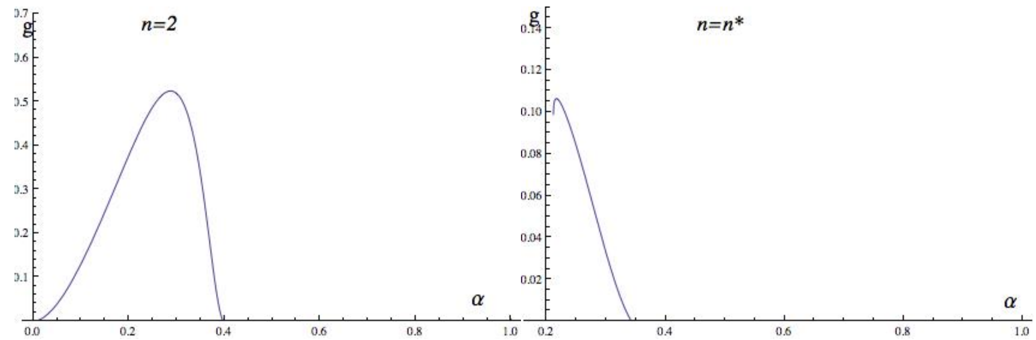

Figure 5.2: n endogenous

6 Conclusions

Empirical evidence suggests the presence of an inverted U-shaped relationship between competition and growth. But early models of endogenous growth show that a stronger competition erodes the innovator's prospective monopoly rent and reduces the incentive to innovate. Only recently theory was able to explain the nonmonotonicity of the above relationship. Our model can be viewed as another attempt to justify it from a theoretical point of view. We found a set of circumstances under which the behavior of the growth rate as a function of the number of firms in each industry switches form increasing to decreasing. The growth rate increases with the number of firms for small degrees of competition, as the spillover effect dominates the business-stealing effect; when competition becomes tougher, and the Schumpeterian effect of a reduction of profits prevails, the growth rate decreases with the number of firms.

By applying our model to the UK data, for the 1973-1994 period, we found that the calibrated value of the spillover parameter lies in the region where the the relationship between competition and growth is non-monotonic.

We then recasted the analysis by using the degree of substitability between the intermediates as measure of competition and we proved the robustness of our result. Finally we endogenized the number of firms and found that the relationship between competition and growth is still an inverted-U shape.

These considerations may provide a rationale for antitrust policies aimed at fostering competition in innovative sectors: in industries where the strategic complementarities are not too strong and not too weak, policy makers should enhance competition in order to reach a higher growth rate.

References

[1] **Acemoglu, D., Gancia, G., and Zilibotti, F.** (2010) Competing engines of growth: innovation and standardization. NBER Working Papers No. 15958.

[2] **Adams, J. D. and Jaffe, A. B.** (1996) Bounding the effect of R&D: an investigation using matched establishment-firm data, *RAND Journal of economics*, **27**, 700-21.

[3] **Aghion, P., Dewatripont, M., and Rey, P.** (1999) Competition, financial discipline, and growth, *Review of Economic Studies*, **66**, 825-52.

[4] **Aghion, P., Bloom, N., Blundell, R., Griffith, R., and Howitt, P.** (2005) Competition and innovation: an inverted-U relationship, *The Quarterly Journal of Economics*, **120**, 701-28.

[5] **Aghion, P. and Griffith, R.** (2005) *Competition and growth: reconciling theory and evidence*, Cambridge, MA: MIT Press.

[6] **Aghion, P., Harris, C, Howitt, P., and J. Vickers** (2001) Competition, imitation and growth with step-by-step innovation, *Review of Economic Studies*, **68**, 467-92.

[7] **Aghion, P, Harris, C, and Vickers, J.** (1997). Competition and growth with step- by-step innovation: an example, *European Economic Review*, **41,** 771-82.

[8] **Aghion, P. and Howitt, P.** (1992) A model of growth through creative destruction. *Econometrica* **60**, 323-51.

[9] **d'Aspremont, C., Dos Santos Ferreira, R., and Gerard-Varet, L. A.** (2010) Strategic R&D investment, competition toughness and Growth, *International Journal of Economic Theory*, **6**, 273-95.

[10] **d'Aspremont, C. and Jaquemin, A.** (1988) Cooperative and noncooperative R&D in duopoly with spillovers, *American Economic Review*, **78**, 1133–37.

[11] **Badinger, H. and Egger, P.** (2008) Intra- and inter-industry productivity spillovers in OECD manufacturing: a spatial econometric perspective, CESIFO Working Paper No. 2181.

[12] **Barro, R. and Sala-i-Martin, X.** (2004) *Economic growth*, New York, McGraw-Hill.

[13] **Basu, S. and Fernald, J. G.** (1997) Returns to scale in U.S. production: estimates and implications, *Journal of Political Economy*, **105**, 249-83.

[14] **Bernstein, J. I., Nadiri, I. M.** (1989) Research and Development and intra-industry spillovers: an empirical application of dynamic duality. *Review of Economic Studies*, 56, 249- 69.

[15] **Blundell, R., Griffith, R., and Van Reenen, J.** (1999) Market share, market value and innovation in a panel of British manufacturing firms., *Review of Economic Studies*, **66**, 529-54.

[16] **Brandt, N.** (2007) Mark-ups, economies of scale and the role of knowledge spillovers in OECD industries, *European Economic Review*, **51**, 1708-32.

[17] **Caballero, R. J. and Jaffe, A. B.** (2002) How high are the giants' shoulders: An empirical assessment of knowledge spillovers and creative destruction in a model of economic growth, in A. Jaffe & M. Trajtenberg (eds) *Patents, citations and innovations: A window on the knowledge economy*, 89–152. Cambridge, MA: The MIT Press.

[18] **Ciccone, A. and Hall, R. E.** (1996) Productivity and the density of economic activity, *The American Economic Review*, **86**, 54-70.

[19] **Coe, D. and Helpman, E.** (1995) International R&D spillovers, *European Economic Review*, **39**, 859-87.

[20] **Cohen, W. and Levin, R.** (1989) Empirical studies of innovation and market structure, in: Chapter 18 of R. Schmalensee and R. Willig (eds), *Handbook of Industrial Organization*, Elsevier.

[21] **Denicolò, V. and Zanchettin, P.** (2004) Competition and growth in Neo-Schumpeterian models, Discussion Papers in Economics No. 04/28, Department of Economics, University of Leicester.

[22] **Dixit, A. and Stiglitz, J.** (1977) Monopolistic competition and optimum product diversity, *The American Economic Review*, **67**, 297-08.

[23] **Eaton, J. and Kortum, S.** (1996) Trade on ideas: patenting and productivity in the OECD, *Journal of International Economics*, **40**, 251-78.

[24] **Eaton, J. and Kortum, S.** (1999) International technology diffusion: theory and measurement, *Journal of International Economics,* **40**, 537-70.

[25] **Ellison, G., Glaeser, E. L., William R. Kerr, W. R.** (2010), "What Causes Industry Agglomeration? Evidence from Coagglomeration Patterns."American Economic Review, **100**, 1195–1213.

[26] **Geroski, P.** (1995) *Market structure, corporate performance and innovative activity*, Oxford: Oxford University Press.

[27] **Glaeser, E., Kallal, H., Scheinkman, J., and Shleifer, A.** (1992) Growth in cities, *Journal of Political Economy*, **100**, 1126-52.

[28] **Grosfeld, I. and Tressel, T.** (2001) Competition and corporate governance: substitutes or complements? Evidence from the Warsaw Stock Exchange, Working Paper DELTA No. 2001-06.

[29] **Grossman, G. M. and Helpman, E.** (1991) *Innovation and growth in the global economy*, Cambridge, MA: MIT Press.

[30] **Hart, O.** (1983) The market mechanism as an incentive scheme, *Bell Journal of Economics*, **14**, 366-82.

[31] **Henderson, J. V.** (1986) Efficiency of resource usage and city size, *Journal of Urban Economics*, **19**, 47-70.

[32] **Henderson, J. V., Kuncoro, A., and Turner, M.** (1995) Industrial development in cities, *Journal of Political Economy*, **103**, 1067-85.

[33] **Jaffe, A. B. and Trajtemberg, M.** (1999) International knowledge flows: evidence from patent citations, *Economics of Innovation and New Technology*, **81**, 105-36.

[34] **Jimenez, M. and Marchetti, D.** (2002) Interpreting the procyclical productivity of manufacturing sectors: can we really rule out external effects? *Applied Economics*, **34**, 805-17.

[35] **Keller, W.** (2002) Geographic localization of international technology diffusion, *The American Economic Review*, 92, 120–42.

[36] **King R. and Rebelo S.** (2000) Resuscitating Real Business Cycles, NBER Working Paper No. 7534.

[37] **Koeninger, W. and Licandro, O.** (2006) On the use of substitutability as a measure of competition, *Topics on Macroeconomics*, **6**, Article 2.

[38] **Levin, R., Cohen, W., and Mowery, D.** (1985) R&D appropriability, opportunity, and market structure: new evidence on some Schumpeterian hypotheses, *The American Economic Review Proceedings*, **75**, 20-24.

[39] **Malerba, F., Mancusi, M., and Montobbio, F.** (2004) Innovation and knowledge: evidence from European data, Paper presented at the American Economic Association annual meetings, San Diego 2004.

[40] **Moomaw, R. L.** (1981) Productivity and city size: A critique of the evidence, *The Quarterly Journal of Economics*, **96**, 675-88.

[41] **Motta, M.** (2004) *Competition policy:theory and practice*, Cambridge UP.

[42] **Nakamura, R.** (1985) Agglomeration economies in urban manufacturing industries: a case of Japanese cities, *Journal of Urban Economics*, **17**, 108-24.

[43] **Nickell, S.** (1996), Competition and corporate performance, *Journal of Political Economy*, **104**, 724-46.

[44] **Nickell, S., Nicolitas, D., and Dryden, N.** (1997) What makes firms perform well?, *European Economic Review*, **43**, 783-96.

[45] **Rosenthal, S., Strange W. C.** (2001), "The determinants of Agglomeration", *Journal of Urban Economics*, **50**, 191-229.

[46] **Rouvinen, P.** (2002) The existence of R&D spillovers: a cost function estimation with random coefficients, *Economics of Innovation and New Technology*, **11**, 525-41.

[47] **Salop, S.** (1997) The noisy monopolist: imperfect information, price dispersion, and price discrimination, *Review of Economic Studies*, **44**, 393-06.

[48] **Sbordone, A. M.** (1997) Interpreting the procyclical productivity of manufacturing sectors: external effects or labor hoarding?, *Journal of Money, Credit and Banking*, **29**, 26-45.

[49] **Scherer, F.** (1967) Market structure and the employment of scientists and engineers, *The American Economic Review*, **57**, 524-31.

[50] **Suzuki, K.** (1993) R&D Spillovers and technology transfer among and within Vertical Keiretsu Groups: Evidence from the Japanese electrical machinery industry, *International Journal of Industrial Organization*, 11, 573-91.

[51] **Sveikauskas, L.** (1975) The productivity of cities, *The Quarterly Journal of Economics*, **89**, 393-13.

[52] **Van Stel, A. and Nieuwenhuijsen, H.** (2004) Knowledge spillovers and economic growth: an analysis using data of Dutch Regions in the period 87-95, *Regional Studies*, **38**, 393-407.

A Derivations of the optimal price and the optimal quantity

Each representative firm in sector h solves the following problem

$$\max_{x_{hjk_h}} \pi_{hj} = p_{hk_h} x_{hjk_h} - \frac{x_{hjk_h}}{(x_{-j}\ )^{\gamma}}$$

The first order condition is:

$$\begin{aligned} \tfrac{\partial \pi_{hj}}{\partial x_{hjk_h}} &= 0 \Rightarrow \\ p'_{hk_h} x_{hjk_h} + p_{hk_h} &= \tfrac{1}{(x_{-j}\ )^{\gamma}} \end{aligned}$$

Summing all first order conditions for all firms in an industry (the sum over j allows us to use the aggregate demand function $x_{hk_h} = \sum_i x_{ihk_h}$), we obtain:

$$\begin{aligned} p'_{hk_h} \sum_{j=1}^{n} x_{hjk_h} + np_{hk_h} &= \frac{n}{(x_{-j}\ )^{\gamma}} \\ p'_{hk_h} x_{hk_h} + np_{hk_h} &= \frac{n}{(x_{-j}\ )^{\gamma}} \\ p_{hk_h} &= \frac{1}{(x_{-j}\ )^{\gamma}} - \frac{1}{n} p'_{hk_h} x_{hk_h} \end{aligned}$$

Equation (2.2) can now be derived with respect to x_{hk_h}:

$$\begin{aligned} p'_{hk_h} &= \alpha(\alpha-1) q^{\alpha k_h} x_{hk_h}^{\alpha-2} L^{1-\alpha} \\ p'_{hk_h} x_{hk_h} &= \alpha(\alpha-1) q^{\alpha k_h} x_{hk_h}^{\alpha-1} L^{1-\alpha} \end{aligned}$$

By using (2.1), the last equation turns out to be equal to:

$$p'_{hk_h} x_{hk_h} = \alpha(\alpha-1) q^{\alpha k_h} \left(L q^{\frac{\alpha k_h}{1-\alpha}} \left(\frac{\alpha}{p_{hk_h}} \right)^{\frac{1}{1-\alpha}} \right)^{\alpha-1} L^{1-\alpha} = (\alpha-1) p_{hk_h} \tag{A.1}$$

Now consider the term $\frac{1}{(x_{-j})^{\gamma}}$. By definition it is: $x_{hk_h} = \sum_{j=1}^{n} x_{hjk_h}$, while, by the assumption of symmetry, it is $x_{hk_h} = \sum_{j=1}^{n} x_{hjk_h} = n x_{hjk_h} \Rightarrow x_{hjk_h} = \frac{1}{n} x_{hk_h}$. So $x_{-j} = \sum_{l \neq j} x_{hlk_h} = \frac{n-1}{n} x_{hk_h}$. These facts, together with expression (2.1). allow us to write:

$$\begin{aligned} \frac{1}{(x_{-j})^{\gamma}} &= \left(\frac{n}{n-1}\right)^{\gamma} \frac{1}{(x_{hk_h})^{\gamma}} = \left(\frac{n}{n-1}\right)^{\gamma} \left(Lq^{\frac{\alpha k_h}{1-\alpha}} \left(\frac{\alpha}{p_{hk_h}}\right)^{\frac{1}{1-\alpha}}\right)^{-\gamma} \\ &= \left(\frac{n}{n-1}\right)^{\gamma} L^{-\gamma} q^{-\frac{\gamma\alpha k_h}{1-\alpha}} \alpha^{-\frac{\gamma}{1-\alpha}} p_{hk_h}^{\frac{\gamma}{1-\alpha}} \end{aligned} \tag{A.2}$$

By plugging (A.1) and (A.2) into the sum of the first order conditions of industry h, we obtain:

$$p_{hk_h} = \left(\frac{n}{n-1}\right)^{\gamma} L^{-\gamma} q^{-\frac{\gamma\alpha k_h}{1-\alpha}} \alpha^{-\frac{\gamma}{1-\alpha}} p_{hk_h}^{\frac{\gamma}{1-\alpha}} - \frac{1}{n} (\alpha - 1) p_{hk_h}$$

which can be divided by p_{hk_h}

$$\begin{aligned} 1 &= \left(\frac{n}{n-1}\right)^{\gamma} L^{-\gamma} q^{-\frac{\gamma\alpha k_h}{1-\alpha}} \alpha^{-\frac{\gamma}{1-\alpha}} p_{hk_h}^{\frac{\gamma+\alpha-1}{1-\alpha}} - \frac{1}{n} (\alpha - 1) \\ n &= n\left(\frac{n}{n-1}\right)^{\gamma} L^{-\gamma} q^{-\frac{\gamma\alpha k_h}{1-\alpha}} \alpha^{-\frac{\gamma}{1-\alpha}} p_{hk_h}^{\frac{\gamma+\alpha-1}{1-\alpha}} - (\alpha - 1) \\ n + \alpha - 1 &= n\left(\frac{n}{n-1}\right)^{\gamma} L^{-\gamma} q^{-\frac{\gamma\alpha k_h}{1-\alpha}} \alpha^{-\frac{\gamma}{1-\alpha}} p_{hk_h}^{\frac{\gamma+\alpha-1}{1-\alpha}} \\ p_{hk_h}^{\frac{\gamma+\alpha-1}{1-\alpha}} &= (n + \alpha - 1) \frac{1}{n} \left(\frac{n-1}{n}\right)^{\gamma} L^{\gamma} q^{\frac{\gamma\alpha k_h}{1-\alpha}} \alpha^{\frac{\gamma}{1-\alpha}} \end{aligned}$$

Thus the optimal price is

$$p_{hk_h}^{*} = \left\{(n + \alpha - 1) \frac{1}{n} \left[\left(\frac{n-1}{n}\right) Lq^{\frac{\alpha k_h}{1-\alpha}} \alpha^{\frac{1}{1-\alpha}}\right]^{\gamma}\right\}^{\frac{1-\alpha}{\alpha+\gamma-1}}$$

This expression allows us to compute the optimal quantity produced by each firm in h. By the assumption of symmetry, it is

$$x_{hjk_h} = \frac{1}{n} x_{hk_h}$$

$$
\begin{aligned}
x_{hjk_h} &= \frac{1}{n} L q^{\frac{\alpha k_h}{1-\alpha}} \left(\frac{\alpha}{p_{hk_h}} \right)^{\frac{1}{1-\alpha}} \\
&= \frac{1}{n} L q^{\frac{\alpha k_h}{1-\alpha}} \alpha^{\frac{1}{1-\alpha}} \left\{ (n+\alpha-1) \frac{1}{n} \left[\left(\frac{n-1}{n} \right) L q^{\frac{\alpha k_h}{1-\alpha}} \alpha^{\frac{1}{1-\alpha}} \right]^{\gamma} \right\}^{\frac{1-\alpha}{\alpha+\gamma-1}\left(-\frac{1}{1-\alpha}\right)}
\end{aligned}
$$

Thus the equilibrium quantity produced by the sector h oligopolists is equal to:

$$
x^*(h) = x^*_{hjk_h} = \frac{1}{n} L^{\frac{\alpha-1}{\alpha+\gamma-1}} q^{-\frac{\alpha}{(\alpha+\gamma-1)} k_h} \alpha^{-\frac{1}{(\alpha+\gamma-1)}} \left\{ (n+\alpha-1) \frac{1}{n} \left(\frac{n-1}{n} \right)^{\gamma} \right\}^{-\frac{1}{\alpha+\gamma-1}}
$$

Strategic uses of patents on markets for technology: Technological firms, brokers and trolls

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Abstract

This paper analyses the strategic uses of patents on markets for technology. In particular, we study the behaviors of technological firms, patent brokers and patent trolls and explore their consequences on the amount of R&D investments of the economy. With a basic model including a technological firm which supplies knowledge to a manufacturing firm we show that patent brokers, in their pure form, are R&D increasing (i.e. they increase the R&D investments of both supplier and manufacturing firms) while patent trolls, in their pure form, are R&D decreasing. Nevertheless, we also show that there exists an optimal positive level of trolling if the probability to secure market transactions and the probability to encounter trolls are positively correlated. These results have important normative implications. Among others, they suggest that, in order to foster knowledge based economies, which largely rely on the raise of markets for technology and independent technological firms, it is critical to implement patent changes in order to limit the possibility of trolling. Yet, it also suggests that those changes must, if possible, remain neutral for technological firms and brokers. Several possible evolutions of international patent laws are hence discussed.

Keywords: Markets for technology, technological firms, patent, troll, broker, start-up.
JEL classification: O2.

1. Introduction

In the patent literature non practicing entities (NPEs in the following) are "firms that rarely or never practice their patents, and instead focus on earning licensing fees" (Shrestha, 2010, p. 114). By practicing a patent, it is meant here to manufacture and sell the product or process described in the patent and to use the patent to secure a monopoly over this product or process. NPEs do not use their patents in this way because, conversely to manufacturing firms, they do not manufacture any innovative tangible product.

NPEs are an important feature of the knowledge based economy, which is largely linked to the raise of independent technological firms (following the logic of open innovation, Chesbrough, 2003). Yet, the issue of NPEs social desirability is vividly debated in the economic, legal and managerial literature on intellectual property rights. On the one hand, many authors are worried about the emergence of perverse patenting strategies adopted by patent trolls[1] (or patent sharks) and warn against their potential detrimental effect on R&D investments, especially those from manufacturing firms (Jaffe and Lerner, 2004; Lemley, 2007). The damages caused by patent trolls might be specifically important in fields where technology is complex, such as electronics and software. On the other hand, other scholars emphasize the importance of NPEs in order to secure markets for technology, thus fostering vertical division of labor and sustaining the emergence of technological firms specialized in knowledge production (MacDonough, 2006; Magliocca, 2006; Golden, 2007; Shrestha, 2010).

We argue in this paper that most of the divergences between those two standpoints come from the ambiguity around the definition of a NPE, word which encompasses many different types of organizations: Technological firms, intellectual property brokers, patent trolls and even universities. Most of the time pro and cons do not speak about the same thing and, among others, tend to confuse patent brokers and patent trolls. Our purpose is therefore twofold: First we provide a clear definition of technological firms, (pure) patent brokers and (pure) patent trolls, which dismisses any ambiguity between those three actors of the knowledge economy.

[1] The expression "patent troll" has first been used by Peter Detkin in 2001, while he was working for Intel and complained about the patenting strategy of a NPE, Tech-Search, which he was in litigation with. Detkin claimed that "a patent troll is somebody who tries to make a lot of money off a patent that they are not practicing and have no intention of practicing and in most cases never practiced" (cited by McDonough, 2006). According to this definition, technological firms and even universities would therefore be patent trolls since they do not manufacture any tangible good but use their patent to collect licensing fees (Lemley, 2007).

Second, we investigate the consequences of patent trolls and patent brokers on R&D investments.

In the next section we define patent trolls, patent brokers and technological firms (section 2). We show that those three actors rely on very different patenting strategies, even though the common point is that they all three need a strong patent system. Among others, we show that a critical difference between trolls and brokers deal with the implementation of hold-up strategies. Unlike patent brokers, which have no interest to hide or to refuse to license their patents, trolls try to provoke hold-up situations in order to increase artificially the value of their intellectual property. In the third section, we propose a model in order to assess the implications of (pure) patent trolls and (pure) patent brokers on R&D investments (section 3). We show that although patent trolling in its pure form is detrimental to R&D investments, patent brokers are not, since they encourage the raise of firms specialized in knowledge production. This result has important policy implications, which we examine in the last section (section 4). In particular, we argue that one important challenge for policy makers will be to design systems of intellectual property rights which reduce the possibility of trolling but are not detrimental to the emergence of technological firms.

2. The actors on markets for technology

Markets for technology have entailed the emergence of at least three new players in the knowledge economy: Technological firms, intellectual property brokers and patent trolls. At first glance those actors exhibit many similarities. They are all NPEs, they all rely strongly on intellectual property rights and they are all not interested by cross-licensing their patents (they are looking for royalties). This explains why they are often mistaken by manufacturing companies and external observers (Lemley, 2007). The original definition of a patent troll given by Detkin (see footnote 1) contributed to this confusion. Yet, beyond their apparent likeness, trolls, brokers and technological firms largely differ with respect to several dimensions.

Technological firms. Technological firms (often call fabless firms) are firms specialized in upstream R&D activities. They produce knowledge and new technologies that they sell to manufacturing firms (located downstream on the value chain) which use it to develop, produce and sell tangible goods. Technological firms are therefore clearly NPEs since they do not manufacture themselves the good described in their patent. The link between technological firms and manufacturing firms is operated via "markets for technology" (Rivette and Kline, 2000; Arora *et al.*, 2001; Arora and Merges, 2004; Gambardella *et al.*, 2007; Arora and Gambardella, 2010), which ensure the flow of knowledge from the former to the latter. From a social point of view, the raise of markets for technology has many good properties (Arora *et al.*, 2001): First, it lowers duplication of research, firms having the opportunity to acquire new technologies from outside rather than re-inventing them. Second, it speeds knowledge dissemination within the economy, which fosters the cumulative process of innovation. Third, and most important, it favors vertical division of labor and specialization.

Technological firms need strong patents in order to secure their investments in R&D. Without patent, those firms would find it difficult to sell their knowledge to manufacturing firms, the latter having to some extent the possibility to free ride and to have it for free. In other words, the patent system contributes solving the Arrow's paradox (1962), thus fostering the emergence of markets for technology and encouraging the raise of firms specialized in knowledge production (Anand and Khanna, 2000; Arora and Merges, 2004).

Patent brokers. Patent brokers are complement to technological firms. They are companies specialized in technology transfer, and more specifically, in intellectual property transfers. In a sense, patent brokers play in between technological firms and manufacturing companies on markets for technology (Benassi and Di Minin, 2009). Concretely, patent brokers can take two forms: They can buy patents and other intellectual assets to technological firms and then sell them to other firms (mostly manufacturing firms). Or they can take in charge the transfer of the patent without buying it. In this second case, patents remain the property of technological firms and brokers contribute to their financial evaluation, their marketing via specialized web platforms and the securing of their transfer. Most famous examples of this kind of brokers are Yet2.com, Oceantomo, Avenium (a CEA spinoff), BTG (former UK National Research Development Corporation, specialized in pharmaceuticals), F2T (France Technology Transfer), TEchTransferOnline.com, Innocentive (rather focused on crowdsourcing), etc. (Yanagisawa and Guellec, 2009)[2].

[2] As suggested by those examples, the activity of intellectual property brokers relies massively on the technology of information and communication and, more precisely, on internet market places, such as patent online auctions

Patent brokers do not invest in R&D themselves. In most cases they are composed of experts (in law, finance, management, etc.) specialized in IP evaluation, transaction and litigation. Therefore, they are clearly NPEs but of a different kind than technological firms. For McDonough (2006), the emergence of patent brokers (or patent dealers as he calls them) is a natural evolution of markets for technology and an indication of their maturity.

Although patent brokers can develop heterogeneous strategies[3], their primary role is to reduce transaction costs and to assist the transfer of intellectual assets from technological to manufacturing firms. In particular, patent brokers help reducing two important failures of markets for technology: Incomplete information and externalities. First, in a context where information about inventions is far from perfect, where uncertainty about the value of inventions and intellectual property rights is high and where knowledge transactions are complex, they help to identify promising technologies and to transfer them to the firms who want them the most. In other words, they contribute to improve the information on markets for technology, thus reducing the lemon problem raised by Akerlof (1970).

Second, patent brokers also help protecting technological firms from attempts of free riding from manufacturing firms. Indeed, by specializing on technology transfer they remove the burden of IP litigation from R&D companies, which are hardly specialists of those issues. Without patent brokers, technological firms, not experienced with IP, may hence fear free riding behaviors from manufacturing firms, thus lowering their incentives to invest in R&D. The role of patent brokers is here to provide a credible threat of litigation in case of manufacturing firms try to free ride, thus reducing the externality problems and the Arrow's paradox (1962) on markets for technology (MacDonough, 2006).

In conclusion, the main role of patent brokers on markets for technology is to help securing mutually advantaging technology deals which, in their absence, would not be realized. One important point might nevertheless soften their importance: Patent brokers are not knowledge

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for instance (Dushnitsky and Klueter, 2010). Yet, Lichtenthaler and Ernst (2008) have recently questioned the efficiency of those pure online exchanges when they are completely disconnected from other transfer channels which involve face to face meetings, such as consultancy for instance.

[3] Benassi and Di Minin (2009) propose to distinguish between consultants (which provide general information and insights during the transactions), shields (which help keeping the transaction anonymous), technology evaluators and promoters (which provide information about the value of the technology), patent enforcers (which prevent against opportunistic behaviors), and patent aggregators (which assemble complementary patents in a single portfolios in order to increase its value).

brokers. They do not transfer knowledge but just a property right, i.e. a piece of paper. They transfer the right to use a given technology to firms which already know how to use it. In other words, they operate on markets for IPR and not on markets for knowledge (Fischer and Henkel, 2009). This reduces their field of action and their social desirability. As stated by Lemley (2007), a market for right of exclusion has a lower value for society than a market for knowledge.

Patent trolls. Although similar to patent brokers at first glance, the strategy of patent trolls is very different. Patent trolls are patent holders who try to provoke hold-up situations, i.e. who do not want to grant license (at least not too early) but to provoke infringement[4]. Hence, while patent brokers in their pure form try hard to grant licenses (they are looking for customers, advertize their technology on the Internet, etc.), patent trolls keep their patent portfolio hidden and want to be infringed[5] (Henkel *et al*., 2007; Reitzig *et al*., 2010). Trolls are not engaged into licensing activities but into litigation ones. They speculate on patent litigation. The patenting strategy of trolls constitutes therefore a radical hijacking of the primary role of patents. Originally patents have been designed to prevent infringement whereas trolls use them precisely in order to be infringed.

Delayed infringement has a value for patent trolls because most of the time their patents have low value in an *ex-ante* negotiation (before a manufacturing firms has made sunk investments to manufacture the product) but become highly valuable in *ex-post* negotiations after important investments have been sunk by manufacturing firms. This hold-up strategy enables trolls to earn a disproportionately large fraction of the value of a technology (a fraction which is far higher than the intrinsic value of the component brought by the troll) (Shapiro, 2001; Farell e*t al*., 2007; Lemley and Shapiro, 2007). The most famous illustration of the way patent trolls operate has been given by the Blackberry case which opposed NTP, a US NPE firm, and Research in Motion (RIM), the firm which has developed and commercialized the Blackberry (Magliocca, 2006).

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[4] The strategy of patent trolls is encouraged by the proliferation of patents and the complexity of their writing. Hence, although patents are public, it is increasingly difficult to find relevant and exhaustive information in the patent literature. This is especially true for complex technologies, like electronics, in which hundreds of patents are overlapping for a given piece of technology.

[5] The word "patent troll" is precisely expected to reflect the fact that trolls remain hidden while waiting for their victims. It is indeed well-known that in Scandinavian mythology, trolls are ugly monsters who stay hidden in the wood, wait for innocent victim to cross the wood, and then attack and rob them. The analogy with patent trolls is obvious.

Patent trolls' business model contains 5 steps (Pénin, 2010):

1) Operate in sectors where the probability to be infringed is high. For instance, sectors in which technology is complex (Kingston, 2001), like electronics, are highly favorable to patent trolling.
2) Buy cheap patents to financially distressed firms (or to universities)[6].
3) Identify potential infringers.
4) Wait for sunk investments before launching the attack.
5) Threaten (to stop production for instance) and compromise in order to earn substantial compensation from the attacked manufacturing company. The amount of the compensation may vary according to cases[7].

It is interesting to remark that according to our definition it is their behaviors and not their ad-hoc features that characterize trolls. A patent holder which is hiding and waiting for infringement behaves like a troll[8]. Hence, technological firms and even universities can be considered as trolls if they behave accordingly. Yet, in many instances, unlike trolls, universities and technological firms are actively looking for licensees and have no interest to hide or to reject reasonable licensing deals.

To summarize, the raise of markets for technology, sustained by strong intellectual property rights, has contributed to the emergence of new economic actors. We have defined in this section three of those new firms which belong to the knowledge economy and have insisted on their difference. The next section endeavors to (1) formalize behaviors of pure patent brokers and pure patent trolls and (2) explore the consequences of trolls and brokers on R&D investments realized by both technological and manufacturing firms.

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[6] Cheap patents may not mean low quality patents. It is true that the strategy of patent trolls is compatible with low quality patents. The proliferation of those weak patents might hence serve the strategy of patent trolls (Jaffe and Lerner, 2004). Yet, some studies tend to stress the good quality of trolls' patent portfolio measured by the number of received citations (Fischer and Henkel, 2009).

[7] It is worthwhile noticing that, since patent trolls are NPEs and do not practice their patent, they cannot infringe patents held by other firms. Hence, they still diminish the defense of the manufacturing firms they attack (Grindley and Teece, 1997).

[8] An important consequence of our definition of patent trolls is that it may be very difficult, if not impossible, to study patent trolling empirically. Collecting a database of firms assimilated to patent trolls is indeed strongly complicated by the fact that an organization can behave only occasionally like a troll. Furthermore, observing during litigation that a firm is in a situation of hold-up is not sufficient to conclude that the other firm is a troll. One must show that the firm has acted deliberately in order to provoke the hold-up (Fisher and Henkel, 2009). In other words, existing databases of patent trolls are likely to encompass also firms that do not practice trolling voluntarily or only occasionally.

3. The consequences of patent trolls and patent brokers on R&D investments

3.1 The basic model

Two firms, a supplier of technology (called *S*) and a manufacturer (called *M*), are playing a two stages game: At the first step, *S* chooses to invest an amount *x* in R&D. At the second step, *M* observes *x* and chooses its own level of R&D, *y*. *M*'s R&D investments consist of customization and development, which therefore complement *S*'s R&D. The total value created by the two firms is $V(x,y)=x^{\alpha}y^{\gamma}$ (where α and γ $\epsilon[0,1]$ and $\alpha + \gamma < 1$)[9]. Furthermore, we assume that costs of R&D are linear and similar for the two firms: $C(x) = cx$ and $C(y) = cy$.

M can access to the knowledge produced by *S* via two different mechanisms:

- First, via a market arm-length transaction (technology licensing, Katz and Shapiro, 1985): *S* receives a share β ($0 \leq \beta \leq 1$) of the total value it has contributed to create and *M*, in exchange, receives the right to use *x* and to encompass it in its product. In this case, *S* and *M*'s revenues are respectively $\beta V(x,y)$ and $(1-\beta)V(x,y)$.
- Second, via knowledge spillovers: *M* benefits of a gratis externalities equals to *sx* ($0 \leq s \leq 1$). In this case, *M* keeps for itself the total amount of the created value *V(sx,y)* and *S* receives nothing.

The probability that *S* manages to find a buyer *M* and to handle a complex intellectual property transaction in order to receive βV is *p* (the probability that *M* benefits of a free knowledge spillover that amounts to *sx* is therefore *1-p*). In a sense, *p* can be interpreted as the strength of the patent system for technological firms like *S*. When *p* is small, spillovers are likely and the expected outcome for *S* is low. Conversely, the higher *p*, the lower the probability of spillovers, i.e. the bigger the probability that *M* will have to pay *S* for its contribution.

If *p* reflects the probability of spillovers, *s* rather stands for the intensity of knowledge flows in case of there is not a market transaction. Different combinations of *p* and *s* account

[9] Firms have perfect information about the value of the technology. Many authors have explored the issue of technology licensing when the value of the technology is not known either for the seller, for the buyer or for both (Gallini and Wright, 1990; Martimort *et al.*, 2010; Jullien *et al.*, 2011).

therefore for different technological regimes and degree of appropriation (Winter, 1984). For instance, in the case of the pharmaceutical industry both p and s are high because it is well known in this industry that patents are efficient to prevent imitation and that, since the knowledge base is largely codified, knowledge flows are easy. Conversely, in craft industries, where the tacit dimension of knowledge is prevailing, both p and s are small. It is indeed difficult to rely on intellectual property rights to prevent imitation but in the same time, knowledge flows are made very difficult by the tacit dimension of the know-how and skills.

When *S* chooses its level of R&D investments it does not know whether or not it will be able to find a buyer, but only the probability p to do so. Yet, at the second stage of the game, we assume that *M* knows whether or not the transaction was a market one (see the simple decision tree of the game in Annex 1). The subgame perfect Nash equilibrium (SPNE) of this simple two-stages game can be found directly by backward induction (Annex 1) and is given by $(x^* ; (y_1^*, y_2^*))$ where:

$$x^* = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (p\beta)^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta))^{\frac{\gamma}{1-\alpha-\gamma}}$$

$$y_1^* = \frac{[\gamma(1-\beta)]^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}}$$

$$y_2^* = \frac{\gamma^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}} (1-\beta)^{\frac{\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}} s^{\frac{\alpha}{1-\gamma}},$$

and where x^* stands for *S*'s R&D investments in the first stage of the game and y_1^* and y_2^* for *M*'s R&D investments, respectively in case of market transaction and spillovers.

It is interesting to notice that at the equilibrium, for a given level of x, *M*'s R&D investments are not always higher when it benefits of a free spillovers then when it must buy a license via a market for technology. When the price to pay to acquire the technology via the market (β) and the intensity of knowledge flows in case of spillovers (s) are reasonably small, $y_1^* > y_2^*$ (Lemme 1).

Lemme 1: $y_1^* > y_2^*$ if and only if $\beta < 1 - s^{\alpha}$.

Proof: Follows directly from the expression of y_1^* and y_2^*.

Another important result is that, whatever the value of the parameters of the model, S and M R&D investments at the equilibrium are always increasing with the probability to secure a market transaction (Lemme 2). As we will see in the next section, this result might legitimate the intervention of market intermediaries (brokers), which aim at reinforcing patent rights (decrease spillovers) and lowering transaction costs in order to improve market based technology transfer.

Lemme 2: x^*, y_1^* and y_2^* are all three strictly increasing with p.

Proof: Follows directly from the expression of x^*, y_1^* and y_2^*.

3.2 Patent brokers and R&D investments

The role of patent brokers is to secure market based IP transaction and to reduce the ability of manufacturing firms to free ride on technological firms. In other words, patent brokers increase p, the probability to realize a market transaction. We assume that when S relies on a patent broker, the probability to secure a market based transaction becomes $q > p$. Yet, the use of patent brokers is not free of charge. If they successfully manage to secure a market transaction, brokers receive a fraction δ of the total value created V (but if they do not manage to secure a market transaction they earn nothing). Furthermore, we assume that the earning of patent brokers does not affect the share that goes to M (which continues to earn $(1-\beta)V$) but are debited directly from the share that goes to technological firms (so that S earns now $(\beta-\delta)V$).

The introduction of patent brokers changes the structure of the game (see the decision tree in Annex 2). Now, S, after having chosen x, decides whether or not to rely on a patent broker. Then, in the last stage of the game, M, knowing whether the knowledge was transferred via a market transaction or spillovers, chooses y. Again, the SPNE of this game can easily be obtained by backward induction (Annex 2). Actually, two different SPNE are possible in this game according to the decision of S to rely or not on a broker (Lemme 3).

Lemme 3: $E_S(b) > E_S(\not{b})$ if and only if $q/p > \frac{\beta}{\beta-\delta}$.

Proof: Obvious and omitted.

If S does not choose to rely on a broker $\left({}^{q}/_{p} < \frac{\beta}{\beta-\delta}\right)$ then the SPNE is $(x^*\ ; \not{b}; (y_1^*, y_2^*, y_1^*, y_2^*))$[10]. Conversely, if S chooses to rely on a broker $\left({}^{q}/_{p} > \frac{\beta}{\beta-\delta}\right)$ then the SPNE is $(x_b^*; b; (y_{1b}^*, y_{2b}^*, y_{1b}^*, y_{2b}^*))$ where:

$$x_b^* = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (q(\beta-\delta))^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta))^{\frac{\gamma}{1-\alpha-\gamma}}$$

$$y_{1b}^* = \frac{[\gamma(1-\beta)]^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (q(\beta-\delta))^{\frac{\alpha}{1-\alpha-\gamma}}$$

$$y_{2b}^* = \frac{\gamma^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}} (1-\beta)^{\frac{\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (q(\beta-\delta))^{\frac{\alpha}{1-\alpha-\gamma}} s^{\frac{\alpha}{1-\gamma}} ,$$

and where x_b^* stands for S's R&D investments in the first stage, knowing that it will rely on a broker in the next step of the game, and y_{1b}^* and y_{2b}^* for M's R&D investments, respectively in case of market transaction and spillovers and knowing that S invests x_b^*.

<u>Lemme 4:</u> x_b^*, y_{1b}^* and y_{2b}^* are all three strictly increasing with q and strictly decreasing with δ.

<u>Proof:</u> Follows directly from the expression of x_b^*, y_{1b}^* and y_{2b}^*.

One can observe from the second SPNE (in which S relies on a broker) that both S and M R&D investments are strictly increasing with the performance of the patent broker (the extent to which it manages to increase q) and directly decreasing with the price the technological firm has to pay to the broker (Lemme 4). Furthermore, under the condition stated in Lemme 3, one can also show that both S and M levels of R&D investment in the economy increases with respect to the situation without broker (Lemme 5).

<u>Lemme 5</u>: When ${}^{q}/_{p} > \frac{\beta}{\beta-\delta}$, then $x_b^* > x^*$, $y_{1b}^* > y_1^*$ and $y_{2b}^* > y_2^*$.

<u>Proof:</u> Follows directly from the expression of x^* , y_1^*, y_2^*, x_b^*, y_{1b}^* and y_{2b}^*.

In other words, the presence of IP brokers always increases the aggregated level of R&D investment in the economy (at worst it is neutral) (Proposition 1). If the condition stated in

[10] The six arguments accounts respectively for S's investments at the first stage of the game (x^*), S's decision to rely or not on a patent broker (b or $\not{b}$) and M's R&D investments at the second stage of the game knowing whether or not x relied on a broker and whether or not the transaction was a market one.

Lemme 5 holds, the presence of brokers increases *S* and *M*'s level of investments and, if it does not hold, *S* will chose not to hire a broker, which will therefore not change the total level of R&D investments. In consequence, patent brokers are always R&D increasing. This result shed lights on the statement of McDonough who claims that: "the activity of patent dealers in their pure form benefits society" (2006, p. 204).

Proposition 1: The presence of patent brokers either is neutral (does not decrease) or increases the R&D investments of both *S* and *M*.
Proof: Follows directly from Lemme 5.

It is important to remark that the result emphasized in proposition 1 holds provided that patent brokers do not decrease the share of the value that goes to *M*. It might also be interesting to explore the situation in which patent brokers lower this share. All the more that this hypothesis is all but irrelevant since the experience of patent brokers in intellectual property valuation and transfer might clearly increase their bargaining power vis-à-vis manufacturing firms as compared to a situation in which manufacturing firms would have to deal directly with technological firms alone. Another qualification deals with the ability of manufacturing firms to use the knowledge produced by technological firms for free. We assumed here that *M* has a perfect absorption capacity which enables it to absorb at no cost the technology bought to *S*. It is usually not the case. However, it is likely that this issue of absorptive capacity does not affect the welfare implications of patent brokers in our model for, whatever the decision of *S* to rely or not on a broker, *M* must invest in an absorptive capacity. In other words, the social desirability of brokers is likely to be independent of firms' absorption capacity.

3.3 Patent trolls and R&D investments

Now, we envisage the possible intervention of patent trolls. Trolls operate late on markets for technology. They hide and as soon as a manufacturing firm has engaged R&D investments they claim patent infringement and ask for indemnification. When choosing its level of R&D *M* does not know whether or not it will have to indemnify an eventual troll. The main consequence of patent trolls is therefore to introduce uncertainty with respect to *M*'s freedom to operate. We assume that the probability to meet a patent troll is r (thus, the probability to have a freedom to operate is $1-r$). In case of *M* encounters a patent troll, the latter claims a share ε of V, the total value created by S and M. Hence, M receives only a payoff equals to $(1-\beta-\varepsilon)V$.

The presence of patent trolls changes again the structure of the game. The new SPNE can be obtained directly by backward induction (Annex 3) and is given by $(x_T^*; (y_{1T}^*, y_{2T}^*))$ where:

$$x_T^* = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (p\beta)^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta-r\varepsilon))^{\frac{\gamma}{1-\alpha-\gamma}}$$

$$y_{1T}^* = \frac{[\gamma(1-\beta-r\varepsilon)]^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}}$$

$$y_{2T}^* = \frac{\gamma^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}} (1-\beta-r\varepsilon)^{\frac{\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}} s^{\frac{\alpha}{1-\gamma}},$$

and where x_T^* stands for S's R&D investments in the first stage, and y_{1T}^* and y_{2T}^* for M's R&D investments in the second stage, respectively in case of market transaction and spillovers.

<u>**Lemme 6**</u>: S and M's R&D investments at the SPNE with patent troll are strictly decreasing with r and with ε.
<u>Proof:</u> Follows immediately from the expression of x_T^*, y_{1T}^* and y_{2T}^*.

<u>**Proposition 2**</u>: x_T^*, y_{1T}^* and y_{2T}^* are always smaller than x^* , y_1^* and y_2^* respectively. In other words, the presence of patent trolls decreases the R&D investments of both S and M.
<u>Proof:</u> Obvious and omitted

Proposition 2 states that patent trolling is always R&D decreasing in the economy. It is in line with Jaffe and Lerner (2004) and Henkel and Reitzig (2007) who explain that patent trolls' strategy is based exclusively on value destruction and that patent trolls create no surplus for society. It perfectly illustrates what Reitzig *et al*. (2010) call "collateral damage for R&D manufacturer". The likelihood to encounter a troll decreases the incentives of R&D manufacturers to invest in R&D which, in turn, decreases R&D investments of technological firms. However, this result holds under the hypothesis that trolls do not increase *p*, the probability for *S* to secure a market transaction. Yet, it is unlikely that pure patent trolls affect *p*, since pure patent troll are, by definition, not interested by technology transfer.

However, although trolls are unlikely to increase the probability to secure market transaction, p and r might nevertheless be positively correlated. Since both probabilities depend to some extent on characteristics of the patent system, they are indeed likely to be linked. For instance, if the patent system is strongly in favor of patent holders and makes it difficult for manufacturing firms to free-ride on non-practicing entities, it both increases p and r. Conversely, if the patent system makes it difficult for non-practicing firms to enforce their patents, it both decreases p and r. Hence, let us now assume that both p and r are positive functions of Φ, which might reflect the strength of the patent system for non practicing firms. In this case it is easy to see that R&D investments of both S and M are not monotonic functions of Φ (Lemme 7).

Lemme 7: In case r and p are both positive functions of Φ, S and M's R&D investments at the SPNE with patent troll are not always strictly increasing or decreasing with Φ.
Proof: Follows immediately from the expression of x_T^*, y_{1T}^* and y_{2T}^*.

Proposition 3: The optimal level of trolling might not be zero when r and p are both positive functions of Φ.
Proof: Follows immediately from lemme 7.

The intuition underlying proposition 3 is the following: When Φ varies it triggers two opposing effects. On the one hand an increase of Φ favors market transaction and decreases spillovers, which is R&D augmenting; On the other hand, it also favors trolling, which is R&D decreasing. The optimal level of Φ must thus balance those two effects. An important implication of this result is that, according to the context, there might exist a non-zero optimal level of trolling that must be tolerated in order to benefit from markets for technology and the raise of specialized technological firms.

4. Policy implications

Although trolling, in its pure form as it has been defined in the former section, is likely to entail important social costs, the activities of technological firms and pure knowledge brokers have a positive impact on R&D investments (and by extension on social welfare). One central challenge for policy makers is thus to design patent systems which limit the activity of trolling but are not detrimental to technological firms and brokers, the later being a critical part of a knowledge-based economy.

The raise of patent trolling is linked to three elements (Reitzig *et al*., 2007): First, the number and the quality of delivered patents; Second, the structure of patent litigations; and third the facility for trolls to operate in order to place other firms in a situation of hold-up.

First, patent trolls raise the issue of the number of delivered patents and, most of all, of their quality. In an ideal world, only inventions that are sufficiently new and inventive should be granted a patent. Yet, in the real economy of the past 20 years (mostly in the US) thousands of inventions that were not particularly new or inventive have been granted a patent (Jaffe and Lerner, 2004). This proliferation of low quality patents feeds patent trolling. It gives trolls access to cheap raw materials (existing patents), thus contributing to blur information for manufacturing companies. This is all the more exact that trolling strategies are compatible with low quality patents.

Hence, a first political measure to limit patent trolling might be to increase the standard to obtain patents, or at least to respect existing ones. This might strongly increase the quality of delivered patents, improve the visibility of manufacturing firms and decrease uncertainty. Consequently, this change might make the job of trolls more complex for, if the number of delivered patents decreases, it will be more and more difficult for trolls to hide the patents with which they operate[11]. This is clearly reflected in our model in which aggregated R&D investments are negatively linked to r. Thus, under the assumption that r depends on the number of delivered patents (the more patent delivered, the more likely to encounter a troll), reducing this number directly increases the R&D investments of the economy[12]. Notice that a measure that goes in the direction of increasing patent quality is to increase the cost to obtain a patent (Harhoff, 2009). This provides a strong argument against most patent practitioners and lawyers who fiercely advocate for decreasing patenting costs.

[11] Yet, increase patentability standards in order to improve patents' quality, although it goes in the right direction, will not be enough in itself to limit trolling activities. Patent trolls can and often do base their activities on high quality patents (Fisher and Henkel, 2009).

[12] However, making the delivery of patents more costly and/or more difficult might also penalize pure technological firms (it might decrease p). As a consequence, as stated by proposition 3, optimal patenting policy must be the outcome of a delicate balance between limiting trolling and encouraging technological firms.

Second, the structure of patent litigations in most countries makes the activity of patent trolls very attractive. Policies that reduce the interest of firms for trolling can play on three parameters of a patent litigation: The winning probability for patents' holders, the rules of indemnification and the possibility for patent holder to stop the activity of infringers.

- Nowadays, and this is especially true in the USA with the implementation of the Court of Appeal of the Federal Circuit (CAFC), the firm which is accused of infringement has a very high probability to lose the trial (Jaffe and Lerner, 2004). This obviously encourage patent trolling by inducing manufacturing firms to compromise, independently of the quality of the patents held by trolls.
- Indemnification rules also often make the practice of trolling very attractive. Those rules vary from one country to another (Reitzig *et al.*, 2007), but they often imply that it is more profitable for a firm to be infringed rather than to bargain a licensing agreement *ex-ante*[13].
- During a patent litigation the firm which is infringed can ask the judge to close the activity of the infringing firm (this can be done after the verdict is announced or even before by asking for a preliminary injunction, which may be granted if the judge considers that the survival of the infringed firm is threatened). This is a highly problematic issue for manufacturing firms that have engaged into costly sunk investments in order to manufacture their product. The possibility to require them to stop their activity obviously eases their willingness to compromise.

A second policy measure to limit trolling might hence play on those three dimensions of litigations. First, in the US, a rebalancing of the ruling of the court more in favor of defenders might help to make trolling less profitable. Yet, this is obviously a very delicate issue for policy makers, the outcome of a trial resting exclusively in the hands of judges. Second, it might be possible for judges to improve the indemnification rules in order to make trolling less interesting. In our model, for instance, aggregated R&D investments are negatively linked to ε, which depends directly on the indemnification structure of patent litigations. Thus, changes of the rules of indemnification that would decrease ε would in turn increase the total

[13] For instance, many courts assess the amount of royalties that infringing firms must pay to patentees on the basis of the average rate of royalties of the sector. This rule introduces obvious auto-selection problems, since firms who expect more than the average (because they have a valuable technology) have an incentive to bargain *ex-ante* while firms who expect less have an incentive to wait for litigation (Reitzig *et al.*, 2007). Another feature that favors trolling is that in the USA, the loser of a trial does not have to reimburse the money advanced by the winner, as it is the case for instance in France. This rule, by decreasing the cost associated to trolling also favors its development.

R&D investments of the economy. But again, this is also likely to affect β, the share that goes to technological firms. Third, a correction of the injunction rule, which might make it more difficult for fabless firms (including trolls and brokers) to close manufacturing activities, might also seriously reduce the attractiveness for trolling. Such correction is all the more important that in the case of litigation between a troll (or other fabless types of firms) and a manufacturing company this measures might not be justified. Indeed, since the troll does not commercialize any tangible products the activity of manufacturing companies do not threaten them and there is no reason to close the activity of the infringer.

The third characteristic that favors trolls' business model is based on the facility for firms to provoke hold-up. A manufacturing firm can be trapped in a hold-up situation for three reasons (Reitzig *et al.*, 2007): It can be victim of a submarine patent, which cannot be detected before its attribution (this is specific to the US system). It can miss to identify a relevant patent during its freedom to operate analysis, the multiplication of patents making those analyses more and more complexes. And, third, it might have identified the relevant patents but might have considered its holder as not dangerous (a partner for instance). Yet, the owner of a patent can change (buyout, bankruptcy) and become owned by a troll.

A third set of policy measures might hence consist in reducing the easiness to provoke hold-up. First, it is admittedly possible (and desirable) to improve patents information and to lower the number of low-value patents (by increasing the level of requirement as discussed above). It is also possible to implement a system of compulsory licensing which may prevent fabless firms from refusing to grant a license to a manufacturing company. Yet, those two measures, although they can improve slightly the situation, might not really prevent firms from strategically maneuvering in order to provoke hold-up and to earn a bigger share of the total value than what the intrinsic value of their technology might have allowed them to pretend in the first place.

Consequently, another measure that aims at decreasing radically the possibility to provoke hold-up might be to make it possible for manufacturing firms to signal publicly their manufacturing projects during a given period of time at the end of which, if no patent holders has came up, they achieve an entire freedom to operate. A website (largely advertised) could be specifically dedicated to this purpose. On this website, manufacturing firms could publicly announce the launch of a new innovation project before they engage sunk costs. During a certain period (for instance 3 months) patent holders would therefore have the opportunity to approach *ex-ante* the manufacturing company. For sure, true patent brokers would not hesitate to do so. Yet, at the end of the announcing period it would not be possible anymore for holders of patents applied for before this period to ask royalties to the manufacturing firm. This would clearly prevent trolling behaviors and ensure manufacturing firm of a clear freedom to operate after the closing of the announcing period[14].

5. Conclusion

This paper has explored the behaviors of pure patent trolls and pure patent brokers and their consequences on global R&D investments. We have showed that if patent brokers in their pure form always increase total R&D investments, pure patent trolls do not, on the contrary. This work stresses therefore clearly that one must distinguish between different kinds of NPEs. All are not trolls. Furthermore it teaches us that the raise of markets for technology might not always be welfare increasing, if in the same time it fosters the proliferation of trolling behaviors (Reitzig *et al.*, 2010).

We have also discussed the policy measures that can be implemented in order to limit patent trolling. Some of them have already been adopted or will be soon (Magliocca, 2006; Golden, 2007; Lemley and Shapiro, 2007). For instance, in the USA, the "patent reform act" passed in 2007 defines the payment of royalties on a more reasonable basis. Still in the USA, today it is almost impossible for fabless firms to require a preliminary injunction against manufacturing firms (this follows a recent ruling of the Supreme Court in the case MercExchange vs. Ebay Inc, McDonough, 2006). The quality of attributed patents is also improving significantly. Similarly in Europe, the 2004/48/EC directive attempts to harmonize the litigation practices across European countries.

However, it is important to keep in mind that, although those changes might contribute to limit patent trolling, the objective of policy makers might not be to eliminate completely patent trolls, if this also requires endangering technological firms. Indeed, patent trolls, patent

[14] Interestingly, this solution already exists with respect to new real-estate projects. In this case also, property developers often face hold-up situations provoked by neighbors who can block the project for a while by arguing diverse nuisances. To counter those trolling behaviors, in many countries real-estate property developers must publicly announce and describe (at the city house, for instance, or by displaying a sign at the place where the project will occur) their project before starting it. This aims at allowing neighbors to react to the project. And after a given period it is then not possible for neighbors to block the project.

brokers and technological firms all represent different faces of the same phenomenon: The raise of markets for technology. In this sense they all rely on strong patent systems. Hence, changes that limit trolling might also be detrimental to brokers and technological firms[15]. As emphasized by McDonough (2006), it seems inevitable that the fight against patent trolls, which means in some sense to weaken patents held by NPEs, affect also technological firms, thus harming the knowledge based economy at its heart. At the end it is likely that a balance will have to be found. As usual with respect to patent systems, the optimum is a matter of compromise and maybe a certain level of trolling might be socially desirable.

To conclude on an optimistic note, it is important to remind that our analysis of patent trolls was entirely static. However, in an evolutionary perspective, the episode of intense trolling faced in the last decade in the USA might, paradoxically, have been welfare increasing at least for two reasons: First because it has forced the patent law to change and to adopt a more balanced policy (especially in the US). Second, because it has forced manufacturing firms to improve their routines and practices of technology watch and freedom to operate analysis. It is hence likely that, nowadays, manufacturing firms are better prepared to react to the aggressive behaviors of some NPEs.

References

Akerlof, G., 1970. The Market for Lemons: Quality Uncertainty and the Market Mechanism. Quarterly Journal of Economics 84, 488-500.

Anand, B. N., Khanna, T., 2000. The structure of licensing contracts. Journal of Industrial Economics XL (VIII), 103-135.

Arora A., Gambardella A., 2010. Ideas for rent: An overview of markets for technology. Industrial and Corporate Change 19, 775-803.

Arora, A., Merges, R., 2004. Specialized supply firms, property rights and firm boundaries. Industrial and Corporate Change 13, 451–475.

Arora, A., Fosfuri, A., Gambardella, A., 2001. Markets for Technology: The Economics of Innovation and Corporate Strategy. Cambridge, MA, MIT Press.

Arrow, K. J., 1962. Economic Welfare and the Allocation of Resources for Invention.

[15] Linked to this point, it is also important to remind that we have studied here pure behaviors of brokers and trolls. Yet, in reality, the likelihood to find pure type of trolls and brokers on markets for technology is weak, since borders between trolls and brokers might largely be blurred.

In The Rate and Direction of Inventive Activity: Economic and Social Factors, Princeton University Press, 609-625.

Benassi, M., Di Minin, A., 2009. Playing in between: Patent brokers in Markets for technology. R&D Management 39(1), 68-86.

Chesbrough, H., 2003. Open innovation: The new imperative for creating and profiting from technology. Boston, Harvard Business School Press.

Dushnitsky, G., Klueter, T., 2010. Is there an eBay for idea? Insights from the online knowledge market places. European Management Review.

Farell, J., Hayes, J., Shapiro, C., Sullivan, T., 2007. Standard setting, patents and hold-up. Antitrust Law Journal 74, 603-670.

Fischer, T., Henkel, Y., 2009. Patent Trolls on Markets for Technology – An Empirical Analysis of Trolls' Patent Acquisitions. Presented at the 4th EPIP conference, Bologne, 24-25 septembre 2009.

Gallini, N., Wright, B., 1990. Technology transfer under asymmetric information. The RAND Journal of Economics 21, 147-160.

Gambardella, A., Giuri, P., Luzzi, A., 2007. The Market for patents in Europe. Research Policy 36 (8), 1163-1183.

Golden, J. M., 2007. "Patent trolls" and patent remedies. Texas Law Review 85, 2111-2161.

Grindley, P., Teece, D., 1997. Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics. California Management Review 39, 8-41.

Harhoff, D., 2009. Patent value and patent rating. Presented at the 4th EPIP conference, Bologne, 24-25 septembre 2009.

Jaffe, A., Lerner, J., 2004. Innovation and its discontents: How our broken patent system is endangering innovation and progress and what to do about it. Princeton University Press.

Jullien, B., Pouyet, J., Sand-Zantman, W., 2011. Make or sell? Innovation Licensing and market structure. Presented at the AFSE thematic meeting on "law and economics". Besançon, France, June, 9-10, 2011.

Katz, M., Shapiro, C., 1985. On the licensing of innovations. The RAND Journal of Economics 16 (4), 505-520.

Kingston, W., 2001. Innovation Needs Patent Reform. Research Policy 30, 403-423.

Lemley, M., 2007. Are universities patent trolls?. Fordham Intellectual Property, Media & Entertainment Law Journal, 18, 611-631.

Lemley, M. A., Shapiro, C., 2007. Patent hold-up and royalty stacking. Texas Law Review 85, 1991-2009.

Lichthenthaler, U., Ernst, H. 2008. Innovation intermediaries: Why internet marketplaces for technology have not yet met the expectations?. R&D Management 17(1), 14-25.

Magliocca, G., 2006. Blackberries and Barnyards: Patent Trolls and the Perils of Innovation. Notre Dame Law Review 82, 1809-1870.

Martimort, D., Poudou, J.C., Sand-Zantman, W., 2010. Contracting for an innovation under bilateral asymmetric information. Journal of Industrial Economics 48, 324-348.

McDonough, J. F., 2006. The myth of the patent troll: an alternative view of the function of patent dealers in and idea economy. Emory law journal 56, 188- 228.

Pénin, J., 2010. Le problème des « patent trolls » : comment limiter la spéculation sur la propriété intellectuelle dans une économie fondée sur les connaissances ?. Innovation : cahiers d'économie de l'innovation 32(2), 35-53.

Reitzig, M., Henkel, J., Heath, C. H., 2007. On sharks, trolls, and their patent prey –Unrealistic damage awards and firms' strategies of "being infringed". Research Policy 36, 134-154.

Reitzig, M., Henkel, J., Schneider, F., 2010. Collateral damage for R&D manufacturers: How patent sharks operate in markets for technology. Industrial and Corporate Change 19, 947-967.

Rivette, K. G., Kline, D., 2000. Rembrandts in the attic: Unlocking the hidden value of Patents. Harvard Business School Press.

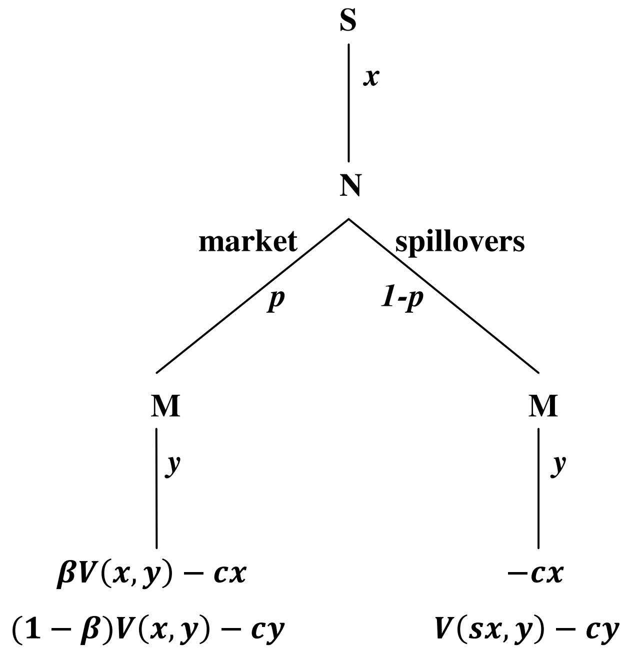
Shapiro, C. 2001. Navigating the patent thicket: cross licenses, patent pools, and standard Setting. In Jaffe, A., Lerner, J., Stern, N. (eds), Innovation Policy and the Economy. MIT Press.

Shrestha, S.K., 2010. Trolls or market-makers? An empirical analysis of non practicing entities. Columbia Law Review 110, 114-160.

Winter, S. G., 1984. Schumpeterian competition in alternative technological regimes. Journal of economic behavior and organization 5 (3-4), 287-320.

Yanagisawa, T., Guellec, D., 2009. The emerging patent marketplace. OECD Science, Technology and Industry working papers, 2009/09.

Annex 1: Decision tree of the basic game



The SPNE of this simple two stages game $(x^* ; (y_1^*, y_2^*))$ can be found directly by backward induction. At the second step of the game, *M* knows *x* and whether or not the technology has been acquired via a market transaction or spillovers.

In the first case (market transaction), *M* must therefore solve the following problem of payoff maximization:

$$\max_y (1-\beta)\, x^\alpha y^\gamma - cy \ ,$$

which implies that $y_1 = \left(\frac{\gamma(1-\beta)x^\alpha}{c}\right)^{\frac{1}{1-\gamma}}$ (for a market transaction)

In the second case (spillovers), *M* solves the following problem:

$$\max_y (sx)^\alpha y^\gamma - cy$$

which implies that $y_2 = \left(\frac{\gamma(sx)^\alpha}{c}\right)^{\frac{1}{1-\gamma}}$ (for a spillover)

At the first step of the game, *S* maximizes its expected payoff, knowing the best responses of *M*:

$$\max_x p\left[\beta x^\alpha y_1^\gamma - cx\right] + (1-p)[-cx]$$

which implies that:

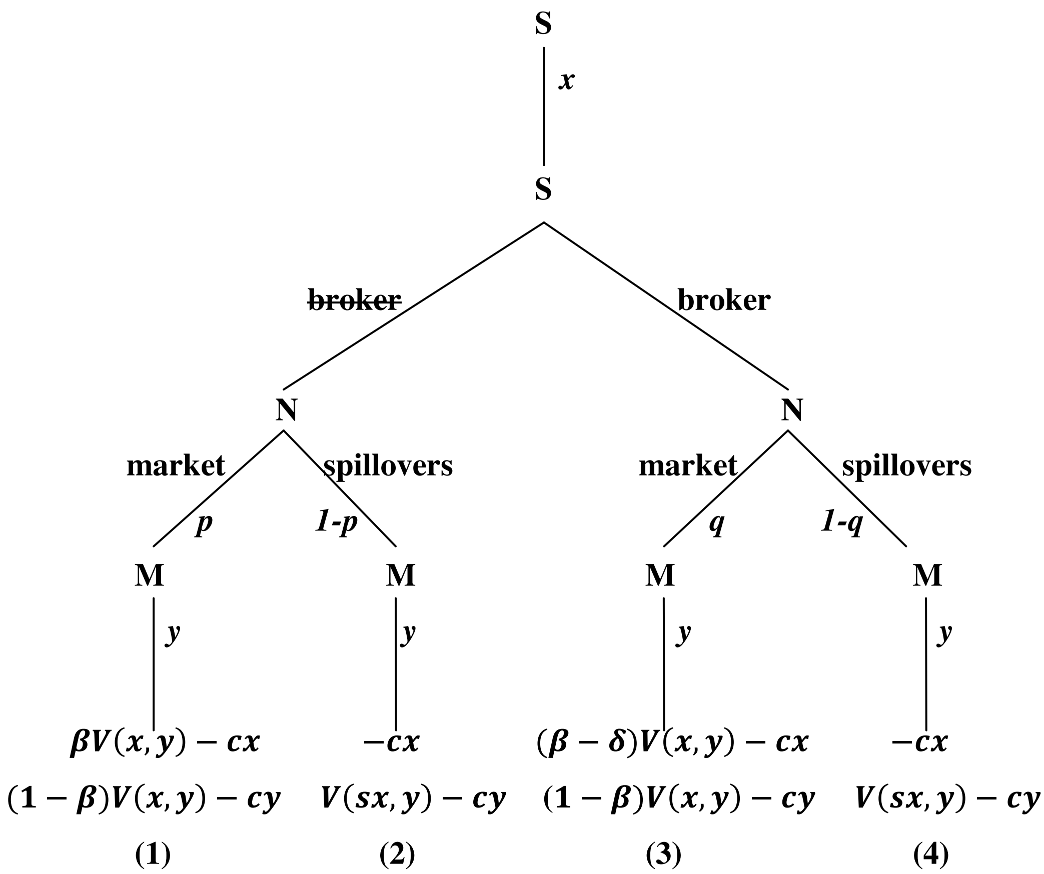
$$x^* = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (p\beta)^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta))^{\frac{\gamma}{1-\alpha-\gamma}}$$

Given *S*'s R&D investments, *M* will then choose the following optimal actions at step 2:

$$y_1^* = \frac{[\gamma(1-\beta)]^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}} \qquad \text{(for a market transaction)}$$

$$y_2^* = \frac{\gamma^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}} (1-\beta)^{\frac{\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}} s^{\frac{\alpha}{1-\gamma}} \quad \text{(for a spillover)}$$

Annex 2: Decision tree of the game with patent brokers



The SPNE of this game can be obtained by backward induction as follows: At the third stage of the game, *M*'s choice remains y_1 for a market base transaction and y_2 for spillovers. At the second stage of the game, *S* must choose whether or not to use a broker. Lemme 3 indicates that *S* will choose the broker as soon as the augmentation of the probability to secure a market transaction ensured by this option $\left(q/_p\right)$ is relatively higher than the cost δ (more precisely if $q/_p < \frac{\beta}{\beta-\delta}$). Then, at the first step *S* must choose its level of R&D investments. If $q/_p < \frac{\beta}{\beta-\delta}$, one obtains therefore a SPNE in which *S* chooses not to hire a broker and thus:

$$x^*_{\not b} = x^* = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (p\beta)^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta))^{\frac{\gamma}{1-\alpha-\gamma}}$$

In this case, since $x^*_{\not b} = x^*$, at the third step of the game, *M* will choose to invest $y^*_{1\not b} = y^*_1$ for a market transaction and $y^*_{2\not b} = y^*_2$ for a spillover and the SPNE of the game is $(x^*\,; \not b; (y^*_{1\not b}, y^*_{2\not b}, y^*_{1\not b}, y^*_{2\not b}))$.

Conversely, if $q/_p > \frac{\beta}{\beta-\delta}$, one obtains a SPNE in which *S* chooses to hire a broker and thus:

$$x^*_b = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (q(\beta-\delta))^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta))^{\frac{\gamma}{1-\alpha-\gamma}}$$

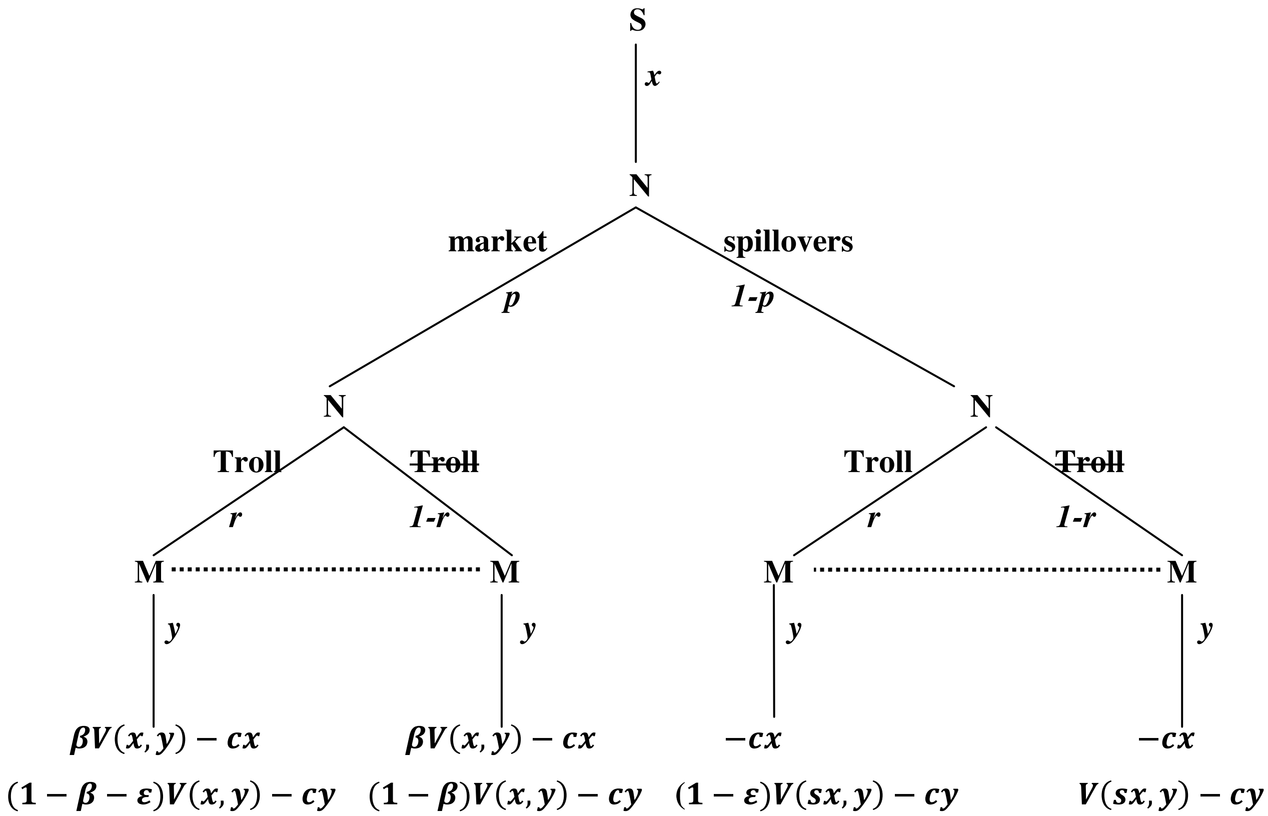
Then, at the third stage of the game, *M* will chose to invest:

$$y^*_{1b} = \frac{[\gamma(1-\beta)]^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (q(\beta-\delta))^{\frac{\alpha}{1-\alpha-\gamma}} \qquad \text{(for a market transaction)}$$

$$y^*_{2b} = \frac{\gamma^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}} (1-\beta)^{\frac{\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (q(\beta-\delta))^{\frac{\alpha}{1-\alpha-\gamma}} s^{\frac{\alpha}{1-\gamma}} \quad \text{(for a spillover)}$$

If $q/_p > \frac{\beta}{\beta-\delta}$ the SPNE of the game is thus $(x^*_b; b; (y^*_{1b}, y^*_{2b}, y^*_{1b}, y^*_{2b}))$.

Annex 3: Decision tree of the game with patent trolls



The SPNE of this game can be obtained by backward induction as follows: At the last period of the game, *M* invests in R&D an amount $y_{1T} = \left(\frac{\gamma(1-\beta-r\varepsilon)x^{\alpha}}{c}\right)^{\frac{1}{1-\gamma}}$, for a market transaction, and an amount $y_{2T} = \left(\frac{\gamma(1-r\varepsilon)(sx)^{\alpha}}{c}\right)^{\frac{1}{1-\gamma}}$, for a spillover. This implies that at the first stage of the game S chooses to invest and amount:

$$x_T^* = \left(\frac{1}{c}\right)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{1-\gamma}{1-\alpha-\gamma}} (p\beta)^{\frac{1-\gamma}{1-\alpha-\gamma}} (\gamma(1-\beta-r\varepsilon))^{\frac{\gamma}{1-\alpha-\gamma}}$$

Finally, given S's R&D investments, M will then choose the following optimal actions at step 2:

$$y_{1T}^* = \frac{[\gamma(1-\beta-r\varepsilon)]^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}} \quad \text{(for a market transaction)}$$

$$y_{2T}^* = \frac{\gamma^{\frac{1-\alpha-\gamma+\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}(1-\beta-r\varepsilon)^{\frac{\alpha\gamma}{(1-\gamma)(1-\alpha-\gamma)}}}{c^{\frac{1}{1-\alpha-\gamma}}} \left(\frac{\alpha}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha-\gamma}} (p\beta)^{\frac{\alpha}{1-\alpha-\gamma}} s^{\frac{\alpha}{1-\gamma}} \quad \text{(for a spillover)}$$

The SPNE of the game with patent troll is therefore $(x_T^*; (y_{1T}^*, y_{2T}^*))$.

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The Invisibility of the Public Domain in European IP Law

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- **What is the public domain (PD)?**
  - No exclusive IP rights, no statutory remuneration (levies)
  - Equal liberty to access and use intangibles (innovations, signs) for any lawful purpose
  - 4 Dimensions of the PD
    - Structural PD (requirements of protection)
      - Abstract ideas, concepts, formulas
      - Non-original, non-inventive applications of PD knowledge
    - Time-dependant PD (term of protection)
    - Voluntary PD (no application/waiver)
    - Specific PD (limitations/exceptions/scope of protection)

The invisibility of the

Public Domain

In European IP law

The invisibility of the PD

- **On the conceptual/semantic level**
  - All knowledge is "intellectual property"
    - "Commission Recommendation on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations" of 2008:
      - "Effectively exploiting publicly-funded research results depends on the proper management of intellectual property (i.e. knowledge in the broadest sense, encompassing e.g. inventions, software, databases and micro-organisms, *whether or not they are protected by legal instruments such as patents*)"
    - Commons as the dominant alternative narrative
      - But: open source, creative commons etc. also rely on IP rights

The invisibility of the PD

- **On the political level**
  - Commission Recommendation “on the digitisation and online accessibility of cultural material and digital preservation“ 2006
    - (c) promote the availability of lists of known orphan works and works in the public domain,
    - (d) identify barriers in national legislation to the online accessibility and subsequent use of cultural material that is in the public domain and take steps to remove them
  - But no reactions in this regard on the national (Communication 2008/513 final) or European level

The invisibility of the PD

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- **EU legislation:**
  - Directive Copyright Term of Protection 2006/116
    - Art. 5: “Member States may protect critical and scientific publications of works which have come into the public domain.“
    - But Art. 4: protection of previously unpublished works “after the expiry of copyright protection”

The invisibility of the PD

- **On a comparative level:**

	Art. 5 Dir. 2006/116	ECJ Flos/Semeraro
Spanish	dominio público	dominio público
Danish	offentlig ejendom	offentligt tilgængelig
German	gemeinfrei	gemeinfrei
Swedish	som inte längre skyddas av upphovsrätt	rättsskydd löpte ut
Greek	κτήμα του δημοσίου/ κτήμα δημοσίου	κοινό κτήμα

The invisibility of the PD

- **EU law <u>removes</u> works/designs from the PD**
  - ECJ *Sony Music/Falcon Neue Medien* 2009:
    - Requirement to grant copyright protection to works which had fallen into the public domain or had never been protected in member state A if only the work is still protected in one other member state
  - ECJ *Flos/Semeraro* 2011:
    - Requirement to grant copyright protection to designs which had been protected by a national design right but which had entered the public domain in that country *before the implementation of the respective Design Directive*

The invisibility of the PD

- **But see Golan v Holder in the U.S.**
  - “Restoration” of copyright in foreign works which had never been protected in the U.S.
  - There is a bedrock principle of copyright law that works in the public domain remain there
  - Removing works from the public domain alters the traditional contours of copyright protection
  - In this case, courts review whether such legislation violates the fundamental right of freedom of speech

- **How to counter this systemic imbalance**
  - Study the PD
    - Functions: economic, culture, education, democracy …
  - Legal doctrine:
    - Analyze the IP system from the perspective of the PD
    - Identify principles and rules which reflect/ignore the PD in the IP system and beyond

- **In particular: establish a *European Public Domain Supervisor* as an independent “guardian” of the PD**
  - Who would
    - monitor all legal developments;
    - advise all EU and national institutions;
    - hear and investigate complaints lodged by any person;
    - intervene in actions brought before the courts subject to applicable procedural law;
    - bring further limitations of the public domain to the attention of the public.

- **Some more self-promotion:**
  - See *Alexander Peukert*
    - "Die Gemeinfreiheit. Begriff, Funktion, Dogmatik"
      - forthcoming 2011/2012 Mohr Siebeck, Tübingen
    - "A European Public Domain Supervisor"
      - IIC 42 (2011), 125-129
      - http://www.ssrn.com/abstract=1711745

6th Annual Conference of the European Policy for Intellectual Property Association: Fine-tuning IPR debates

Bruxelles, 8-9sept-2011

Session 6 – IPRs, entrepreneurship and growth: is there a causal relationship?

Environment-friendly technologies and entrepreneurship: what do we learn about patents data?

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1. Introduction

The recent interest in green, or clean, technology is based on observations of the destabilising effects of human activity on the environment. Among these anthropic effects, changes affecting the climate appear to be some of the most significant, to the point that they have become a major concern for many scientists. Climate change is closely linked to the quantity of greenhouse gases (GHG) in the atmosphere, and asks the question of how to reduce them. In June 1992, the Rio Framework-Convention on Climate Change restated the need to stabilise the concentration of GHG in the atmosphere from the viewpoint of sustainable economic development. Subsequently, the signing of the Kyoto protocol in December 1997 represented the first step in international environmental regulation to reduce GHG emissions by industrialised countries.

In this context, green technologies seem to represent a way to reconcile human activity with the need to protect the environment by reducing the environmental damage caused by this activity and promoting the ecological transition of our economies[1]. These technologies are more efficient in their use of energy and more environmentally friendly than conventional technologies. They either provide solutions for environmental problems (adaptive technologies) or aim to reduce or stop the environmental impact of human activities (transformative technologies) (WTO and UNEP 2009).

However, regarding the evolution of material and immaterial investments in sustainable growth (Lorenzi and Villemeur 2009, Depret and Hamdouch 2010) and the necessary changes in the behaviour of economic actors, the mechanism of this ecological transition remains unknown. If there is no doubt concerning the increase of knowledge production in this field (OECD 2010), the way to generate economic value (i.e. transforming new ideas and knowledge into objects of value likely to attract a market) is uncertain. Moreover, reducing GHG emissions in the coming decades will have more to do with environmental regulation than with technological innovation, favouring technological continuity rather than generating new trajectories (Jorgenson *et al* 2009). Even if various initiatives emerge to promote entrepreneurship and innovation in green technology (specifically in US), they do not resolve the question of how to evaluate these new technologies and what forms the associated entrepreneurial opportunities might take.

We believe this question may be related to the problem of "entrepreneurial opportunity": how, and by whom, opportunities for bringing new products and services to market are discovered and created (Venkatamaran 1997, Shane, Venkatamaran 2000, Shane 2003)[2]? This entrepreneurial opportunity paradigm (Verstraete and Fayolle 2005) highlights the complexity of the entrepreneurial process, combining the economic and industrial aspects of the business environment with individual factors to explain how new companies and activities are created. This notion of entrepreneurial opportunity is particularly illuminating in the case of green technologies, exploring the questions of the dialectic relationship between the individual and his or her environment (technological, institutional etc.) (Chabaud, Messenghem 2010). The valorisation of entrepreneurial opportunities covers a variety of forms, in which the creation of new legal entities is just one aspect. Shane (2003: 224) emphasises that the exploitation of entrepreneurial opportunities can also involve licensing, corporate venturing and spin-offs. The question is which entrepreneurial form will best enable this technological knowledge to generate economic value? Will the development of a green economy involve the creation of new entities or the ecological transition will be driven by existing entities? According to us, answering this question gives the means to establish an environmental policy appropriate to the dynamic of green innovation.

[1] See for example the new review *Environmental Innovation and Societal Transition*.
[2] For a survey, see Short *et al* 2010.

This article aims to evaluate the potential forms by which entrepreneurial opportunity can be expressed in the area of green technology, which we define here as technology that helps to limit climate change due to greenhouse gas emissions, including technologies that save energy (energy efficiency), new sources of energy (solar, wind, biomass etc.) and systems to filter or capture CO_2 emissions. Building on Shane's work (2001, 2003), the central hypothesis of our research is that the organisational forms of entrepreneurial opportunity, in a given technological field, depend on the characteristics of the technological opportunities of this field. Analysing the characteristics of the technological opportunities provides an indicator of the entrepreneurial opportunities organisational forms. In order to characterise the technological opportunities provided by green technologies, we propose to study green patents (class Y02 in the European patent classification) in the three largest European countries, Germany, France and the United Kingdom, between 1998 and 2007.

Our research contribution has a dual aim. From an empirical viewpoint, we propose to characterise green patents from the three main European countries both quantitatively and qualitatively. From an analytical viewpoint, we propose to widen Shane's approach (2001) to the level of technological fields and countries. This paper is divided into four sections. The first sets out the theoretical foundations of our approach and shows that entrepreneurship can be a useful organisational form for supporting the development of green technologies. The second describes our research methodology, focusing on the relationships between technological opportunities and entrepreneurial opportunities, and presents the database used. The third section is devoted to a presentation of our results, and the last section concludes the article and opens a discussion of a future research agenda.

2. Entrepreneurship at the heart of green growth?

Traditionally, the literature has well described the limits associated with small organisations: weak efficiency, less attractive salaries, lower capacity to innovate etc. (Audretsch 2006: 47-48). However, both in theories of growth and in work on the economics of innovation, it appears that entrepreneurship can constitute a key means of renewing the economic system and promoting the development of a variety of technological options. Having been tolerated, ignored or despised until the 1990s, entrepreneurship has now been rehabilitated as a driver of economic growth and a vehicle for innovation. In this section, we examine the role to entrepreneurship in economic analysis.

2.1. Entrepreneurship, economic growth and externalities

A major part of endogenous growth theory literature highlights the role of knowledge as a factor in a country's economic growth. Considering the volume of investment necessary to produce this knowledge, it is clear that large companies potentially contribute more than small ones. As consequence, small companies or start-ups play a marginal role due to their limited resources. Consequently entrepreneurship seems to be underestimated in the initial endogenous growth theories.

However, recent work has emphasised that new entrepreneurs stimulate growth (Audretsch *et al* 2006). Entrepreneurship creates network externalities that promote the circulation of new ideas and the formation of new markets (Minniti 1999), acting as vehicles for knowledge spillover effects (Carlsson *et al* 2009, 2010). This work leads to the rehabilitation of the entrepreneur's role in economic growth (Facchini 2007) and even in regional development. Audretsch and Keilbach (2008) demonstrate that entrepreneurship in German regions is important in knowledge spillovers processes. Existing companies generate knowledge but do not exploit them. Regions provided with entrepreneurial capital in this way can use these opportunities and obtain better levels of economic growth "*[…] the creation of new technological opportunities through R&D increases economic performance directly but also indirectly through inducing knowledge-spillover entrepreneurship*" (Audretsch and Keilbach 2008: 1704). Finally, Audretsch's key argument, concluding his article on the emergence of an entrepreneurial economy, is relevant here: "*Entrepreneurship gains a new importance in knowledge-based economy, and serves a key mechanism by which the knowledge created in an organisation is exploited commercially by a new company. In this way, it contributes to economic growth, employment and overall economic vitality*" (2006: 67 – our translation). Entrepreneurship imposes itself as the previously missing link between knowledge spillovers in the economy and the commercialisation of new ideas (Audretsch 2006: 66). Centrals to models of endogenous growth, knowledge spillovers mechanisms rehabilitate entrepreneurship as a relevant organisational form.

2.2. Entrepreneurship and the dynamic of innovation

Traditionally, the economic theory of innovation highlights the role of large companies in the dynamic of productive change, emphasising their ability to mobilise major human and financial resources. However, various research have shown that large companies have little incentive to innovate because of their dominant competitive position, their organisational inertia or their lake of responsiveness due to their routines. It would seem that a large proportion of current innovation comes from "*high-tech entrepreneurship in regional innovation clusters such as Silicon Valley, Research Triangle, Austin, Texas and Route 128 around Boston*" (Audretsch 2006 : 53). In other words, small companies' potential for innovation and change should not be underestimated.

2.3. Entrepreneurship and the emergence of new industries

Industrial studies of innovation have shown that small companies have a key role in emerging industries such as biotechnology or software. Their ability to offer radical innovations, their flexibility, their responsiveness and their willingness to take risks make small companies catalysts for change. They are the ones responsible for most innovation in these industries (Audretsch 1995). In older industries such as pharmaceuticals or aeronautics large corporations, relying on their R&D capacity, are the most innovatives. Industries at the beginning of their life cycle have a relatively greater potential for radical innovations than mature industries. These radical innovations carry the promise of technological trajectories that can revolutionise existing technology. The emergence of new industries frequently is related to worldwide growth in knowledge production and patent applications (Guellec *et al* 2010).

Taken together, these approaches rehabilitate the entrepreneurial dynamic in economic analysis. Recent developments in green technology suggest that this is an emerging industry with disruptive technologies, new trajectories, radical innovations, supporting new forms of economic growth. So we may reconsider the entrepreneurial problem and develop research into entrepreneurial processes in green technology.

2.4. From technological opportunity to entrepreneurial opportunity

This research revives entrepreneurial economics, but it does not tell us either what triggers entrepreneurial opportunity or what form it can take. This is why it is interesting to compare this work with recent theoretical developments in "entrepreneurial opportunity". Matching these literatures, questions whether technological opportunities encounter and generate entrepreneurial opportunities, and in which organisational forms?

The existence of technological opportunities is not a sufficient condition for the creation of new businesses. Generating economic value from technological opportunities can take a variety of forms, and their exploitation does not necessarily involve business creation. There is a process of divergence which means that individuals doesn't see the same potential in an idea, allowing it to spread beyond the firms frontiers by knowledge spillovers. "*Due to the fundamental characteristics inherent in new ideas, an idea which an agent thinks may potentially generate value may not be seen in the same way by the people who take the decisions in the company, [especially] if the new knowledge is not consistent with the company's central skills or with [its] technological trajectory. [This] divergence [...] subjects individual workers [or teams] contributing to knowledge to a fundamental choice: ignore the idea and redirect their activities in a direction more compatible with the organisation, or try to appropriate the value of the new idea in the organisational context of a new company*" (Audretsch 2006: 64 – our translation).

Patents are an interesting indicator to follow technological and entrepreneurial opportunities. Their trends and qualitative characteristics approximate their entrepreneurial potential of green technologies. If we consider patents as markers of technological and entrepreneurial opportunity (Kreft, Sobel 2003:5), the central questions remains how.

3. An exploratory approach to entrepreneurial opportunity in a sustainable economy based on invention patents

It is now well established that many patents applied for or granted are never commercially exploited (Trajtenberg 1990). There is thus no direct link between the number of patents applied for or granted in a particular technological field and the creation of new companies or, more broadly, new activities. As Shane (2001)[3] reminds us, we need to identify the nature of the technological opportunities associated with the patents in order to understand the process and the organisational form by which technological opportunities can be transformed into entrepreneurial opportunities.

3.1. Research methodology

Based on a study of 1397 inventions patented by MIT between 1980 and 1996, Shane (2001) selects three criteria to evaluate entrepreneurial opportunity and shows that the importance, radicalness and patent scope have a positive influence on the decision to create a company and to exploit the patent commercially[4]. Firstly, the importance of a patent, measured by the total number of citations it receives in subsequent patents, suggests the hypothesis that the more important a patent is, the more likely it is to be exploited commercially with the creation of a new business. Secondly, the patent radicalness implies that the more radical a technology is the more it will have to be supported by new technological skills. It is more difficult for existing companies to make this technological change, going beyond their established skills and even cannibalising their own products. Consequently, radical innovations tend to be introduced by new entrepreneurs. The technological radicalness of a patent is measured by the number of technology classes of the patents cited by a particular patent. Thirdly, the patent scope suggests the diversity of applications of the newly created technology. It is measured by the number of technology classes in which the patent is submitted.

In summary, the relevance of business creation as the organisational form for the commercial exploitation of entrepreneurial opportunities is linked to the qualitative analysis of patents. This paper presents an exploratory statistical analysis of the citations in published patents by technological fields and countries, concentrating on the importance of technological opportunity.

3.2. Our database

Since late 2010 green technologies have been classified at the European Patent Office with a specific ECLA code, which breaks down as follows.

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[3] « *Technological opportunities differ from each other on several dimensions, which influence the decision to found a new firm* » (Shane 2001: 205).
[4] « *The probability that an invention will be commercialized through the creation of a new firm varies with the nature of the technological opportunity discovered* » (Shane 2001: 217).

Y General tagging of new technological developments

Y02 Technologies or applications for mitigation or adaptation against climate change

Y02C Capture, storage, sequestration or disposal of greenhouse gases

Y02C10 CO2 capture or storage
Y02C20 Capture or disposal of greenhouse gases other than CO2 (nitrous oxide, methane, perfluoroncarbons [PFC], hydrofluorocarbons [HFC], sulfur hexafluoride SF6])

Y02E Reduction of greenhouse gases emissions, related to energy generation, transmission or distribution

Y02E10 Energy generation through renewable energy sources
Y02E20 Combustion technologies with mitigation potential
Y02E30 Energy generation of nuclear origin (excluded from out database)
Y02E40 Technologies for an efficient electrical power generation, transmission or distribution
Y02E50 Technologies for the production of fuel of non-fossil origin
Y02E60 Technologies with potential or indirect contribution to GHG emissions mitigation
Y02E70 Other energy conversion or management systems reducing GHG emissions.

In these two subclasses, Y02C and Y02E, we identify eight principal groups (which are divided very unequally into 180 subgroups). Patents relating to nuclear technology, Y02E30, are excluded. The documents analysed are patent families. A family is defined as a set of documents with the same priority number. Each family includes a set of documents (patents and extensions) relating to the same invention.

The global figures of patent families published during the period 1998-2007 according to this classification is as follows:

ECLA code	Number of patent families published worldwide (1998-2007)	% of patent families published worldwide (%)
Y02C10	1,719	1.1%
Y02C20	1,412	0.9%
Y02E10	41,033	26%
Y02E20	5,698	3.6%
Y02E30	3,823	2.4%
Y02E40	2,618	1.7%
Y02E50	8,647	5.5%
Y02E60	94,704	60%
Y02E70	1,116	0.7%
Total	**157,734**	**100%**

It is interesting to note that two groups (Y02E10 and Y02E60) account for 86% of green patents published. This is due to American and Japanese involvement in technologies that contribute indirectly to reduce GHG emissions (energy storage, hydrogen technology, fuel cells etc.)[5]. This distribution confirms that the "sectoral" aspect should not be neglected. The rate of patent deposit changes from one technological field to another: "*usually one patent that covers the whole product in the case of plant or chemical products. In contrast, a software product can easily involve hundreds of patents for a single product*" (Mergers, 2006:2), and patents have different roles depending on the technology (Lemley 2005).

According to the EPO-ICTSD report (2010), 80% of green innovations developed in the world come from six countries: Japan, the United States, Germany, Korea, France and the United Kingdom. Here we take a particular attention in patent applications in three European countries: France, Germany and the United Kingdom. These three European countries have the most innovative contribution in the field of green technologies (Glachant *et al* 2011). Together, these countries account for nearly 10% of patent families published in the world during the period. The other three contributing countries, Japan, Korea and the USA, account 26.5% of patent publications in the world over the period. We propose to concentrate our analysis on a relatively homogeneous group of applicant countries. More precisely, we select the patents based on the applicant's country rather than the inventor's country.

ECLA code	Number of patent families published by German applicants	Number of patent families published by British applicants	Number of patent families published by French applicants	Number of patent families published by American applicants	Number of patent families published by Japanese applicants	Number of patent families published by Korean applicants	Number of patent families published by German, British or French applicants
Y02C10	118	52	114	598	147	40	280
Y02C20	121	49	77	359	203	46	246
Y02E10	3,886	763	578	2,977	2,283	1,409	5,182
Y02E20	627	119	180	1,061	446	107	916
Y02E30	410	35	264	799	267	114	706
Y02E40	202	44	39	386	178	89	276
Y02E50	666	145	116	803	249	300	919
Y02E60	4,879	827	1,184	11,759	11,729	6,097	6,830
Y02E70	111	11	11	109	74	55	133
Total excluding nuclear	**10,322**	**1,950**	**2,244**	**17,546**	**15,030**	**8,073**	**14,382**
Total	10,729	1,985	2,507	18,337	15,292	8,187	15,084

Applicant's country, publication date between 1/1/1998 and 31/12/2007.

Finally, the period chosen for the analysis covers ten years, from 1/1/1998 to 31/12/2007. The choice of the lower limit is justified by the signature of the Kyoto protocol (10/12/1997), which is known to

[5] Y02E60 counts for 64% of US patent families and 77% of japanese patent families.

have had a clear impact on the direction of knowledge production (EPO-ICTSD 2010). For the upper limit, we exclude the period of the financial crisis to examine patents prior to 2008. This cut-off point also gives enough time, more than three years, for the patents granted to be cited by subsequent patents.

4. The results

The research is part of a wider programme aiming to evaluate the organisational forms associated with entrepreneurial opportunities generated by green technologies. We have already shown that, from theoretical point of view, the choice between creating new entities and exploiting an entrepreneurial opportunity within an existing company is partly linked to the characteristics of the technological opportunity. Here we present the initial results obtained by analysing these characteristics based on patent citations published in three European countries between 1998 and 2007.

4.1. Evaluation of technological opportunity in each country

Worldwide, there are currently 474,590 patent families aiming to reduce climate change (Y02). Around 270,230 patent families (57%) were published since the signing of the Kyoto protocol and 157,734 in the 10 years covered by our study, representing a third of the total. Globally, the mid-1990s represented the start of growth in the publication of green patents in the three countries. But it was in Germany that the Kyoto protocol had the greatest impact. 1998 was marked by the publication of 3.5 times as many patents published as in 1997, compared with 2.4 times in France and 2.3 in the United Kingdom. This German dynamism, is confirmed over the period examined and puts the country in fourth place in the world in applications for green patents.

The estimate of the green technologies importance in each country is based on the number of citations of the patents published. In the table below, we see that Germany is well ahead of France and the United Kingdom. Not only do the patents published by German applicants have a higher level of citation (28% compared with 22% for the UK and 19% for France), but more importantly the average number of citations for each patent published or cited is also high (0.63 and 2.23 respectively). Clearly, the importance of the technological opportunities associated with German green patents suggests that the country could create new companies to exploit these entrepreneurial opportunities commercially.

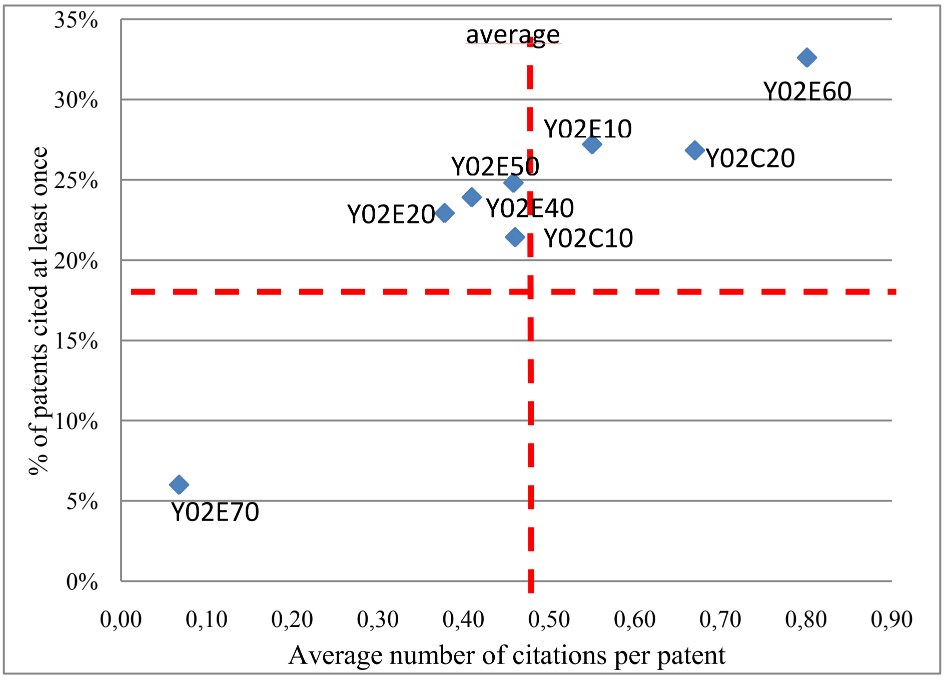
Statistical analysis of citations of patent families published between 1998 and 2007 by country

Applicant country	Number of patent families published	Number of patents cited at least once	Percentage of patents cited at least once	Total number of citations	Average number of citations of each published patent	Average number of citations of each cited patent	Maximum number of citations for the most cited patent
FR	2240	435	19%	769	0.34	1.77	9
GB	1950	429	22%	740	0.38	1.72	9
DE	10322	2930	28%	6521	0.63	2.23	21

4.2. Evaluation of technological opportunity in each technological field

We know that the higher a patent's citation statistics are (the number of times a patent is cited by a patent applied for subsequently), the more important and economically valuable the patent is (Hall *et al* 1998, Harnoff *et al* 1999). We measure the importance of a technological field by the number of citations obtained by patents in the field from other patents in the same field; here the pools of cited and citing patents are the same, and correspond to the technological field.

Distribution of technological fields according to the average number of citations per patent and the percentage of patents cited



The first observation is that a relatively high number of patents are never cited. On average, 23% of patents are cited at least once. Moreover, although a few patents are cited more than 10 times, the average number of citations for each patent published is 0.47, and 1.93 for each patent cited. Three technological fields have above average citation values: Y02E010 (energy generation through renewable energy sources), Y02E60 (technologies with potential or indirect contribution to GHG emissions mitigation) and Y02C20 (capture or disposal of GHG other than CO2). The first two fields are also the areas with the strongest invention activity. We could deduce that these areas have the higher probability to generate new businesses. On other hand, the Y02E70 field appears very weak (it is also the area with the lowest volume of patents published over the period), and thus probably presents few entrepreneurial opportunities.

5. Conclusion

Based on the theoretical observation that the emergence of a green economy could rehabilitate entrepreneurship with the paradigm of entrepreneurial opportunity, this article assesses the potential forms by which this opportunity could be expressed in the area of green technologies by describing technological opportunities.

Analysing green patents over time clearly shows the impact of the Kyoto protocol on the search for innovative solutions to mitigate GHG emissions. Based on the analysis of green patent citations, we have shown that the main European countries of Germany, France and the United Kingdom do not have homogeneous pools of patents. Consequently, the organisational forms of entrepreneurial opportunities should take different configurations, and Germany stands out with a higher potential for new businesses creation.

Moreover, the entrepreneurial dynamic is also unequal by technological fields. While certain fields present a high level of publication associated with large numbers of citations, indicating the importance of these patents (Y02E10 and Y02E60), other fields remain less dynamic (Y02E70), suggesting that technologies are less mature and require more fundamental research – this is the case with the GHG capture and storage technologies, for example (Picard 2011).

This first empirical study has a number of limits, and several perspectives of research can be underline. Firstly, the analysis should be improved with further indicators to characterise technological opportunity (in particular, radicalness and scope). It will then be important to examine the ambiguity of whether the existence of technological opportunities sustains business creation or if the willingness to create companies leads to the technological opportunities creation. To clarify this, analysing the institutional origin of patent applicants may be interesting. Additionally, if we accept the role of spillovers in entrepreneurship, it is important to evaluate these and trace flows of knowledge more precisely. Finally, this work cannot be completed without comparing the results obtained with the statistics for green start-ups in Europe.

References

ACS Z., M. SANDERS (2011), "Patents, knowledge spillovers, and entrepreneurship", *Small Business Economics*.

ACS Z., D. AUDRETSCH (eds) (2003), *Handbook of Entrepreneurship Research*, vol.1, Kluwer Academic Publishers, Dordrecht.

ACS Z., D. AUDRETSCH, P. BRAUNERHJELM, B. CARLSSON (2004), "The missing link: the knowledge filter, entrepreneurship and endogeneous growth", *WP Centre for Economic Policy Research*, London discussion paper n°4783.

ACS Z., D. STOREY (2004), "Introduction: entrepreneurship and economic development", *Regional Studies*, 38: 871-877.

AGHION P. (2009), "Quelles politiques pour encourager l'innovation verte?", *La Revue Socialiste*, 4è trim. (69): 45-51.

ANSELIN L., A. VARGA, Z. ACS (1997), "Local geographic spillovers between university research and high technology institutions", *Journal of Urban Economics*, 3(42): 422-448.

ANTONELLI C. (1999), "The evolution of the industrial organisation of the production of knowledge", *Cambridge Journal of Economics*, 23(2): 243-260.

AUDRETSCH D. (1995), *Innovation and Industry Evolution*, Cambridge, MIT Press.

AUDRETSCH D. (2006), "L'émergence de l'économie entrepreneuriale", *Reflets et perspectives de la vie économique*, 1, tome XLV: 43-70.

AUDRETSCH D. (2007), *The Entrepreneurial Society*, Oxford University Press, New York.

AUDRETSCH D., M. KEILBACH (2008), « Resolving the Knowledge Paradox: Knowledge-spillover Entrepreneurship and Economic Growth", *Research Policy*, 37: 1697-1705.

AUDRETSCH D., M. KEILBACH, E. LEHMANN (2006), *Entrepreneurship and Economics Growth*, Oxford University Press, New York.

CARLSSON B., Z. ACS, P. BRAUNERHJELM, D. AUDRETSCH (2009), "The knowledge spillover theory if entrepreneurship", *Small Business Economics*, 32(1): 15-30.

CARLSSON B., Z. ACS, P. BRAUNERHJELM, D. AUDRETSCH (2010), "The missing link: knowledge diffusion and entrepreneurship in endogeneous growth", *Small Business Economics*, 34(2): 105-125.

CHABAUD D., K. MESSENGHEM (2010), "Le paradigme de l'opportunité. Des fondements à la refondation", *Revue Française de Gestion*, 7(106) : 93-112.

FACCHINI F. (2007), "Entrepreneur et croissance économique: développements récents", *Revue d'Economie Industrielle*, 3è trim. (119).

GUELLEC D., T. MADIES, J.C. PRAGER (2010), *Les marchés de brevets dans l'économie de la connaissance*, La documentation française.

GLACHANT M., A. DECHEZLEPETRE, I. HASCIC, N. JOHNSTONE, Y. MENIERE (2011), "Invention and transfer of climate change mitigation technologies on a global scale: a study drawing on patent data", *Review of Environmental Economics and Policy*,

HALL B.H., C. HELMERS (2010), "Innovation in clean/green technology: can patent commons help?", *WP Berkeley Center for Law and Technology*, California.

HALL B.H., C. HELMERS (2010), "The role of patent protection in (clean) technology transfert", *Santa Clara High Technology Law Journal* (à completer).

JOHNSTONE N., I. HASCIC, F. WATSON (2010), *Climate policy and technology innovation and transfer: an overview of recent results*, Paris, OCDE: OECD Report ENV/EPOC/GSP(2010)10.

JORGENSON D., R. GOETTLE, M. SING HOC, P. WILCOXEN (2009), "Cap and trade climate policy and US economic adjustments", *Journal of Policy Modeling*, 31: 362-381.

KREFT S.F., R.S. SOBEL (2003): "Public policy, entrepreneurship, and economic growth", *West Virginia University Economics Working Papers 02-2003*, Morgantown.

LEMLEY M.A. (2005), "Patenting nanotechnologies", *Stanford Law Review*, 58(2): 601-630.

LORENZI J.H., A. VILLEMEUR (2009), *L'innovation au coeur de la nouvelle croissance*, Economica.

MERGES R.P. (2006), "Patents, Entry and Growth in the Software Industry", *Working Paper*.

MINNITI M. (1999), "Entrepreneurial activity and economic growth," *Global Business and Economics Review*, 1(1): 31-42.

PICARD F. (2011), "L'Open Innovation dans les « Green Technologies » : le cas des technologies de capture et de stockage des gaz à effet de serre", *Colloque ISERAM « Innover seul ou avec les autres »*, Paris, janvier.

POTTS R.G., J. FOSTER, A. STRATON (2010), "An entrepreneurial model of economic and environmental co-evolution", *Ecological Economics*, 70: 375-383.

SHANE S. (2003), *A general theory of entrepreneurship*. *The individual-opportunity nexus*, Edward Elgar, Northampton, MA.

SHANE S., S. VENKATARAMAN (2000), "The promise of entrepreneurship as a field of research", *Academy of Management Review*, 25 (1): 217-226.

SHORT J.C., D.J. KETCHEN, C.L. SHOOK, R.D IRELAND (2010), "The concept of 'opportunity' in entrepreneurship research: past accomplishments and future challenges", *Journal of Management*, 36 (1): 40-65.

STOREY D.J. (1991), "The birth of new firms – does unemployment matter? A review of evidence", *Small Business Economics*, 13(1): 27-55.

TRAJTENBERG M. (1990), "A penny for your quotes: patent citations and the value of innovations", *Rand Journal of Economics*, 21(1), spring.

VERSTRAETE T., A. FAYOLLE (2005), "Paradigmes et entrepreneuriat", *Revue de l'entrepreneuriat*, 4(1): 34-52.

The Structural Transformations of Internationalized R&D Activities: An Analysis of Patent Data

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Abstract

We discuss the extent and characteristics of the internationalization of world-wide inventive activity between 1990 and 2006 using a novel set of sectoral patent-based indicators. We carry out the analysis separately for five broad technological areas, so as to appreciate differences cross-country, cross-technology, and their evolution in time.

The observed level of internationalization of inventive activities varies importantly across both technologies and countries, and it has increased in time in all sectors and in most countries. Compositional effects, which derive from changes in the relative shares of the technological sectors, generally play a positive but modest role in explaining the observed aggregate increase in internationalization. A novel indicator, named "applicant surplus", allows to appreciate the presence of systematic asymmetries in how countries participate to the production of innovation globally. Important structural characteristics of internationalization differ both cross-country, and also, within countries, across sectors.

JEL classification: O31; O34; F21; F23; F29.
Keywords: Patents; R&D; Internationalization; Technological Sectors; Gravity Model.

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1. Introduction

The internationalization of inventive activity has long been identified as an area of economic endeavour which is "far from globalised", to cite a paper that twenty years ago underlined the asymmetry between the realities of contemporary production of goods, where the concept of distance, if not dead, is at least blurred, and the production of immaterial goods such as blueprints and inventions, much of which still takes place in geographically proximate sites (Patel and Pavitt 1991). Lately, this opinion has been challenged (Patel and Vega, 1999; Le Bas and Sierra, 2002). There is a perception that R&D internationalization has made considerable inroads over the last two decades, deriving in part from anecdotal evidence – witness the spur in media coverage on multinational enterprises (MNE) setting up R&D labs in places such as China and India[2] (e.g. The Economist, 2010; Overby, 2007) – but also the appearance of several scholarly sectoral case studies (e.g. pharmaceuticals, Bennato and Magazzini, 2009; Penner-Hahn and Shaver, 2005; biotech, Shan and Song, 1997; semiconductors, Almeida, 1996).

Not only have observers described an increase in the *quantity* of international collaborations, but also a modification of their *qualitative aspects*. Several taxonomies have been proposed of the motivations and characteristics of R&D internationalization. In one of the simplest and most widely adopted, a contrast is drawn between "home-base exploiting" and "home-base augmenting" objectives (Kummerle, 1997). According to the former, on the one hand MNE set up R&D labs abroad in order to exploit their already developed assets, and their inventive activity is mostly of the adaptive type. Patel and Vega (1999) and Le Bas and Sierra (2002) provide evidence in support of this perspective (see also Vernon, 1966 for an early product-cycle rationale of this argument). Following home-base augmenting motivations, on the other hand, MNEs seek to obtain abroad strategic assets that are complementary with those which are already available to them (e.g. Kummerle, 1997; Florida, 1997; and Serapio and Dalton, 1999).

Several analysis underline how the latter type of R&D internationalization has built speed, and is gradually shaping a panorama where the production of innovation is carried out by truly

[2] Consider this excerpt from The Economist (2010): "The world's biggest multinationals are becoming increasingly happy to do their research and development in emerging markets. Companies in the *Fortune* 500 list have 98 R&D facilities in China and 63 in India. Some have more than one. General Electric's health-care arm has spent more than $50m in the past few years to build a vast R&D centre in India's Bangalore, its biggest anywhere in the world. Cisco is splashing out more than $1 billion on a second global headquarters—Cisco East—in Bangalore, now nearing completion. Microsoft's R&D centre in Beijing is its largest outside its American headquarters in Redmond."

international networks, to fit – finally – the presumption which we may have on how a truly globalized world should work (e.g. Griffith et al. 2006; Cantwell and Piscitello, 2005).

Organizational and managerial studies of the firm also have considered the issue. The focus, generally, is not on internationalization proper, but on the organizational set-up of the R&D function. In a corporate world where the multidivisional "M-form" is a standard, there are two logical polar models (and all the hybrids of these two that could possibly be conceived) to manage R&D: a decentralized organization, where each division has its own R&D lab, which it manages in autonomy; and a centralized organization, substantiated by the presence of a single corporate R&D lab, whose director reports directly to a corporate-level executive such as the CEO (Argyres and Silverman, 2004; see also Singh, 2008 and Arora et al., 2011).

The relationship between ways of managing R&D and its geographic dispersion (of which internationalization is one aspect) are not obvious: an organizationally centralized R&D could branch out to several international locations, just as a set of divisional R&D labs could be geographically proximate. However, and although in non-obvious ways, the geographic dispersion of R&D is linked with the way it is organized, if nothing, for the reasons that geographic distance presents a coordination problem that needs to be managed, one way or another.

Case studies shed light on the ongoing intensification and transformation of R&D internationalization but, by their selective nature, come short of providing a much desired overall picture. On the other hand, the type of anecdotal evidence that makes it to the pages of the specialized press (witness, the article in The Economist, 2010) tends to suffer from a selection bias: what obtains visibility are the big events in R&D internationalization, while the less-glamorous production of innovation according to the good old ways risks of being under-reported.

In this paper we follow a different route and we use patent data that, although with the known caveats, allow to obtain a comprehensive view on the production of innovation at the world level. This is particularly true given that, to harness the power of patent data, we adopt an innovative approach (documented in de Rassenfosse et al. 2011), which draws on the data of all the (at least marginally significant) patent offices in the world, as they are collected and organized in the Patstat database (European Patent Office, 2009a and 2009b). The result is a truly global view of what gets patented worldwide. We identify international collaborations as those patent applications which have inventors and/or applicants from different countries, an approach that has several antecedents, such as Guellec and van Pottelsberghe de la Potterie (2001), OECD (2008) and, most recently, Picci (2010).

Those works considered aggregate measures of patents, regardless of their technological field. However, we know from case studies that the innovation process differs across technologies in several dimensions, the degree and characteristics of internationalization being one of them. For example, referring again to the home-base exploiting vs. augmenting debate, different technologies have different needs in terms of local adaptation, so that the exploitation of the home base is likely to happen in varying degrees and forms across technologies. Also, regardless of the *nature* of internationalization, its *intensity* varies across sectors, witness the fact that most stories which we hear about R&D outsourcing to India and to China refer to the information and communication technologies (ICT), leading to the belief that innovation in ICT is more internationalized than the average (a belief that, we anticipate, is confirmed by our analysis). But the intuition drawn from case studies and anecdotal evidence may be wrong, and it is only a comprehensive analysis, like the one that we propose, that may help in establishing some useful stylized facts on the intensity and structural characteristics of international R&D activities. To do this, we adopt WIPO's International Patent Classification (IPC) taxonomy, to consider a subdivision of technologies into five sectors.[3]

A focus at the level of individual technologies offers several analytical advantages. First, obviously, it permits to appreciate any differences that there may be in the extent and characteristics of internationalization across technologies. In this context, it is particularly instructive to consider the contrast between the alternative measures of internationalization which have been introduced in Picci (2010), where a distinction is made between focusing on country A applicants and country B inventors, or vice versa (what in our analysis below, will translate in the difference between two measures that, we anticipate, we will call *InvApp|App* and *InvApp|Inv*). The relation between these measures may change (and, we anticipate, *does change*) not only across countries, as already shown in Picci (2010), but also across technologies within countries, and in time, reflecting the presence of time-changing structural differences in the innovation processes, across countries *and* technologies.

Secondly, attention toward individual technologies allows us to appreciate what produces the aggregate results that we observe when we look at internationalization of R&D *tout court*. In particular, it allows to measure to which extent the observed increase in internationalization is

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3 We will indifferently use the term "technological sector", "macro-technology" (to underline the fact that, within each, a finer subdivision is possible), or sectors. Their detailed definition, in terms of the IPC taxonomy, is in Appendix A. The use of the word "sector" is made purely out of convenience, and has no relation with the concept of industrial sector, as incarnated, for example, by the NACE code system. There is no direct link between the NACE code of a firm, and the IPC code of its patent application. See Schmoch et al. (2003).

driven by the presence of compositional effects – i.e., by the possibility that the more internationalized sectors (such as, the ICT) have increased their relative share over the last twenty years in many countries. Compositional effects, that is, could explain an increase in the degree of internationalization at the aggregate level, even when there is no increase of internationalization at the sectorial level. We anticipate that this is not the case, that compositional effects have not played an important role in most countries and that, in conclusion, the overall increase in internationalization which we observe is driven by increased internationalization across the technological spectrum.

The rest of the paper is structured as follows. The next section frames the problem within the debate on the internationalization of R&D, and on the organizational characteristics of R&D within the firm. We then present and justify the measures of internationalization which we use. After a description of the data, we consider the possible presence of compositional effects in the observed growth of the rate of internationalization. Last, we introduce an indicator that we call "Applicants surplus" (or alternatively, "Inventors deficit"), and we analyze its variations across countries and across sectors.

2. The internationalization of R&D

We define a patent to be international if at least one inventor and one applicant are from different countries[4]. While inventors are always individuals, applicants may be entities of different nature: firms, universities and other research institutions, government branches, non-profit organizations and, finally, also individuals. Picci (2010) analyzes a sample of 1000 patents which present this characteristic[5], and shows that in the 79% of cases, the applicant of internationalized patents involve the cooperation of a MNE's subsidiary or headquarter (and another 15% of cases involve firms which are not multinationals - see his Table 3). In our population of international patents we do not identify the nature of the applicant, for the simple reason that it would be prohibitively costly to do so. The sample analysis in Picci (2010), however, shows that roughly in four cases out of five, a patent application has been filed by a MNE. It follows that the type of

[4] Please note that we use the term "international patent (application)" as a short hand, and with no reference to where it is filed (nationally, or via the so called "international route").

[5] The population from which the sample is drawn is not the same as ours, which is about 10% more numerous, since more (minor) patent offices have been included into the analysis. For the rest, the same criterion of analysis, documented in De Rassenfosse et al. (2011) is adopted. The type of internationalization we are referring to is defined of the "InvApp" both in Picci (2010) and in this paper.

internationalization of inventive activity which we observe, by and large is determined by behaviours of MNEs, and we will interpret the data accordingly.

We interpret the behaviour of these MNEs from two distinct angles. First, a firm chooses the locations where its R&D activities are carried out, and they can be more or less dispersed in space. Secondly, firms choose to carry out their R&D by means of an organizational set-up that, as a first approximation, may be seen as a point within an interval, defined at one extreme by complete centralization, and at the other extreme, full decentralization. We consider these two aspects in turn.

Kuemmerle (1997) contrasts two alternative motives for carrying out R&D activities internationally: the intent may be "home-base exploiting", focusing on leveraging on existing R&D expertise in new markets abroad, or "home-base augmenting", whereby firms seek knowledge available only in specific locations. In the first case, R&D abroad is predominantly of the applied and adaptive type, and the innovation developed in the firm's home country, whose potentiality of exploitation in foreign markets are pursued, occupies the central stage. Within "home-based exploiting" internationalization, the logical centre of the innovation process is the R&D lab (a single corporate lab, or possibly a plurality of decentralized labs) residing in the home country, and the R&D lab abroad plays an ancillary role within the innovation process of the MNE.

The "home-base augmenting" type of internationalization, on the other hand, taps at new knowledge in foreign locations, and gets closer to a model of innovation which is truly international and which does not depend (as strongly) from the corporate R&D labs residing in the home country. The R&D labs abroad do not play an ancillary role any longer, but participate to the firm's innovation process by contributing original assets adding to the firm's knowledge base (Song et al. 2011)[6].

While the literature finds evidence of a shift from "home-base exploiting" R&D activities to "home-base-augmenting" ones (e.g. Song et al. 2011; Kuemmerle, 1999; Almeida, 1996), Penner-Hahn and Shaver (2005) suggest that the two may be complementary, rather than alternative models. Studying a sample of Japanese pharmaceutical industries, they find that even though firms operate R&D activities in foreign countries to tap into local knowledge, these investments are effective only if the MNE already masters the underlying technology. Leiponen and Helfat (2011) in a study of Finnish manufacturing firms find that multi-location R&D enhances the output of

[6] The distinction between "home-base exploiting" and "home-base augmenting" echoes a debate on the nature of FDI, which is "asset-based" when the international expansion is based on existing technological advantage, and "asset-seeking" when it is a means to access new localized knowledge. This specific local knowledge may be acquired from different sources, ranging from research labs to customers (e.g. in user-based innovation) and competitors (Leiponen and Helfat, 2011; Penner-Hahn and Shaver, 2005).

imitative innovation, but not of new-to-the-market innovations. In fact, their study shows that the choice of multi-located R&D is important also *within* the national borders. Locating firms abroad should be thus determined by specific characteristics that require the internationalization of R&D, such as specific characteristics of national innovation systems (Nelson, 1993). Nevertheless, the conclusions drawn from these two papers are not easily amenable to generalization, since they are based on case studies.

The way firms organize their R&D activity varies widely, unlike what we observe in the overall organization of firms, given nowadays the predominance of the "M-form" (Argyres and Silverman, 2004). Indeed, since research has a public-good nature which produces important spillovers, centralized forms of R&D successfully capture these externalities. By contrast, in a decentralized organization, divisional managers whose reward is tied to performance have little incentive to facilitate the flow of knowledge across divisions, which end up not appropriating intra-firm's rents (Kay, 1988). It may also be the case that competition for resources among divisions provides incentives *against* those research projects which present strong spillovers (Arora et al. 2011). A decentralized solution would then lead to underinvestment in R&D, because the hurdle that potential project would have to pass in order to be financed would be decided at the divisional level, without consideration for benefits accruing to the other divisions. Centralization of R&D would internalize such research spillovers, allowing to fund projects that divisions would not undertake otherwise.[7] Heavy-spillover projects are also of broader impact, and this implies that in a centralized form R&D research will target non-specific, long-run projects, while in a decentralized form managers will be likely to invest in short-run, specific projects (Lerner and Wulf, 2007; Arora et al. 2011).

In addition, given that the output of non-specific R&D projects are more difficult to measure, the "high powered" incentives operating at the division level are going to be more effective with easy-to-measure output while, in a centralized form, low powered would lead to non-specific research (Argyres and Silverman, 2004). The flipside is that researchers belonging to corporate R&D lab have more freedom in selecting projects according to their scientific interest rather than for their economic relevance, while decentralized research lab have privileged access to information about the market value of innovation.

Given that a decentralized structure will favour product-specific research, the divisional innovation is likely to draw from downstream information such as user needs, competitors characteristics, and local knowledge. This implies that the activities of the divisional research team

[7] One may argue that internal licenses or ex ante taxes could internalize intra-firm spillovers. This is not likely to happen given the presence of uncertainty and informational asymmetry, resulting in commitments and credibility problems typical of principal-agents settings (Argyres and Silverman, 2004).

need be more interdependent with other personnel, and it is thus preferable to cluster them in a single division (Argyres and Silverman, 2004). By contrast, non-specific knowledge is typically up-stream and impacts on a higher number of subsequent innovations and on a broader range of technologies, and it gains lower benefits from specialized, divisional information.

Decentralized forms of R&D have thus the advantage of increasing efficiency by improving the processing of information and reducing the opportunism of management and R&D personnel. However, this efficiency gains may also be outweighed by the inability to exploit economies of scales deriving from the management of multiple or sequential projects (Henderson and Cockburn, 1996). Argyres and Silverman (2004) suggest that this argument does not hold only when internal transactions costs are low, in which case administrative economies of scope can be exploited without requiring the centralization of authority. By contrast, when transaction costs are high a centralized structure is to be preferred from an efficiency standpoint.

Summing up, a more decentralized organization of R&D is expected to lead to narrower, product-specific innovations of a more applied nature. The empirical findings of the organizational literature supports these hypothesis, suggesting that different organizational choices target different kinds and quality of R&D output. Arora et al. (2011), studying about 4000 corporations and affiliate firms and 600.000 matched patents, find support for such a view. Centralization favours R&D which is broader in scope and has a high technological impact, while decentralized R&D favours research which is narrower in scope. The findings by Arora et al. (2011) are also consistent with a previous study by Argyres and Silverman (2004) and, from a different perspective, with Singh (2008), who investigates the relationship between geographical dispersion and the quality of innovations, finding a negative relationship. Interestingly, Arora et al. (2011) also show that the extent of decentralization is associated with higher market value, while centralization provides value through efficiency and projects' coordination. They thus suggest, somehow in line with Penner-Hahn and Shaver (2005), that the greater value in R&D may be created by linking centralized R&D to customer-based business. With this respect, notice that Argyres and Silverman (2004) found that the hybrid type of R&D organization is preponderant (50% of the sample, to be contrasted with 10% fully decentralized structures and 31% fully centralized structures), but, by contrast, produces innovations of narrower impact with respect to fully decentralized structures.

As noted by Singh (2008), geographic configuration and formal organization are two related but distinct issues. For instance, a firm may have a relatively small number of R&D locations and a decentralized organization. To reconcile the organizational and geographical angles, Leiponen and Helfat (2011) propose that if on the one hand a decentralized MNE with multiple locations has high coordination costs, on the other hand coordination between physically distant units is not a relevant issue when considering applied and market-specific R&D. Intriguingly, while Arora et al. (2011) find that firms in the electronics technological area are less decentralized, in section 4 we show that the electronics area is the most internationalized. This evidence further supports the view that decentralization and internationalization may be issues which are distinct not only from a logical standpoint.

3. Measuring internationalization

To measure the internationalization of inventive activity, we draw from Picci (2011), where three (absolute) measures of internationalization are defined: *InvInv*, corresponding to a situation where at least two inventors are from different countries; *AppApp*, whereby at least two applicants are from different countries, and *InvApp*, describing a situation where there is at least one inventor from a country different from at least one applicant. This last concept of internationalization is the most general of all, since if a patent is *InvInv* or *AppApp*, it is also of the *InvApp* type (but not vice versa).

Let's call Inv_{ip} the fractional attribution of patent p to an inventor of country i. To clarify this, consider a patent which has four inventors, one German, one French, and two Americans: then, $Inv_{US,p}=0.5$; Inv $Inv_{DE,p}=0.25$; $Inv_{FR,p}=0.25$. Analogously, App_{ip} is the fractional attribution of patent p to an applicant from country i. We can then construct the following *absolute* measure of strength of collaboration between inventors of country i and applicants of country j in patent p:

$$InvApp_{ijp} = Inv_{ip} \cdot App_{jp}$$

Summing over patents $p=1,\dots,P$ we obtain a measure of the overall strength of the collaboration between inventors of country i and applicants of country j:

$$InvApp_{ij} = \sum_{p=1}^{P} InvApp_{ijp} .$$

These are *absolute* measures, because they represent numbers of international patents. Besides absolute measure, we also consider *relative* ones, representing the fraction of internationalized patents, i.e., one of the absolute measures of internationalization divided by the total number of patents. The *InvApp* absolute measure generates two alternative relative measures, *InvApp|Inv* and *InvApp|App*, whose differences, as we will argue, convey interesting information on the nature of internationalization of R&D. The *InvApp|Inv* derives from the absolute measure by normalizing it by the total number of inventors of country i :

$$InvApp_{ij|i} = \frac{InvApp_{ij}}{Inv_i}$$

In what follows we will refer to this relative measure as *InvApp|Inv*.[8]

The *relative* measure *InvApp|Inv* expresses the relevance of national inventors and extra-national applicants. The *InvApp|Inv* measure can be usefully contrasted with another *relative* measure, *InvApp|App*:

$$InvApp_{ij|j} = \frac{InvApp_{ij}}{App_j}$$

This measure refers to the relevance that collaborations between national inventors and extra-national applicants. In section 6 we introduce a new measure, the "Applicant surplus" (or "Inventor deficit"), which is defined as the ratio of *InvApp|App* and *InvApp|Inv*.

4. A description of the data

We consider data from the Patstat database (European Patent Office, 2009a and 2009b), covering 34 countries[9] from 1990 to 2006. We consider all priority applications filed at any of a group of 47 patent offices[10], that cover the virtual totality of worldwide patenting activity, using a methodology that is illustrated in de Rassenfosse et al. (2011). The methodology takes full advantage of the fact that Patstat allows to track multiple applications in different offices claiming the right to priority for the same invention. Considering patent applications, instead than granted patents, allows for the analysis of more recent data (since the granting process may take several years). In what follows, whenever for simplicity we will mention patents, we will in fact always mean patent *applications*. We assign patent applications to countries either according to the nationality of the inventor ("inventor criterion"), or of the applicant ("applicant criterion"). We also distinguish the technological field of the patent, and whether the patent is fully "national", i.e., all its inventors and applicants are from the same country, or "international", if the previous statement is not true. In all cases, we employ fractional counting, to reflect the fact that a single patent

[8] For the properties and further details on these measures refer to Picci (2010).

[9] These are: all OECD countries, plus countries invited to open discussions for membership to the OECD: (Brazil, China, India, Indonesia and South Africa) and Taiwan.

[10] These are patent offices from all OECD countries, plus countries invited to open discussions for membership to the OECD: (Brazil, China, India, Indonesia and South Africa), Bulgaria, Honk Kong, Latvia, Lithuania, Romania, Russia, Singapore, Taiwan and the European Patent Office.

application may have to be assigned to different countries fractionally (if, say, inventors are from different countries), or to different technological fields (if a patent application contemplates more than one such field).

Table 1 shows the number of patent applications (according to the inventor criterion) for the 25 most prolific countries in 1990, 1998 and 2006.

[Table 1 about here]

The most prolific patent applicants are Japan, Korea and China, the latter following an impressive surge during the last decade. Their prominence follows, at least in part, from a higher propensity of patenting (see, on Japan: Coehn et al., 2001; on Korea. Hu and Mathews, 2005; on China: Hu, 2010). There follows the United States, whose share of World patents has declined over time, notwithstanding its much-hyped "patent inflation". Within Europe, Germany has the lion's share of patenting activity, followed at a distance by the UK and France. These countries together are responsible for over 90% of patent application's worldwide.

We now turn to the measures of internationalization which we introduced in the previous sector. Out of 10,940,242 priority applications filed at the selected patent offices (between 1990 and 2006), 263,220, or 2.6%, are international according to the *InvApp* measure. In what follows, we only consider the more general measure, *InvApp*.

In Figure 1 we observe the *InvApp|Inv* measure for the United Kingdom, the United States, France, Germany, and Japan. The countries display substantially different levels of internationalization, ranging from the UK, always steadily above 16% since 1992, to Japan, always lower than 1%. Despite being relatively small in size, the internationalization phenomenon has grown considerably since 1990. Nevertheless, after the year 2000, internationalization has been showing a slightly decreasing trend for these countries, with the exception of Germany.

[Figure 1 about here]

In Table 2 we provide a summary of the changes in the degree of internationalization for the 25 countries that file the most patents. For clarity, we only present here measures pertaining to all technologies, and we will consider variations cross-technology below.

[Table 2 about here.]

We present, for 25 countries, both the *InvApp|App* and *InvApp|Inv* relative measures of internationalization. Their difference is instructive and will be considered in a following section. The degree of internationalization increased in most of the countries considered. For example, it more than doubled in the United States, it increased about 50% in the UK, and it increased fivefold in Finland. The variation across countries are wide. Smaller countries tend to be more internationalized than bigger ones, and Japan and China are characterized by a very low degree of internationalization.

Within countries, there tend to be important difference between the *InvApp|App* and *InvApp|Inv* measure. Most notably, the former is bigger than the latter in the United States, indicating the presence of relatively many US applicant who produce international patent, relative to US inventors. The opposite tends to be true for many European Countries, and also for the European Union as a whole (see Picci 2010).

Together with the growth of patenting and internationalization, some countries have changed significantly the technological composition of their patenting activity. We distinguish technologies by taking advantage of the fact that patent applications are assigned one or more codes describing their technological fields, according to the WIPO's International Patent Classification (WIPO, 2011). We adopt the taxonomy proposed by Schmoch (2008), who identifies 35 technological fields, that can be regrouped to form five macro-tecnologies: Electrical engineering (*Electr*), Instruments (*Instr*), Chemistry (*Chem*), Mechanical engineering (*Mech*), and Other technologies (*Other*). See Appendix A for a description of the constituent technologies in terms of the IPC classification, and how they are aggregated to form the five macro-technologies.

[Figure 2 about here]

Figure 2 depicts the shares of patents by technological sector for the six countries which are most prolific in patenting. In Germany and France the shares are roughly constant in time, *Mech* always playing a prominent role. In China, the US and the UK, on the other hand, we observe a marked increase in the share of *Electr*. In particular, the share of *Electr* in the US has grown from about 20% in 1990 to 47% in 2006. By contrast, in Japan there has been a reduction in the share of the same macro-technology during the first half of the nineties, along with *Other*, the technological composition of patents remaining then roughly unchanged through the end of the period.

We now consider how the degree of internationalization varies across macro-technologies. Figure 3 shows the *InvApp|Inv* measure of internationalization for the five macro-technologies in six countries.

[Figure 3 about here]

Despite the heterogeneity in the composition of patenting activity, and their different dynamic evolution, *Electr* is the most internationalized technological sector. Japan is an exception, since until 2002 it is *Chem* that provides the higher contribution to internationalization. The most striking aspect of Figure 3 is that in some countries and in specific sectors the internationalization of research activity is already a significant phenomenon. For example, since the mid-nineties in the UK *Electr* about 30% or more of the patents have been the result of international collaborations. In France the internationalization of the same sector has steadily increased until 2002, reaching a peak of 20%. In Germany, *Electr* has steadily increased its degree of internationalization, oscillating since 2002 from 10% to 12%. The other sectors show a marked increase in internationalization both in Germany and in France.

5. Decomposing the aggregate increase in internationalization

We showed that the degree of internationalization has increased over time in the aggregate (Figure 1), that it is uneven across macro-technologies (Figure 3), and that the relative importance of macro-technologies has changed in time (Figure 2). We now purport to determine to which extent the growth in the aggregate rate of internationalization may be explained by the presence of compositional effects, i.e. effects which are due to the change in the shares observed in Figure 2. To fix ideas, assume that there are only two technological sectors and that, within each, the rate of internationalization stays constant in time. If one sector is more international than the other, and if its relative importance grows over time, than we would observe an increase in aggregate internationalization, which would be the result of a pure compositional effect. We perform a decomposition for the growth rate in internationalization in a "growth" and a "compositional" component, using a formula that we here show for the special case of two technological sectors (extending this reasoning to a context where the sectors are more than two is straightforward) that we identify with *A* and *B*. Moreover, we identify with *TOT* all technologies.

Let's call $Int_{i,t}$ the rate of internationalization of sector *i* at time *t*, equal to the number of international patents of technology *i*, divided by the total number of patents of that technology. $Int_{i,t}$ can be any of the four concepts of relative internationalization introduced in Picci (2010) (*InvInv/Inv, AppApp/App, InvApp|Inv and InvApp|App*), but in what follows, for simplicity, we consider *InvApp|Inv* only. We call $Sh_{i,t}$ the share of sector *i* at time *t* over all technologies, equal to the total number of patents of technology *i*, divided by the total number of patents of all technologies. This share can be computed either according to the inventor or the applicant criterion; since in practice the two deliver very similar measures, choosing one or another makes no difference, and in our computations we adopt the former.

It holds that $0 \leq Int_{i,t} \leq 1$ and $0 \leq Sh_{i,t} \leq 1$, and the overall rate of internationalization is equal to the weighted sum of the rates of internationalization of the two technologies:

$$Int_{TOT,t} = Sh_{A,t} \cdot Int_{A,t} + Sh_{B,t} \cdot Int_{B,t}$$

We want to decompose the growth rate of internationalization into an authentic growth effect and a compositional effect. Let's consider the growth index $Int_{TOT,t} / Int_{TOT,t-1}$ and *t*=1. After simple manipulations, that we report in Appendix B, we obtain:

$$\frac{Int_{TOT1}}{Int_{TOT0}} = \frac{(Sh_{A1} - Sh_{A0})Int_{A1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} + \frac{(Sh_{B1} - Sh_{B0})Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} + \frac{Sh_{A0}Int_{A1} + Sh_{B0}Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}}$$

The first term represents the compositional effect due to sector *A*, the second term the compositional effect due to sector *B*, and their sum the overall compositional effect. The last term is the pure growth effect, which can be broken down into the contributions of each single sector.

[Figure 4 about here]

Figure 6 decomposes the total growth in internationalization, for all technologies, for a selection of countries between 1990 and 2006. Notice that the compositional effect can be negative, if there is a reduction in the share of the more internationalized sectors, as it is the case for Japan. While the compositional effect is relatively small for the majority of countries, in some cases, e.g. China, it is larger than the non-compositional effect. Overall the observed increase in the internationalization in inventive activity at the aggregate level mostly follows from greater internationalization at the macro-technology level, and only to a minor extent to shifts in the composition of technologies.

When these shifts do play a role, in most cases it is positive, and it follows to a great extent the increase in importance over time of the highly internationalized *Electr* sector. Figure 7 shows, for a selection of countries, the evolution of the cumulative compositional effect at the macro-technology level. Notice that its relevance is increasing over time, but its main contribution in all countries is due to *Electr* (which for Japan is largely negative, as predicted above).

[Figure 5 about here]

6. Measuring the "Applicant surplus" (Inventor deficit)

Before we introduce the concept of "applicant surplus", we discuss the measures of relative internationalization which we introduced in section 3: *InvApp|App*, referring to collaborations between national inventors and extra-national applicants, and *InvApp|Inv*, expressing the relevance of national inventors and extra-national applicants. These measures are not only instructive in their own right, but also, their difference is of interest, because it expresses the relative importance of national applicants and inventors from each country in producing international patents.

[Figure 6 about here]

Figure 6 displays both metrics for the US, France, and Germany. First, notice that in the US *InvApp|App* is always higher than *InvApp|Inv*, while the opposite happens for France. These differences can be interpreted as evidence of the pre-eminence of US national applicants in internationalized R&D activities – a result that had already been underlined in Picci, 2010, and that we further discuss. The case of Germany is less straightforward to describe, since the gap between the two measures is relatively small and of varying sign over time.

[Figure 7 about here]

As Figure 7 shows, this happens because in Germany different technological sectors exhibit different patterns of internationalization. For example, while in the *Chem* sector the *InvApp|App* measure is higher, the opposite happens, to a smaller extent, in *Electr*. The traditional strength of the German chemical sector, in other words, is accompanied by an important role of German applicants abroad, while other macro-technologies may display a more important role for foreign applicants employing German inventors. Also, note that the innovation process of another power horse of German innovation, the *Mech* macro-technology has different characteristics when it comes to its internationalization, as it is shown by the fact that the two measures are tangled across years, showing a substantial balance.

To systematically compare the two measures of relative internationalization we create an appropriate index:

$$App\_surplus_{ij} = (1 - InvAppApp_{ij|j} / InvAppInv_{ji|j}) * 100$$

We call this measure "applicant surplus" (or, indifferently, "inventor deficit"). Expressed in percentage points and for country couples *i,j*, it is greater than zero when country *i* contributes relatively more applicants than inventors relative to country j, in all joint international patent applications. A value of $App\_surplus_{ij}$ greater than 0, in other words, means that if we look at the production of international patents involving country *i* and *j*, the former contributed with relatively many applicants, and the latter, with relatively many inventors. When it is smaller than zero, the opposite is true.

Let's consider the case when $i = j$, so that the index refers to the same country. Simple algebra shows that the following holds:

$$App\_surplus_{i} = \frac{InvApp_{ROW,i}}{InvApp_{i,ROW}} \cdot \frac{Inv_i}{App_i}$$

where *ROW* stands for "rest of the world". $InvApp_{ROW,i}$ indicates the number of international patent applications which have applicants from country *i*, and inventors from any country excluding country *i*. Likewise $InvApp_{i,ROW}$ indicates international patent applications which have inventors from country *i* and applicants from any other country. If the former quantity is greater than the latter, then country *i* has relatively many applicants involved in the production of international patents, relative to inventors.

To summarize, we have "country" (when $i = j$) and "bilateral" (when $i \neq j$) measures of applicant surplus. Country measures represent the overall predominance of national applicants, with respect to inventors, in the production of the international patents of that country. According to the general interpretation which we have proposed of our internationalization measures, a positive $App\_surplus_{ii}$ indicates that a given country has relatively many MNEs with R&D labs abroad, and relatively few inventors working for other countries' R&D labs. Bilateral measures, on the other hand, represent the "relative balance" of applicant and inventors between one country and another.

A positive value of $App\_surplus_{ij}$ means that the international patents produced jointly by country *i* and *j* record relatively many applicants from country *i* (relative to country *j*), and/or relatively few inventors from country *i (*relatively to country j). In concrete terms, such a negative value for a bilateral measure between country *i* and *j* would arise in a situation where MNEs from country *i* employ, in country *j*, many inventors of that country. To rephrase again the concept, a positive $App\_surplus_{ij}$ declares the relative strength of applicants from country *i*, and of inventors from country *j*.

Just as in international trade bilateral flows aggregate into national trade accounts, so it is here. The country measure (when $i = j$) expresses the overall applicant surplus for a country, deriving from the aggregation of all bilateral measures, with *i* fixed, and *j* spanning all the countries with which country *i* is producing international patents.

We first compute the "national" measure of applicant surplus for a small selection of important countries, where we average our index within 5 year sub-periods[11]. Table 3 shows the results.

[Table 3 about here]

The United States presents, in all sub-periods, an important applicant surplus, deriving from the fact that, as we saw in Table 2, its InvApp/App measure is consistently greater than the corresponding InvApp/Inv. Table 3 shows that a positive applicant surplus is present in all US technological fields. However, changes occurred over time: while during the period 1990-1994 *Electr* and *Instrum* presented an applicant surplus larger than the one for all technologies, this situation changes with time, and in later years it is *Mech* and *Other* which display an above country average applicant surplus.

Besides the United States, Germany is the only other country considered showing an overall applicant surplus, but with important variation across technological fields. In particular, the aggregate result is driven by the sizeable applicant surplus of the *Chem* sector. The other technological field, with some variation in time, do not show an appreciable applicant surplus or deficit. Please compare these results with what is reported in Figure 5.

The UK, France, and Italy, all present applicant deficits, both overall and, in most cases, across technological fields. However, there are some interesting sectoral variations to underline. The UK presents an above country average applicant deficit in *Electr*, and a below average applicant

[11] These are: 1990-1994, 1995-1999, 2000-2004, 2005-2006 (only two years).

deficit in *Chem*. In Italy, on the other hand, it is *Mech* which present the lowest applicant deficit (and a surplus between 1995 and 1999). For France, we note that the applicant deficit of *Electr* reduced its size over time, and the residual technological field Other, together with *Mech,* have higher than average applicant deficits.

Japan and China are both characterized by a very modest degree of internationalization, as it emerges from Table 2. Japan's applicant deficit, modest in the 1990's, converges to zero in later years. Such a change is driven by the *Electr* technological field, while a sizeable applicant deficit is always present for *Chem*, *Mech* and *Other*. China, whose patent surge is only recent, presents an applicant deficit which is roughly constant in time, and that is more pronounced for the *Electr* technological field, quite likely witness of the dominance of foreign R&D FDI investments in that field.

The last column of Table 3 shows an index of variation of applicant deficit across technological fields, equal to the root mean squared distance of each sectoral applicant surplus with respect to the applicant surplus of all technologies. If the relative importance of national applicants and inventors in the production of international patents were the same for all technological sectors, that number would be zero. The United States presents the higher variation across technological sectors of all countries considered. Variation increases over the years for Germany, France and the UK.

We now consider the "bilateral" measures of applicant surplus. For the sake of simplicity, we focus on a smaller set of countries: the United States, Germany, France, the United Kingdom and Italy. This choice is meant to capture the mutual relations among the geographic and economic core of the European Union and the United States. Table 4 illustrates the results, by reporting bilateral applicant surpluses for each country.

The United States has an applicant surplus with all the countries considered. This is true not only in the aggregate, but also for all technological fields, with the only partial exception of the bilateral surplus with France in *Chem*. The US has a particularly strong applicant surplus with the UK (particularly so in *Electr*) and with Italy, and more modest ones with France and Germany.

Germany, exhibiting an applicant deficits *vis-à-vis* the US, entertains a surplus with the UK and with Italy, particularly so in *Chem.* With respect to France, the situation has changed over the years: an emerging applicant deficit is driven by the *Electr* technology field, which more than offsets small corresponding surpluses in *Chem* and *Mech*. France has a slight applicant surplus *vis-à-vis* the UK and a larger one with Italy, particularly so in *Electr.* The UK has an applicant deficit with respect to all the countries considered, consistently across sectors, with the exception of Italy, with which it has a surplus, particulary so, in more recent years, in *Chem*.

The overall picture that emerges is one where the production of internationalized patents of the United States is characterized by a dominance of applicants (mostly: MNEs) headquartered in the United States, and of inventors from the other countries, and particularly so for the sector *Electr*. Such a unbalanced relation is stronger vis-à-vis the UK, and, for all countries considered, is stronger for the *Electr* technology field. Within Europe, Germany and, to a smaller extent, also France, while contributing relatively more inventors than applicants to the international patents involving the US, see their applicants dominating the production of international patents with the UK and with Italy.

7. Conclusions

In this paper we have shown that since 1990 the observed level of internationalization has considerably increased in time in all sectors and in most countries. Scratching the surface of this apparent homogeneity, important structural differences in the process of internationalization of R&D appear both across countries, and across technologies.

Since 1990, the electrical engineering sector has increased its share in patenting activities, also playing a prominent role in internationalization. In some countries and specific sectors international collaborations have reached considerable levels. For example, in the UK more than 30% of patents in the electrical engineering sector are the result of international collaborations. Contrasting different measures of internationalization we also provided information about qualitative aspects of inventive activity. International inventive activities of the United States are characterized by an important role of their applicants. By contrast, in some countries, e.g. Germany, the relative importance of inventive and applicant activity abroad is more tangled, and our sectoral analysis allows to disentangle the sources of internationalization by technology.

We also controlled for the increase of internationalization to be due effectively to pure growth effects, and not to compositional effects, which derive from changes in the relative shares of the technological sectors. Our findings show that compositional effects play a positive but modest role in explaining the observed aggregate increase in internationalization.

We introduced a measure of "applicant surplus" to assess the relative weights, within countries and across, of applicants and inventors in producing international patents. The analysis of this measure produces an articulate geography. The role of United States applicants is paramount, while inventors are more important in Italy and the UK. Germany and France occupy an intermediate position, by contributing relatively more inventors *vis-à-vis* the Unites States, and applicants *vis-à-vis* the UK and Italy.

Appendix A - Taxonomy of technologies (Schmoch, 2008)

Electr (Electrical engineering)

1 - Electrical machinery, apparatus, energy: F21#, H01B, H01C, H01F, H01G, H01H, H01J, H01K, H01M, H01R, H01T, H02#, H05B, H05C, H05F, H99Z.

2 - Audio-visual technology: G09F, G09G, G11B, H04N-003, H04N-005, H04N-009, H04N-013, H04N-015, H04N-017, H04R, H04S, H05K.

3 - Telecommunications: G09F, G09G, G11B, H04N3, H04N5, H04N9, H04N13, H04N15, H04N17, H04R, H04S, H05K, H04W, G08C, H01P, H01Q, H04B, H04H, H04J, H04K, H04M, H04N1, H04N7, H04N11, H04Q, H04W.

4 - Digital communication : H04L.

5 - Basic communication processes: H03.

6 - Computer technology: G06 (but not G06Q), G11C, G10L.

7 - IT methods for management: G06Q.

8 - Semiconductors: H01L.

Instrum (Instruments)

9 - Optics: G02, G03B, G03C, G03D, G03F, G03G, G03H, H01S.

10 - Measurement: G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, G01N, G01N33G01P, G01R, G01S, G01V, G01W, G04, G12B, G99Z.

11- Analysis of biological materials : G01N33.

12 - Control: G05B, G05D, G05F, G07, G08B, G08G, G09B, G09C, G09D.

13 - Medical technology: A61B, A61C, A61D, A61F, A61G, A61H, A61J, A61L, A61M, A61N, H05G.

Chem (Chemistry)

14 - Organic fine chemistry : C07B, C07C, C07D, C07F, C07H, C07J, C40B, A61K8, A61Q.

15 - Biotechnology: C07G, C07K, C12M, C12N, C12P, C12Q, C12R, C12S.

16 - Pharmaceuticals: A61K, A61K8, A61P (added, not present in WIPO document).

17 - Macromolecular chemistry, polymers: C08B, C08C, C08F, C08G, C08H, C08K, C08L

18 - Food chemistry: A01H, A21D, A23B, A23C, A23D, A23F, A23G, A23J, A23K, A23L, C12C, C12F, C12G, C12H, C12J, C13D, C13F, C13J, C13K.

19 - Basic materials chemistry: A01N, A01P, C05, C06, C09B, C09C, C09F, C09G, C09H, C09K, C09D, C09J, C10B, C10C, C10F, C10G, C10H, C10J, C10K, C10L, C10M, C10N, C11B, C11C, C11D, C99Z.

20 - Materials, metallurgy: C01, C03C, C04, C21, C22, B22.

21 - Surface technology, coating: B05C, B05D, B32, C23, C25, C30.

22 - Micro-structure and nano-technology: B81, B82.

23 - Chemical engineering: B01B, B01D0, B01D1, B01D2, B01D, B01D41, B01D5 (added, not clear in WIPO document), B01D8 (added, not clear in WIPO document), B01D9 (added, not clear in WIPO document), B01D43, B01D57, B01D59, B01D6, B01D7, B01F, B01J, B01L, B02C, B03, B04, B05B, B06B, B07, B08, D06B, D06C, D06L, F25J, F26, C14C, H05H.

24 - Micro-structure and nano-technology: A62D , B01D45 , B01D46 , B01D47 , B01D49 , B01D50 , B01D51 , B01D52 , B01D53, B09, B65F, C02, F01N, F23G, F23J, G01T, E01F8, A62C.

Mech (Mechanical engineering)

25 - Handling: B25J, B65B, B65C, B65D, B65G, B65H, B66, B67.

26 - Machine tools: B21, B23, B24, B26D, B26F, B27, B30, B25B, B25C, B25D, B25F, B25G, B25H, B26B.

27 - Engine pumps, turbines: F01B, F01C, F01D, F01K, F01L, F01M, F01P, F02, F03, F04, F23R, G21, F99Z.

28 - Textile and paper machines: A41H, A43D, A46D, C14B, D01, D02, D03, D04B, D04C, D04G, D04H, D05, D06G, D06H, D06J, D06M, D06P, D06Q, D99Z, B31, D21, B41.

29 - Other special machines: A01B, A01C, A01D, A01F, A01G, A01J, A01K, A01L, A01M, A21B, A21C, A22, A23N, A23P, B02B, C12L, C13C, C13G, C13H, B28, B29, C03B, C08J, B99Z, F41, F42.

30 - Thermal processes and apparatus: F22, F23B, F23C, F23D, F23H, F23K, F23L, F23M, F23N, F23Q, F24, F25B, F25C, F27, F28.

31 - Mechanical elements: F15, F16, F17, G05G.

32 - Transport: B60, B61, B62, B63B, B63C, B63G, B63H, B63J, B64.

Other (Other fields)

33 - Furniture, games: A47, A63.

34 - Other consumer goods: A24, A41B, A41C, A41D, A41F, A41G, A42, A43B, A43C, A44, A45, A46B, A62B, B42, B43, D04D, D07, G10B, G10C, G10D, G10F, G10G, G10H, G10K, B44, B68, D06F, D06N, F25D, A99Z.

35 - Civil engineering: E02, E01B, E01C, E01D, E01F1, E01F3, E01F5, E01F7, E01F9, E01F1, E01H, E03, E04, E05, E06, E21, E99Z.

Appendix B – The decomposition of the aggregate growth in the internationalization rate

We provide here the algebra of the decomposition of the growth index of internationalization into a compositional effect and a pure growth effect, for sectors *A* and *B* and between time 0 and time 1. The decomposition for *n* sector and any time *t* and *t-1* is analogous and will thus be omitted.

$$\begin{aligned}
\frac{Int_{TOT1}}{Int_{TOT0}} &= \frac{Sh_{A1}Int_{A1} + Sh_{B1}Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} = \\
&= \frac{(Sh_{A1} + Sh_{A0} - Sh_{A0})Int_{A1} + (Sh_{B1} + Sh_{B0} - Sh_{B0})Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} = \\
&= \frac{(Sh_{A1} - Sh_{A0})Int_{A1} + Sh_{A0}Int_{A1} + (Sh_{B1} - Sh_{B0})Int_{B1} + Sh_{B0}Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} = \\
&= \frac{(Sh_{A1} - Sh_{A0})Int_{A1} + (Sh_{B1} - Sh_{B0})Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} + \frac{Sh_{A0}Int_{A1} + Sh_{B0}Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} = \\
&= \frac{(Sh_{A1} - Sh_{A0})Int_{A1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} + \frac{(Sh_{B1} - Sh_{B0})Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}} + \frac{Sh_{A0}Int_{A1} + Sh_{B0}Int_{B1}}{Sh_{A0}Int_{A0} + Sh_{B0}Int_{B0}}
\end{aligned}$$

References

Almeida, P., 1996. Knowledge sourcing by foreign multinationals: patent citation analysis in the U.S. semiconductor industry. Strategic Management Journal 17, 155–165.

Argyres, N. S., Silverman, B. S., 2004. R&D, organization structure, and the development of corporate technological knowledge. Strategic Management Journal 25, 929-958.

Arora, A., Belenzon, S., Rios, L. A., 2011, The organization of R&D in American corporations: the determinants and consequences of decentralization. NBER Working Paper 17013.

Bennato, A. R., Magazzini, L., 2009. International cooperation in the pharmaceutical industry. University of Verona, Department of Economics Working Paper Series. n. 62.

Berthelon, M., Freund, C., 2008. On the conservation of distance in international trade. Journal of International Economics 75, 310-320.

Cantwell, J., Piscitello, L:, 2005. Recent location of foreign-owned research and development activities by large multinational corporations in the European regions: The role of spillovers and externalities. Regional Studies 39(1), 1–16.

Cohen, W.M., Goto, A., Nagata, A., Nelson, R. R., Walsh, J.P., 2002. R&D spillovers, patents and the incentives to innovate in Japan and the United States.Research Policy 31(8-9),1349--1367

De Rassenfosse, G., Dernis, H., Guellec, D., Picci, L., van Pottelsberghe de la Potterie, B., 2011. The worldwide count of priority patents: A new indicator of inventive performance. Mimeo.

Disdier, A., Head, K., 2008. The puzzling persistence of the distance effect on bilateral trade. The Review of Economic and Statistics 90 (1), 37-48.

European Patent Office, 2009a. PATSTAT database, April 2009 Edition.

European Patent Office, 2009b. Data catalogue for the EPO Worldwide Patent Statistical Database, April 2009 Edition.

Florida, R., 1997. The globalization of R&D: results of a survey of foreign-affiliated R&D laboratories in the USA. Research Policy 26 (1), 85-103.

Guellec, D., van Pottelsberghe de la Potterie, B., 2001. The internationalization of technology analysed with patent data. Research Policy 30 (8), 1253-1266.

Griffith, R., Harrison, R., van Reenen, J. 2006. How special is the special relationship? Using the impact of U.S. R&D spillovers on U.K. firms as a test of technology sourcing. American Economic Review 96, 1859–1875.

Henderson, R., Cockburn, I., 1996. Scale, scope, and spillovers: the determinants of research productivity in drug discovery. The Rand journal of economics 27(1), 32-59.

Hu, A. G., 2010. Propensity to patent, competition and China's patenting surge. Research Policy 39, 7: 985-993.

Hu, M.C., Mathews, J.A., 2005. National innovative capacity in East Asia.Research Policy 34(9), 1322-1349.

Kay, N., 1988. The R&D function: corporate strategy and structure. In "Technical change and economic theory", eds. G. Dosi et al. London.

Kuemmerle, W., 1997. Building Effective Capabilities Abroad. Harvard Business Review, March–April, pp. 61–70.

Kuemmerle, W., 1999. Foreign direct investment in industrial research in the pharmaceutical and electronics industries—results from a survey of multinational firms. Research Policy 28(2–3) 179–193.

Le Bas, C., Sierra, C., 2002. Location versus home advantages' in R&D activities: Some further results on multinationals' location strategies. Research Policy 31 (4), 589-609.

Leiponen, A., Helfat, C. E., 2010. Location, decentralization, and knowledge sources for innovation. Organization Science 22(3), 1-18.

Lerner, J., Wulf, J., 2007. Innovation and incentives: Evidence from corporate R&D. Review of Economics and Statistics 89(4), 634–644.

Nelson, R. R, (ed), 1993. National Innovation Systems. Oxford University Press: New York.

Niosi, J. 1999. The internationalization of industrial R&D from technology transfer to the learning organization. Research Policy, 28 (2), 107–117.

OECD, 2008. Open Innovation in Global Networks. Paris.

Overby, S., 2007. The next wave of globalization: offshoring R&D to India and China. Available online: http://www.cio.com/article/print/150652

Patel, P., Pavitt, K., 1991. Large firms in the production of the world's technology: an important case of 'non-globalisation'. Journal of International Business Studies 22 (1), 1-22.

Patel, P., Vega, M., 1999. Patterns of internationalisation of corporate technology: location versus home country advantages. Research Policy 28 (2/3), 145-155.

Penner-Hahn, J., Shaver, J. M. 2005. Does international research and development increase patent output? An analysis of Japanese pharmaceutical firms. Strategic Management Journal 26, 121-140.

Picci, L., 2010. The Internationalization of inventive activity: A gravity model using patent data. Research Policy, 39(8), 1070-1081.

Schmoch, U., 2008. Concept of a technology classification for country comparisons. Final report to the World Intellectual Property Organisation (WIPO). Available online: http://www.WIPO.int/export/sites/www/ipstats/en/statistics/patents/pdf/WIPO_ipc_technology.pdf

Schmoch, U., Laville, F., Patel, P., Frietsch, R. 2003. Linking technology areas to industrial sectors. Final report to the European Commission, DG Research. Available online: ftp://ftp.cordis.lu/pub/indicators/docs/ind_report_isi_ost_spru.pdf

Serapio, M. G., Dalton, D. H. 1999. Globalization of industrial R&D: an examination of foreign direct investments in R&D in the United States. Research Policy 28 (2/3), 303–316.

Shan, W., Song, J., 1997. Foreign direct investment and the sourcing of technological advantage: evidence from the biotechnology industry. Journal of International Business Studies 28 (2), 267–284.

Singh, J., 2008. Distributed R&D, cross-regional knowledge integration and quality of innovative output. Research Policy 37(1), 77-96.

Song, J., Asakawa, K., Chu, Y., 2011. What determines knowledge sourcing from host locations of overseas R&D operations?: A study of global R&D activities of Japanese multinationals. Research Policy 40, 380-390.

The Economist, 2010. The world turned upside down. Available online: http://www.economist.com/node/15879369

Vernon, R., 1966. International investment and international trade in the product cycle. Quarterly Journal of Economics 80 (2), 190-207.

WIPO, 2011. International Patent Classification (IPC), www.WIPO.int/classifications/ipc/en/ , accessed online 31 August 2011.

Tables

Table 1. Patents applications around the world

Country	1990	%	1998	%	2006	%
JP	324180	64.8	339863	56.5	314157	40.6
CN	5315	1.1	12096	2.0	108823	14.0
KR	5910	1.2	38729	6.4	106744	13.8
US	60104	12.0	72277	12.0	67864	8.8
DE	26008	5.2	40264	6.7	45067	5.8
RU	14	0.0	768	0.1	24894	3.2
UK	18449	3.7	19495	3.2	17952	2.3
FR	11517	2.3	13238	2.2	15306	2.0
TW	1100	0.2	7166	1.2	15207	2.0
IT	7835	1.6	9047	1.5	11913	1.5
CA	3442	0.7	4900	0.8	5220	0.7
NL	2493	0.5	3677	0.6	5076	0.7
BR	2329	0.5	2533	0.4	3919	0.5
AU	3396	0.7	8318	1.4	3096	0.4
CH	2331	0.5	2823	0.5	3007	0.4
SE	3344	0.7	4651	0.8	2711	0.3
AT	1790	0.4	1954	0.3	2601	0.3
FI	2136	0.4	2533	0.4	2516	0.3
ES	1970	0.4	1775	0.3	2384	0.3
IN	553	0.1	414	0.1	2004	0.3
BE	821	0.2	1424	0.2	1577	0.2
DK	1339	0.3	1196	0.2	1510	0.2
IL	1212	0.2	1750	0.3	1494	0.2
ZA	1284	0.3	1387	0.2	938	0.1
NO	845	0.2	1378	0.2	872	0.1
TOT a	489715	97.9	593655	98.7	766853	99.0
TOT b	500238	100.0	601445	100.0	774609	100.0

Notes

%: percentage of world patent

TOT a: sum of reported countries; TOT b: world total

World: 52 countries

Total number of patents worldwide, 1990-2006: 10940242 (countries for which we have intern. measures) 11,242,777 (52 countries)

Table 2. Measures of relative internationalization. Percentage points

Country	InvApp/Inv,1990	InvApp/App, 1990	InvApp/Inv, 1998	InvApp/App, 1998	InvApp/Inv, 2006	InvApp/App, 2006
JP	0.153	0.135	0.299	0.342	0.436	0.466
CN	0.387	0.189	0.881	0.328	0.833	0.408
KR	0.333	1.548	0.205	0.436	0.121	1.243
US	1.421	4.253	3.157	7.14	3.68	10.776
DE	2.663	2.868	4.301	4.539	7.325	6.628
UK	12.854	8.885	16.629	11.565	16.755	11.829
TW	2.61	6.143	1.483	5.875	8.985	4.87
FR	4.199	1.871	8.844	5.485	11.559	7.041
IT	8.298	6.131	10.793	7.511	13.331	9.239
CA	6.911	4.324	9.41	12.76	19.04	7.47
NL	10.946	16.059	14.295	18.625	14.217	22.091
AU	8.627	7.581	14.252	12.256	10.517	7.502
CH	12.497	28.365	12.682	32.999	11.723	43.101
SE	6.532	7.469	6.931	11.842	16.721	21.915
AT	10.349	3.513	13.593	5.285	24.397	10.914
FI	1.856	2.376	4.291	9.784	11.299	14.319
ES	1.532	1.962	8.761	3.692	7.152	6.726
IN	4.952	1.125	19.441	3.879	32.369	5.021
BE	20.385	12.136	24.596	16.046	30.181	29.202
DK	6.675	3.147	12.513	10.773	19.218	11.739
NO	11.036	9.874	15.617	14.704	19.292	14.952
HU	0.471	0.622	4.106	1.903	10.921	5.853
NZ	17.684	13.942	10.9	7.271	7.705	5.419
CZ	13.158	8.333	4.323	2.537	9.211	4.215

Note: Values in percentage points

Table 3. Applicant surplus (inventor deficit). Percentage points

Period	Country	Technology						Variation
		All tech	Electr	Instrum	Chemic	Mech	Other	
1990-1994	JP	**-16.70**	-23.40	6.18	-28.35	8.43	-7.75	37.62
1995-1999		**-12.68**	-8.88	11.92	-30.24	-4.88	-10.66	31.51
2000-2004		**1.00**	24.08	-12.96	-24.88	-10.16	-17.18	43.04
2005-2006		**-1.63**	6.87	-1.37	-11.10	-11.63	-29.83	32.51
1990-1994	CN	**-46.68**	-60.43	-74.75	-34.65	-41.55	3.88	60.86
1995-1999		**-75.82**	-74.36	-23.64	-69.00	-93.66	-60.94	57.54
2000-2004		**-73.54**	-79.70	-51.60	-82.14	-59.48	-44.16	40.67
2005-2006		**-60.70**	-61.67	-57.23	-61.10	-62.00	-41.97	19.12
1990-1994	US	**174.45**	258.73	268.75	135.65	125.30	169.83	141.20
1995-1999		**172.36**	145.68	257.26	187.92	188.50	249.98	120.20
2000-2004		**91.58**	48.92	90.74	164.74	216.10	173.42	171.39
2005-2006		**151.73**	117.77	103.07	160.50	353.30	298.53	256.47
1990-1994	DE	**21.18**	1.38	19.35	62.50	5.88	-4.13	54.56
1995-1999		**7.52**	-17.32	-6.86	71.66	-5.18	2.18	71.61
2000-2004		**11.58**	-12.58	-5.82	78.28	10.96	1.14	73.79
2005-2006		**-4.87**	-9.97	-23.30	51.63	-12.67	-21.53	62.42
1990-1994	UK	**-32.08**	-56.88	-35.65	-19.68	-23.58	-25.28	30.00
1995-1999		**-32.40**	-60.74	-41.28	-8.46	-19.62	-11.94	45.13
2000-2004		**-31.58**	-60.42	-19.12	-6.06	-19.64	31.58	75.96
2005-2006		**-30.40**	-48.13	-24.87	-13.50	-28.33	63.17	96.90
1990-1994	FR	**-54.40**	-52.18	-68.98	-37.85	-55.15	-71.20	27.82
1995-1999		**-46.80**	-39.94	-47.42	-32.52	-60.20	-64.28	27.14
2000-2004		**-41.08**	-14.14	-41.32	-28.82	-74.26	-72.00	54.16
2005-2006		**-43.07**	-12.47	-58.23	-20.73	-73.33	-80.13	62.89
1990-1994	TW	**487.30**	440.83	640.38	74.40	806.38	1001.78	750.05
1995-1999		**415.68**	499.68	266.72	201.20	567.34	483.60	320.72
2000-2004		**274.02**	425.10	359.22	51.42	188.62	131.76	327.36
2005-2006		**2.47**	14.37	40.37	-53.63	-15.10	-18.63	74.02
1990-1994	IT	**-26.88**	-37.33	-32.55	-31.45	-23.63	3.00	32.64
1995-1999		**-27.58**	-27.04	-38.32	-55.80	22.06	0.16	64.39
2000-2004		**-38.86**	-52.00	-43.92	-53.84	-6.64	-24.54	40.81
2005-2006		**-30.57**	-37.40	-20.47	-34.63	-14.87	-37.93	21.59

Note: Values in percentage points

Table 4. Bilateral Applicant surplus (inventor deficit). Percentage points

Country *i*	Country *j*	Period	All tech	*Electr*	*Instrum*	*Chem*	*Mech*	*Other*
US	DE	1	0.45	1.65	0.60	0.30	0.15	0.13
		2	1.02	2.28	1.46	0.70	0.76	0.36
		3	1.28	2.08	1.52	0.76	1.18	0.64
		4	2.13	2.70	2.00	0.93	2.60	0.90
	FR	1	0.85	2.38	1.05	0.65	0.30	0.53
		2	1.42	4.12	1.24	0.66	1.04	0.28
		3	1.38	2.32	1.62	-0.14	2.12	0.28
		4	2.10	4.90	2.07	-0.17	2.10	0.50
	UK	1	4.85	8.28	5.45	5.73	3.63	2.53
		2	7.34	13.18	8.56	7.40	5.54	3.22
		3	9.82	22.66	7.38	6.14	6.94	3.50
		4	8.40	19.10	6.03	5.07	6.87	2.23
	IT	1	3.10	5.05	6.45	3.90	2.10	0.48
		2	3.50	3.52	7.12	7.18	1.48	0.76
		3	2.74	6.08	5.42	2.10	1.24	2.42
		4	2.83	6.57	5.30	2.27	1.27	2.33

Country *i*	Country *j*	Period	All tech	*Electr*	*Instrum*	*Chem*	*Mech*	*Other*
DE	US	1	-0.20	-0.43	-0.18	-0.08	-0.08	-0.03
		2	-0.50	-0.54	-0.52	-0.34	-0.62	-0.20
		3	-0.62	-0.50	-0.66	-0.48	-1.12	-0.34
		4	-1.20	-0.67	-1.03	-0.73	-3.23	-0.47
	FR	1	0.28	0.08	0.28	0.13	0.43	0.33
		2	-0.34	-2.16	-0.62	0.06	0.34	0.26
		3	-0.32	-4.18	-0.42	0.28	2.12	0.12
		4	0.00	-2.93	0.17	0.00	1.80	0.40
	UK	1	0.48	0.68	0.40	0.90	0.23	0.18
		2	0.50	0.58	0.36	1.02	0.40	0.02
		3	0.80	0.56	0.70	1.02	1.28	0.20
		4	0.87	1.30	0.50	0.57	1.43	0.13
	IT	1	0.78	0.30	1.20	0.83	0.83	0.48
		2	0.48	0.02	0.36	0.90	0.36	0.68
		3	1.06	0.44	0.22	2.26	1.08	0.44
		4	1.60	2.33	0.30	1.70	2.03	0.70

Country *i*	Country *j*	Period	All tech	*Electr*	*Instrum*	*Chem*	*Mech*	*Other*
FR	US	1	-0.15	-0.28	-0.15	-0.10	-0.08	-0.13
		2	-0.22	-0.38	-0.14	-0.08	-0.24	-0.06
		3	-0.24	-0.20	-0.22	0.04	-0.58	-0.10
		4	-0.40	-0.47	-0.30	0.07	-0.80	-0.13
	DE	1	-0.13	-0.05	-0.10	-0.08	-0.15	-0.25
		2	0.10	0.76	0.18	0.00	-0.10	-0.10
		3	0.04	1.54	0.10	-0.12	-0.58	-0.04
		4	-0.03	1.03	-0.07	0.00	-0.53	-0.23
	UK	1	0.20	0.18	0.10	0.45	0.18	0.18
		2	0.10	0.36	0.34	0.10	-0.12	0.16
		3	0.06	0.08	0.26	-0.14	0.06	0.02
		4	0.03	-0.07	0.13	0.07	0.07	-0.07
	IT	1	0.73	2.98	0.33	0.43	0.48	0.43
		2	0.82	2.80	0.36	0.86	0.24	0.62
		3	1.12	4.36	0.90	1.46	0.12	0.20
		4	0.60	3.23	0.57	0.37	0.10	-0.10

Country *i*	Country *j*	Period	All tech	*Electr*	*Instrum*	*Chem*	*Mech*	*Other*
UK	US	1	-1.20	-1.50	-1.18	-1.33	-1.08	-1.00
		2	-1.66	-1.70	-1.68	-1.90	-1.64	-1.22
		3	-2.28	-2.86	-1.70	-2.16	-1.88	-1.52
		4	-1.87	-2.17	-1.40	-1.87	-1.97	-0.93
	DE	1	-0.33	-0.50	-0.28	-0.58	-0.13	-0.20
		2	-0.26	-0.36	-0.24	-0.54	-0.12	-0.02
		3	-0.38	-0.36	-0.38	-0.52	-0.38	-0.20
		4	-0.37	-0.70	-0.23	-0.27	-0.33	-0.10
	FR	1	-0.38	-0.25	-0.18	-0.90	-0.25	-0.33
		2	-0.20	-0.62	-0.62	-0.16	0.12	-0.24
		3	-0.16	-0.30	-0.54	0.24	-0.10	-0.08
		4	-0.10	-0.13	-0.23	-0.10	-0.07	0.07
	IT	1	-0.03	-0.10	0.05	-0.10	0.13	-0.08
		2	0.24	0.14	0.10	0.52	0.18	0.14
		3	0.54	0.30	0.28	1.56	0.12	0.66
		4	0.77	0.57	0.50	2.63	0.20	0.13

Country *i*	Country *j*	Period	All tech	*Electr*	*Instrum*	*Chem*	*Mech*	*Other*
IT	US	1	-0.30	-0.25	-0.35	-0.45	-0.33	-0.05
		2	-0.38	-0.18	-0.52	-0.92	-0.28	-0.10
		3	-0.26	-0.24	-0.36	-0.32	-0.20	-0.36
		4	-0.40	-0.30	-0.53	-0.53	-0.37	-0.57
	DE	1	-0.20	-0.08	-0.28	-0.28	-0.20	-0.18
		2	-0.10	0.00	-0.08	-0.22	-0.10	-0.18
		3	-0.24	-0.16	-0.10	-0.44	-0.20	-0.14
		4	-0.37	-0.43	-0.07	-0.47	-0.47	-0.30
	FR	1	-0.48	-1.35	-0.18	-0.43	-0.35	-0.23
		2	-0.54	-1.50	-0.20	-0.70	-0.20	-0.34
		3	-0.74	-1.70	-0.52	-1.04	-0.16	-0.18
		4	-0.50	-1.50	-0.43	-0.33	-0.10	0.03
	UK	1	0.00	0.03	-0.03	0.05	-0.08	0.03
		2	-0.12	-0.10	-0.04	-0.28	-0.10	-0.04
		3	-0.24	-0.10	-0.08	-0.62	-0.10	-0.24
		4	-0.47	-0.27	-0.23	-1.60	-0.23	-0.10

Figures

Figure 1 Overall degree of internationalization from 1990 to 2006

InvApp|Inv metric, the United Kingdom, France, Germany, US, and Japan

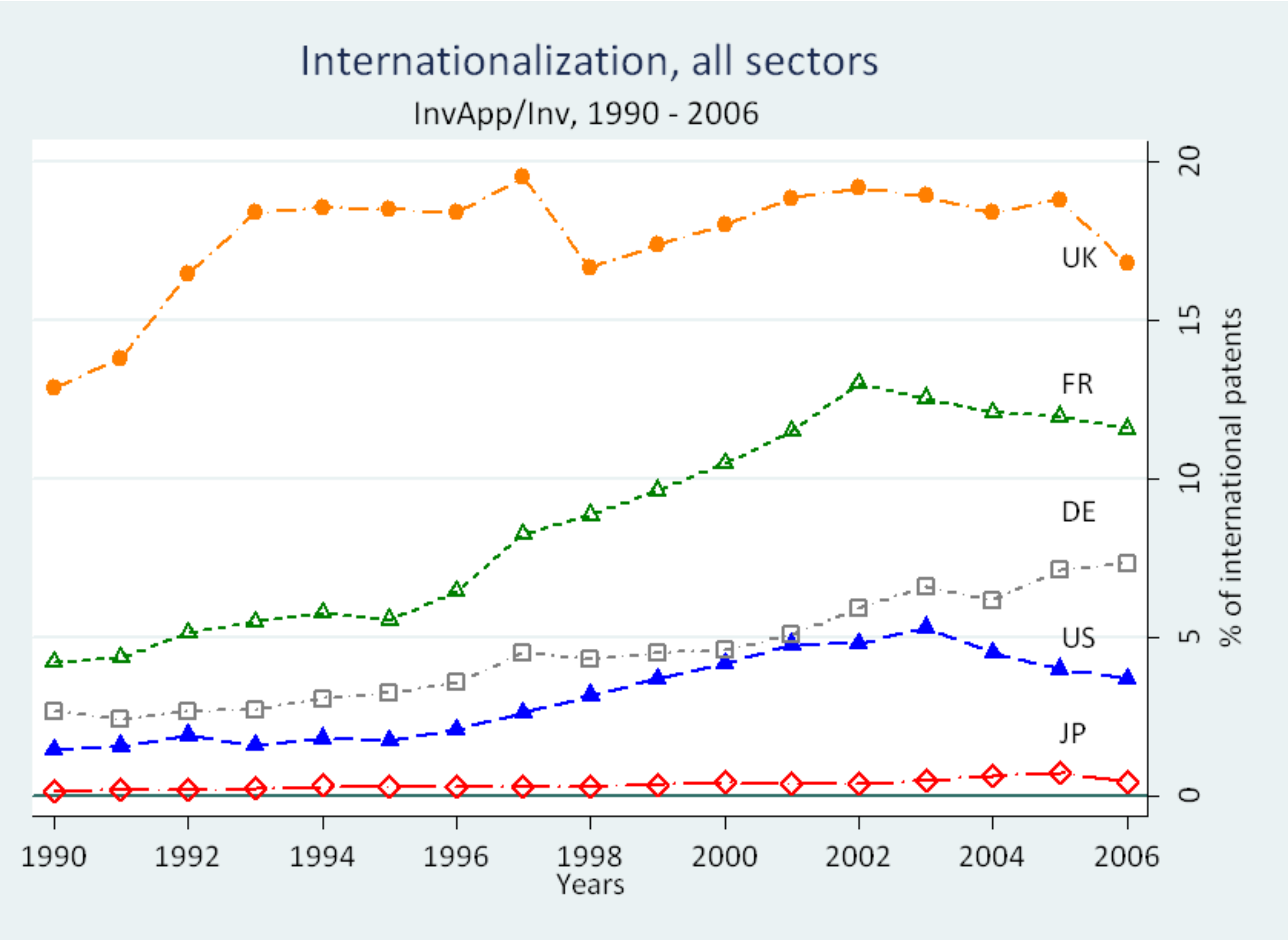


Figure 2

Patents' shares of technological sectors from 1990 to 2006

Inv. from the USA, China, Germany, France, the United Kingdom, and Japan

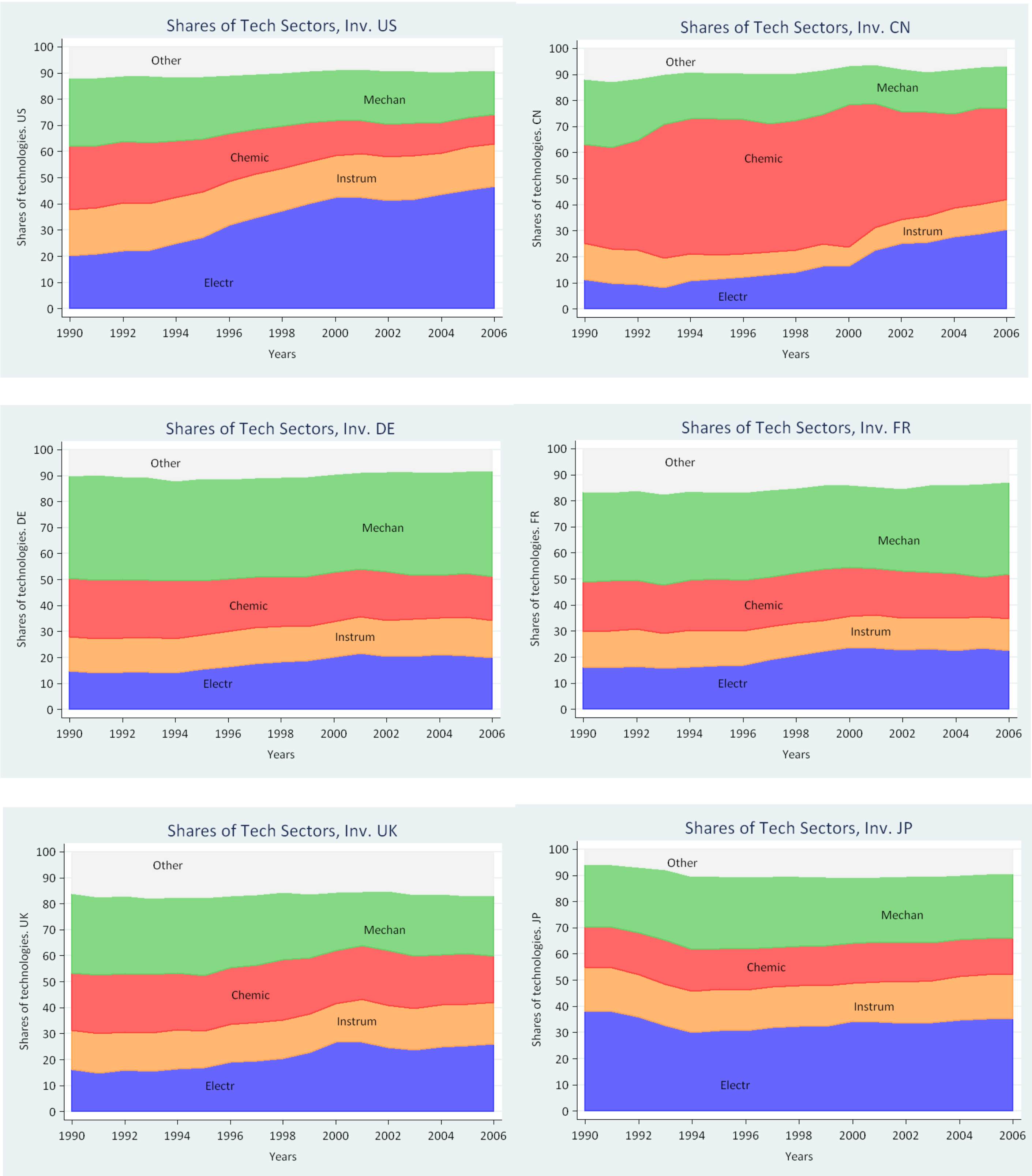


Figure 3

Shares of international patents by technological sector, from 1990 to 2006

InvApp|Inv metric for the USA, China, Germany, France, the United Kingdom, and Japan

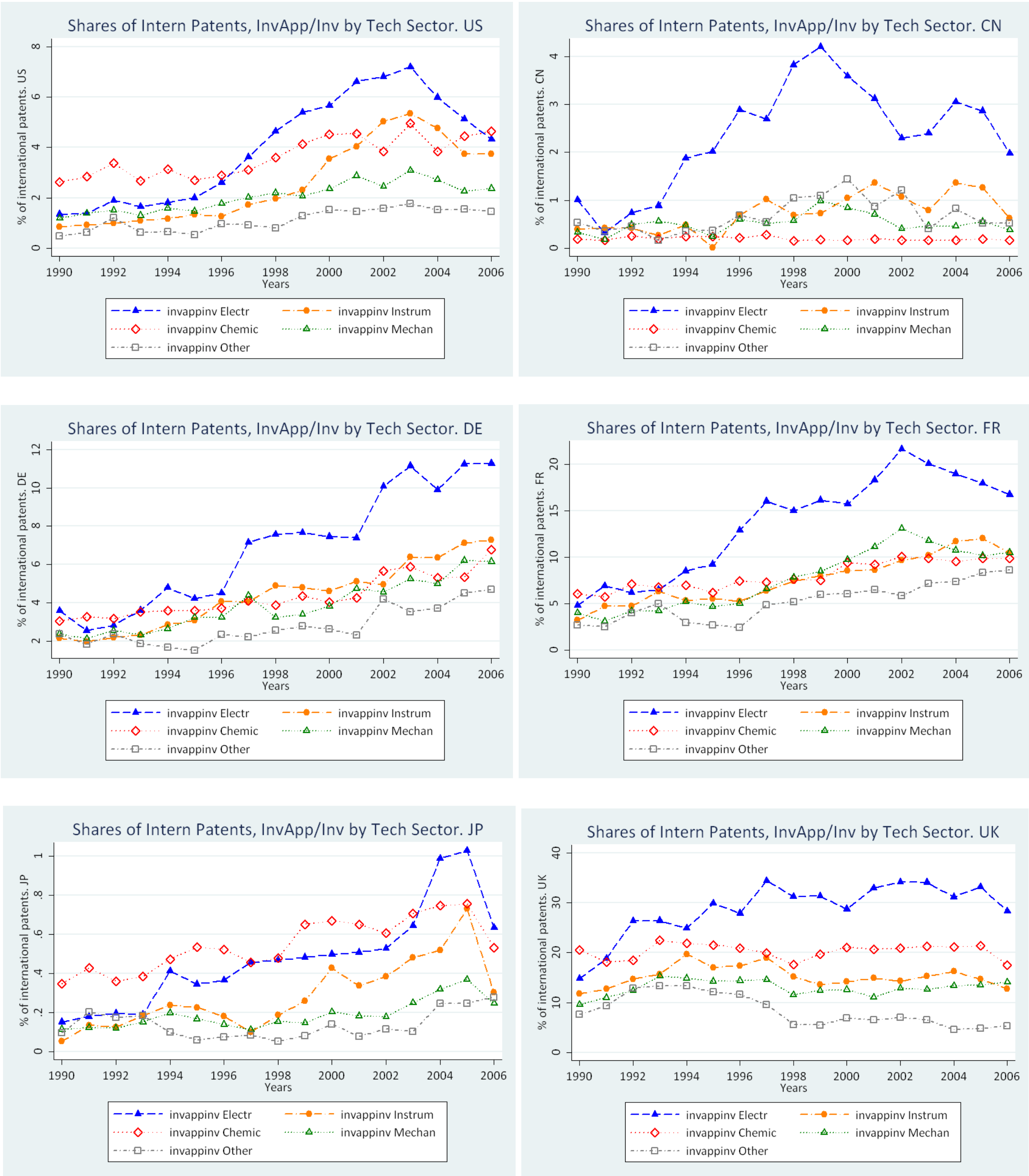


Figure 4

Breakdown in compositional and pure growth effects

Growth rate of internationalization, InvApp|Inv metric for a selection of countries from 1990

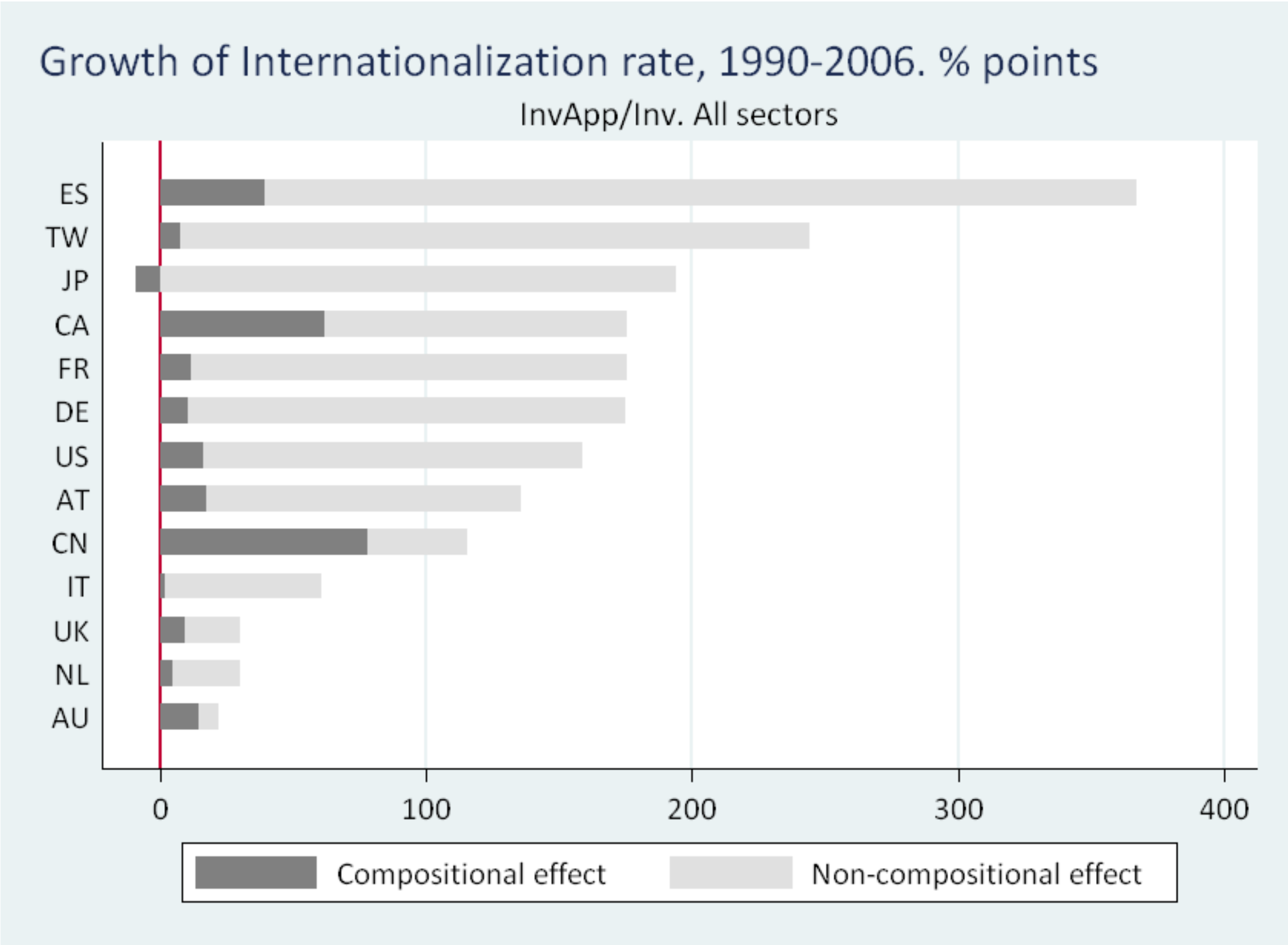


Figure 5

Compositional effect by technological sector from 1990 to 2006

InvApp|Inv metric for the USA, China, Germany, France, the United Kingdom, and Japan

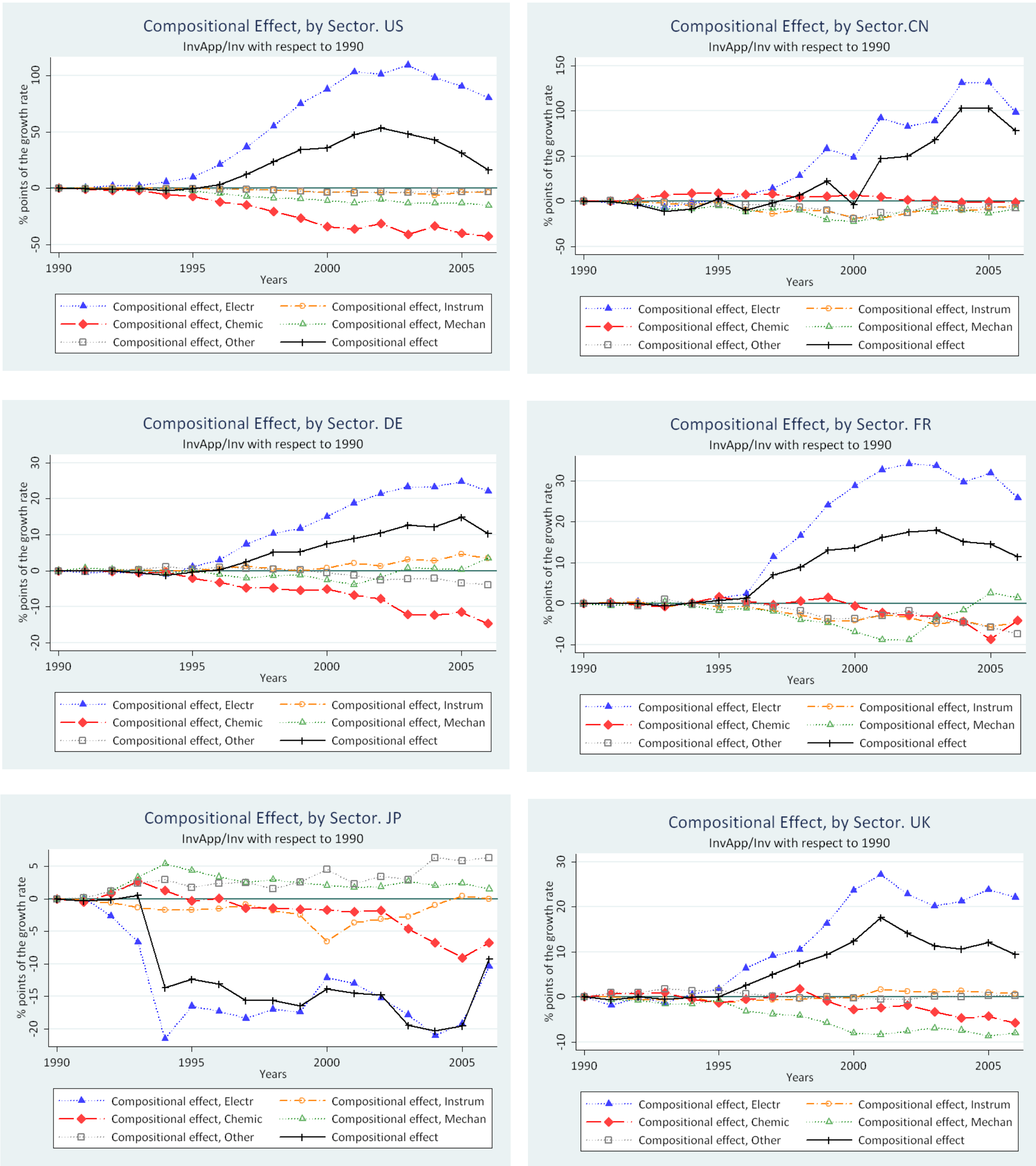


Figure 6

Comparison between different measures of internationalization from 1990 to 2006

InvApp|Inv and InvApp|App metrics for the USA, France, and Germany

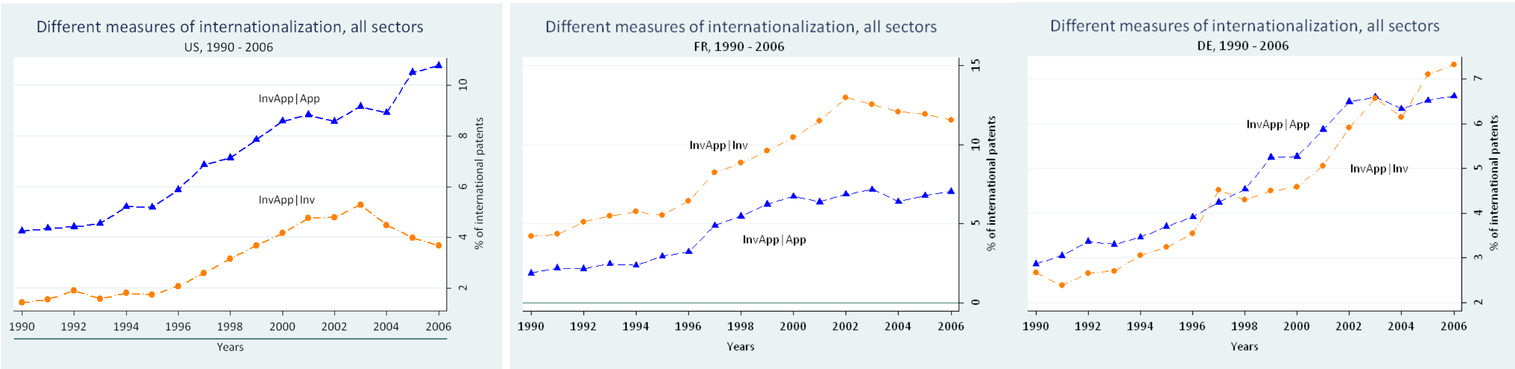
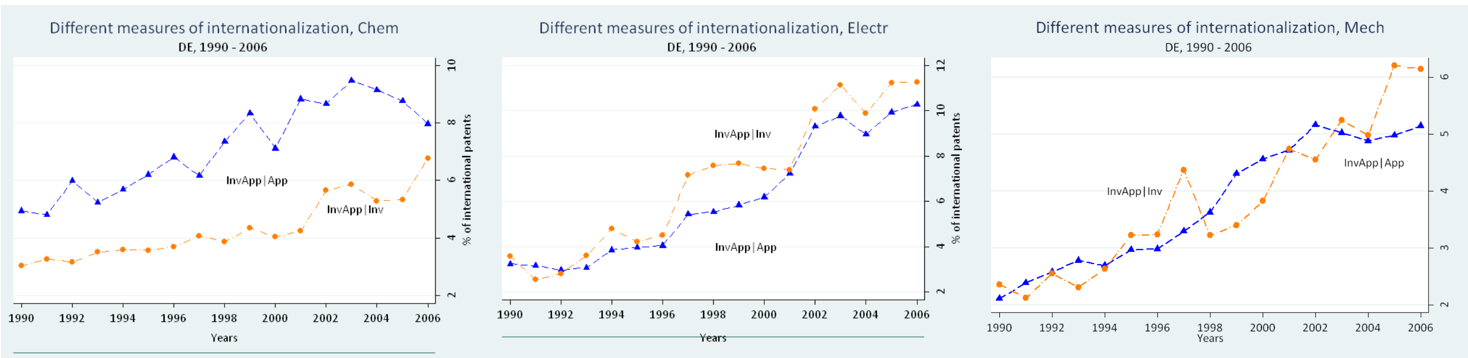


Figura 7

Comparison between different measures of internationalization by technological sector

Germany, 1990 - 2006. InvApp|Inv and InvApp|App metrics for the chemical, electrical, and mechanical sectors



Exploring the supply side of counterfeiting: Strategies, instruments, and capabilities of counterfeiters

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Keywords:

Intellectual Property Infringement, Counterfeiting Management, Resource/Competence Based View of the Firm, Qualitative Research, Exploratory Study, Expert Interview.

JEL classification: M1; M16, O34, O39

Abstract

Counterfeiting has become a multi-billion industry. Insights into counterfeiting management are very limited. Using the resource/competence based view of the firm this paper explores how counterfeiters conduct their business. Specifically, we address two research questions. Which are the strategies and instruments of counterfeiters to secure their competitive position? What determines the success of counterfeiting management? We conduct an explorative study using 230 expert interviews, 70 case studies, and internal information of original manufacturers, service providers, governmental authorities, and research institutions. We present a process oriented view of counterfeiting management and develop a competence based framework for analyzing counterfeiters. We find that counterfeiters act in international networks. They use primary and supporting activities to conduct their business. Counterfeiters are successful if they are able to identify, integrate, transform, and exploit knowledge derived from original manufacturers while they have to mask their activities and organize their network.

1. Introduction: Counterfeiting in innovative industries

From a strategic perspective, competition is based on innovation and imitation as two possible options for market entry. Companies can create innovation as the first utilization of a new combination of productive tangible and intangible resources to provide products and processes (Schumpeter 1934) to gain first mover advantages through temporary monopolies (Lieberman/Montgomery 1988; Nelson/Winter 1982; Porter 1980, 1985; Schumpeter 1934, 1950) e.g. by filing intellectual property rights[2]. Imitation provides a competitive response of later market entrants (Lee et al. 2000; D'Aveni, 1994; Schnaars 1994;

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[2] The term intellectual property rights (IPR) is used in accordance with the definition of the World Intellectual Property Organisation: a construct that covers both copyrights and industrial property. Copyrights result from literary, artistic, and scientific work; industrial property rights result from inventions, industrial designs, trademarks, service marks, commercial names and designations and protect against unfair competition (WIPO 2005).

Lieberman/Montgomery, 1988; Porter, 1980, 1985; Mansfield/Schwartz/Wagner 1981; Levitt 1966; Schumpeter, 1934, 1950). Both strategies cause a competitive advantage and each one's competitive success depends on a company's strategic behavior (Lee et al. 2000). Imitation may even lead to a superior competitive outcome (Ethiraj/Zhu 2008; Markides/Geroski 2005; Schnaars 1994; Connor, 1988; Buggie 1982, Cooper 1981; Baldwin/Childs 1969). According to Schnaars, *„[i]mitation runs the gamut from surreptitious and illegal duplicates of popular products to truly innovative new products that are merely inspired by a pioneer brand. […] Much of the negative image attached to imitative products results from the illicit actions of counterfeiters. Their illegality is obvious, and the impression is widespread that all imitations are of a similar milk.“* (Schnaars 1994, p. 5). Moreover, counterfeiting can be defined as "*[a]ny unauthorized manufacturing of goods whose special characteristics are protected as intellectual property (trademarks, patents and copyrights) […]"* (Cordell/Wongtada/Kieschnick 1996, p. 41). In addition, the infringement of laws against unfair competition or the violation of licensing agreements could be part of counterfeiting (Yang/Sonmez/Bosworth 2004). Following this definitions, imitation can be separated into legal imitation and unintentional or intentional illegal commercial counterfeiting of physical products, intangible assets (e.g. trademarks), and services.

Although counterfeiting is not a new phenomenon (Chaudhry et al. 2009; Johns 2009; Philipps 2007), trade with illegal counterfeited products accounts for one to seven percent of the world trade volume today and has become a professional multi-billion dollar business (Frontier 2011; Staake/Fleisch 2008; OECD 2009; OECD 2008, ICC 2007; Chaudhry 2006; Paradise 1999) that is driven by sellers and buyers (Stumpf/Chaudhry 2010). Based on a literature review, Trott/Hoecht 2007 distinguish two perspectives of counterfeiting: On the one hand, counterfeiters put pressure on R&D intensive firms and brand owners as they illegally benefit from the efforts and knowledge of others whereas R&D and trademark investments are lesser profitable. Anti-counterfeiting efforts increase the cost base, too. Counterfeits confuse or even harm consumers, e.g. in the pharmaceutical industry (Lybecker 2007; Hopkins/Kontnik/Turnage 2003) and undermine trust in brands. The society suffers from increased unemployment and governmental revenues decrease. On the other hand, counterfeits may promote original products, aid innovation, attract new consumers, or transform counterfeit buyers to original buyers. Counterfeits satisfy an existing demand, provide more choice for customers, and promote awareness for original products. Furthermore, counterfeit activities can lead to legitimate business activity (Trott/Hoecht 2007).

Given the different perspectives mentioned above, it is surprising that research with a direct focus on counterfeiters as the counterpart of legally competing companies in academic literature is very limited (Staake/Thiesse/Fleisch 2009). Following this shortcoming, we will focus on the intentional illegal violation of intellectual property rights by counterfeiters in this study. First, we sum up the existing knowledge in academic literature to provide a starting point for our further investigation. Second, we use qualitative empirical information derived from expert interviews and case studies addressing the existing knowledge about counterfeiters to explore and understand counterfeiting management on a corporate level.

In order to investigate these elements, this study is divided into five sections. After having introduced the objectives and the main topics of this study in the first section, the second section provides a literature review of counterfeiting research. Section three includes the methodology and the sample overview. The fourth section reports the results. Section five includes the discussion of our findings and the implications.

2. Literature Review: Counterfeiters in Management Literature

(Anti-)counterfeiting research can be divided into six areas. General descriptions of the phenomenon focus on understanding counterfeiting in general, the public recognition of the phenomenon, and it's relevance for business management. Impact analysis examine consequences and damages due to counterfeiting and piracy as well as implications on key company figures like turnover, brand value, or liability claims. Managerial guidelines focus on best practices in anti-counterfeiting organization, strategy, and instruments. Legal issues and legislative concerns focus on filing and using legal IP rights in fighting counterfeiting and piracy. Supply side investigations focus on counterfeiters‘ strategies and instruments (Staake/Thiesse/Fleisch 2009). According to the OECD, counterfeit supply is driven by (1) large scale markets with strong brands and high unit profitability, (2) moderate investments and technology requirements, unproblematic distribution, easy deceivable consumers, and concealed operations as well as (3) a low risk of discovery, weak enforcement, the relevant penalties and the legal framework (OECD 2008).

Based on our own findings and the literature review by Staake/Thiesse/Fleisch 2009, we searched for supply side investigations from 2007 up to June 2011. We used the keywords “counterfeiter”, “trademark piracy”, “product piracy”, “illegal imitator”, and “pirates” in combination with “strategy”, “instrument”, “process” “organization”, “resource” and “competence” in electronic journal databases for reviewed journals (EBSCOhost Business Source Premier and ScienceDirect) and passages of textbooks that focus on counterfeiting in English language. The existing papers and studies about the management of the supply side focus on strategies, instruments, typologies, and structures.

2.1 Counterfeiting Strategy Formulation

Harvey/Ronkainen 1985 and Harvey 1987 present two basic strategies which include four approaches of counterfeiters for obtaining know-how required to manufacture counterfeit articles from a conceptual point of using company examples for illustration. Direct counterfeiting as first strategy is based on the explicit involvement of the counterfeiter in the theft or duplication of the product. Therefore, counterfeiters (1) are acquiring or purchasing the original product in combination with third country production to serve the counterfeiters home market, or (2) approach employees of the original equipment manufacturer who steal information and deliver it in exchange for payment to produce the counterfeit in their home country and distribute it to other countries. Thus, counterfeiters can reduce costs and the probability of detection, decrease legal, avoid anti-counterfeiting of original manufacturers, and are independent from other companies. Counterfeiters that use an indirect counterfeiting strategy employ a third party to steal product information or specifications. They can use an agent and/or an intermediary to acquire information and (3) produce counterfeits in their home market and export them to foreign countries or (4) produce counterfeits in third-party-countries and distribute them worldwide. Thereby, counterfeiters can reduce the legal consequences of IP theft, profit from low labor costs and weaker legal manufacturing restraints, expand markets, use a selling agent in IP enforcing countries, do not have to pay the original equipment manufacturer, or can even become his supplier (Harvey 1987, Harvey/Ronkainen 1985).

Besides direct or indirect acquisition of knowledge, counterfeiters also think about consumer oriented strategies. They can produce and sell deceptive and non-deceptive counterfeits. A deceptive strategy aims at hiding the illegal origin of the products. This strategy is used if a market consists of uninformed consumers who cannot distinguish between counterfeits and original products or an assessment is not possible in advance of a purchase decision. Using a non-deceptive strategy, counterfeiters do not hide the illegal origin of the counterfeits at least while facing consumers. This strategy is applicable if consumers are informed, able to distinguish product supply, and deliberately buy fake products (Hopkins/Kontnik/Turnage 2003; Grossmann/Shapiro 1988).

Closely linked to the type of consumer orientation, e. g. in terms of quality, functionality, pricing, and the presentation or shape of the product, are production strategies. Counterfeiters may choose between different product types. True counterfeit products resemble originals as much as possible and use the same brand name. Look-alikes (knockoffs) duplicate the original, use a different name, and avoid trademarks. Reproductions are not exact copies of the original product. Unconvincing imitations do not try to pretend an original origin. Another possibility is the adoption of an existing brand to a product that is not offered by the brand owner (Berman 2008; Yang/Sonmez/Bosworth 2004; Chaudhry/Walsh 1996; Harvey 1987). For distribution strategies, counterfeiters can often rely on the cooperation of wholesalers, retails, or end users (Bush/Bloch/Dawson1989). Green and Smith 2002 discuss a longitudinal case study of an alcoholic beverages producer who suffers from counterfeiters in Thailand. The original product manufacturer faced the problem, that the counterfeiters cooperated with legitimate channel members at the end of the channel (namely smaller retailers and barkeepers) who were actively purchasing the counterfeits to improve profits. The counterfeiters also cooperated with each other and were part of organized crime syndicates.

2.2 Counterfeiting Instruments

Counterfeiting instruments are mentioned in almost all publications related to (anti-) counterfeiting. However, they are not systematically described or overlap with strategies. Despite our intense efforts, we could only identify a few publications that include counterfeiting instruments in more detail.

Counterfeiters use “front” companies, “front” personnel for registration, subcontractors, and political influence to mask companies or “secret” subsidiaries that produce counterfeit products. They ship products from sub-contractors via freight forwarders so that it is more difficult to tie the counterfeiter to the seized products. False product names are used in production, sales, and inventory records to hinder governmental authorities. Counterfeits are shipped along with gray market goods (goods purchased through unauthorized channels) and are sold openly via street vendors or over the internet. To make civil or criminal cases more difficult, many counterfeiters will not provide samples and only produce counterfeits to order because a sample of a counterfeit product is needed for prosecution. Low levels of inventory and separated facilities for production and storage enable counterfeiters to minimize losses and penalties. The use of trademarks of legitimate manufacturers and distributors on websites make small firms appear to be subsidiaries of major corporations, and even mask the country where the goods are purchased. Payment is often made to third parties, too. Illegal second or third shifts produce counterfeits that original manufacturers are unaware of based on existing supplier contracts. Reverse engineering, contract manufacturing, positioning as importer, and joint ventures are used to learn and understand underlying technologies and production processes (Berman 2008; Minagawa/Trott/Hoecht 2007; Naim 2005; Hung 2003; Green/Smith 2002).

2.3 Typologies and organizational structures

Up to now, only little research has been conducted to identify and describe different types of counterfeiters or their organizational structures (Staake/Thiesse/Fleisch 2009; Staake/Fleisch 2008).

Staake/Fleisch 2008 and Hopkins/Kontnik/Turnage 2003 illustrate that counterfeiters and their products coexist in final and intermediate markets as in the legal supply chain. They can act on single, several, or all steps of the supply chain.

On a conceptual level, Trott/Hoecht 2007 distinguish between two types of counterfeiters as possible targets for anti-counterfeiting. They discuss the types based on five elements, namely counterfeiting objective, counterfeited product, counterfeiting strategy, effects on original manufacturers, and the attractiveness for consumers. The first type consists of passive imitators and counterfeiters that strive for quick profits from low quality imitated goods for short term gains without repeated consumer interactions. The consumers are sometimes fooled but often deliberately buy the counterfeits. This type mainly damages the reputation of the original manufacturer. The second type includes potential collaborators with “copy and develop” capabilities. They have an interest in building their own new product development capabilities to achieve a similar quality as the original manufacturer. Moreover, they build a brand identity and foster repeated customer transactions. Consumers accept illegality as long as quality is satisfactory or equivalent to the original product. This type is accountable for short term revenue losses for original manufacturers and can emerge as a potential competitor in the long run.

Staake/Fleisch 2008 provide insights from expert-interviews with nine practioners to derive product related (visual and functional quality, product complexity, potential loss or danger for the user, and the degree of conflict with the law) and company specific variables (estimated investment in production facilities and organization, estimated product and brand specialization, and estimated output with applied production technology). These variables were used to conduct an analysis of 128 counterfeits with experts from original manufacturers. Five different types of counterfeit producers were identified in this explorative study. (1) Disaggregators are engaged in the production of average functionality and quality with a low to average complexity. They seem to focus on earnings from brand- name-related counterfeits with minimal investments in production facilities. Conflicts with enforcement agencies are low due to non-deceptive counterfeiting. They are export oriented and use agents in foreign markets to deliver street vendors. The potential danger for consumers is low, too. (2) Imitators focus on counterfeits with a high visual and functional quality whereas the functionality is still below the original product. Investments and specialization are high to achieve a high production output appointed for home market distribution. In the long term, imitators turn to licit competitors if intellectual property rights are strictly enforced.

(3) Fraudsters, sell deceptive counterfeits with a high visual, but low functional quality to achieve sales prices close to those of the original products. Their investments into production facilities are low to avoid financial losses due to seizures. They also try to infiltrate legitimate supply chains. (4) Desperados resemble fraudsters but they do not take care of risking consumer health. They aim at easy to imitate high price products that are hard to evaluate in advance of a purchase. For high profits they are willing to risk severe punishment and use small scale production. (5) Counterfeit smugglers do not focus on brand-related earnings but realize profits from evading taxes. They face severe governmental prosecution and have strong connections to or are part of organized crime.

2.4 Summary:

The available literature demonstrates important elements of counterfeiting management: There are multiple types of counterfeiters who act along the whole supply chain and use strategies and instruments to pursuit their objectives in a professional manner. Strategy formulation includes all stages of the supply chain, knowledge acquisition, geography, production, distribution, customer, and cooperation. Counterfeiters try to decrease prosecution and multiple different instruments as part of their strategies. Table 1 shows a summary of our findings in the literature.

Table 1: Existing elements of Counterfeiting Management

Element of Counterfeiting Management	*Dimension*	*Theoretical/Empirical foundation*	*Authors*
Counterfeiting Strategy formulation	(In-)direct knowledge acquisition; (Non-)deceptive consumer orientation; Counterfeit manufacturing; Counterfeit distribution	Theoretical: Equilibrium Model Empirical: company example, cases study, expert interview	Berman 2008; Yang/Sonmez/Bosworth 2004; Hopkins/Kontnik/Turnage 2003; Green/Smith 2002; Chaudhry/Walsh 1996; Bush/Bloch/Dawson 1989; Grossmann/Shapiro 1988; Harvey 1987; Harvey/Ronkainen 1985;
Counterfeiting Instruments	Masking the illegal origin, knowledge acquisition, logistics, distribution	Theoretical: - Empirical: Case study, expert interview	Berman 2008; Minagawa/Trott/Hoecht 2007; Naim 2005; Hung 2003; Green/Smith 2002
Counterfeiter typology and structure	Supply Chain; passive imitators; possible collaborators; disaggregators, imitators; fraudsters, desparados, smugglers.	Theoretical: Empirical: Expert interviews, cluster analysis	Staake/Fleisch 2008; Trott/Hoecht 2007; Hopkins/Kontnik/Turnage 2003;

From the literature review conceptual, theory-based, and empirical research gaps can be identified: On a conceptual level, the supply side of counterfeiting has never been investigated using a counterfeiting management perspective. Besides the publications already mentioned, there are no publications in the scope of our search that cover internal and external organizational structures (apart from the supply chain considerations of Staake/Fleisch 2008 and Hopkins/Kontnik/Turnage 2003), or counterfeiting management processes. Counterfeiting capabilities are only loosely mentioned in terms of production, technology, or distribution (Staake/Fleisch 2008; Trott/Hoecht 2007). On a theoretical level, no publication is explicitly addressing a theoretical foundation in management science. From an empirical perspective, all but one research design used an indirect approach for data generation. Qualitative research designs using case studies and expert interviews dominate. We did not find quantitative designs, e.g. survey research or experimental designs.

Addressing the conceptual and theory-based research deficits, we focus on an exploratory research design: Backed up by the resource/competence based view of the firm (RBV), appropriability regimes, a firm's (core-) competencies, and dynamic capabilities enable competitive advantages (Grant 2008; Helfat et al. 2007; Teece 2000; Eisenhardt/Martin 2000; Teece/Pisano/Shuen 1997; Barney 1991; Prahalad/Hamel 1990, Dierickx/Cool 1989; Wernerfelt 1984, Rumelt 1984; Penrose 1959). Thus, appropriability regimes determine advantages for innovators, legal imitators, or illegal counterfeiters. Intellectual property rights, especially in developing and transition countries, do not hinder counterfeiters in many countries (Chaudhry/Zimmerman 2009; Yang/Kuo 2008, p. 451; OECD 2008; ICC 2007; Sattler 2003; Arundel 2001; Harabi 1995; Levin et al. 1987). Besides the country specific enforcement of intellectual property rights (Keupp/Beckenbauer/Gassmann 2009, 2010; Shultz/Saporito 1996), counterfeiters use strategies and instruments which depend on specific capabilities and competencies in generating counterfeiting supply to compete with original product manufacturers (Chaudhry/Zimmerman 2009, Staake/Fleisch 2008; Trott/Hoecht 2007) as foundation for a counterfeiting competitive advantage.
Absorptive capacity determines whether followers in terms of innovation have the potential capacity to acquire and assimilate knowledge of others as well as realized capacity to transform and exploit that knowledge into an output, e.g. products (Zahra/George 2002; Cohen/Levinthal 1989, 1990). We assume, that counterfeiters as followers in terms of innovation need the potential capacity to acquire and assimilate knowledge of others as well as realized capacity to transform and exploit knowledge for counterfeiting.
Following these definitions, we define counterfeiting management as a bundle of strategies, instruments, organizational structures, and competencies of counterfeiters for infiltrating existing legitimate markets without own R&D investments before, at the time, or after a new legal original product is available.
Derived from the literature review, we strive to a) sum up the advantages and disadvantages of counterfeiters compared to legal competitors, b) collect and understand their strategies, internal and external organizational structures, and instruments as well as c) explore the underlying competencies of counterfeiting management.

3. Methodology

The basic problems in investigating counterfeiters are the relative absence of related academic literature, the limited access to illicit market participants, the difficulties of obtaining information on clandestine illicit market activities, and the complexity of the counterfeiting phenomenon as well as the counterfeiters themselves (Staake/Thiesse/Fleisch 2009). As a consequence, counterfeiting management can be characterized as a research field that is new, less understood in terms of variables, hard to catch, and difficult to investigate. This implies the utilization of a qualitative research approach to gather information about the research topic. Compared to a quantitative approach, an inductive emergent research design allows both, the establishment of a basis framework at the beginning of the research process and it's further development to specify new elements that arise from new insights based on midterm findings (Denzin/Lincoln 2011; Creswell 2009; Cassell/Symon 2009). This section includes information concerning instrument selection, data collection, sample overview, and data analysis of this study.

3.1 Instrument selection

For the subsequent qualitative data collection, it is important to combine several sources of information to ensure an adequate triangulation of information. In qualitative research, a great variety of instruments is available. Among them, there are archival records, audio-visual materials, case studies, documents, experiments, interviews, observation, and physical artefacts (Denzin/Lincoln 2011; Creswell 2009; Cassell/Symon 2009; Rubin/Rubin 2005). Even though we recognized the potential value that all the instruments could have added to this research, we concentrated on four criteria for the instrument selection. First, we were concerned that access and confidentiality issues would be a significant problem in this sensible field and a trustworthy data collection would be important. Second, we recognized that counterfeiters cannot – or only to a limited extent – be directly observed. Consequently, the provision of insights into historical events and everyday practices is needed. Third, there is only a limited amount of literature that directly investigates counterfeiters to construct a closed design. The need for indirect information requires the control of the data collection for the researcher. This is important because informants should be able to reflect on or add important issues to the research project. Thus, flexible instruments had to be selected.

In other words, we considered the breadth of data achievable and the dynamic character through interview-based inquiry with experts from a range of organizations as more important to the research questions than the depth of data achievable through a multi-methods based methodology in a very limited number of organizations. Nevertheless, the need to understand selected issues or problems of one-sided information still can occur (Denzin/Lincoln 2011). As a consequence, the study uses multiple instruments. These are expert interviews and interview transcripts, case studies, and, if accessible, internal documents.

- Interviews: Given its dominant position in addressing the problems mentioned above, the interview method was the primary form of data collection. It is useful for indirect knowledge acquisition, both historical and day-to-day information, and is a flexible tool for direct control over the research process. Problems are indirect information that is filtered through the informants, the lack of a natural setting, and articulative or perceptive differences of interviewers and interviewees (Creswell 2009). We selected in-depth semi structured interviews with industry, academic, or governmental experts that are confronted with counterfeiting to collect their specific knowledge. We used an interview guide to ensure a structured interview process.

- Case Studies: Case studies are useful to explain past or contemporary information and can describe operational interactions based on documents and interviews in more detail. They also should be used if the researcher cannot manipulate or control the research object in a systematic way (Yin 2009). The cases in this study were used to clarify confusing or interesting information that arouse from the expert interviews.
- Internal documents: The internal documents consisted mostly of presentations, anti-counterfeiting reports, and manuals on anti-counterfeiting processes, counterfeiting cases, and figures about estimated damages. These were primarily used for clarification, validation, and understanding of counterfeiters as the documents were not intended for public use.

In addition to these reflections, expert interviews and case studies have already been successfully used to investigate (anti-)counterfeiting (Chaudhry/Zimmerman 2009; Staake/Thiesse/Fleisch 2009; Keupp/Beckenbauer/Gassmann 2009, 2010 Staake/Fleisch 2008). The insights provided by this methodology are suited to understand the behavior that characterizes counterfeiting management and the conditions that impact on a counterfeiter's behavior.

3.2 Data collection

3.2.1 Interview guide

Rather than following a purely inductive approach, we used the existing knowledge in the literature and our insights into business partners as a basic conceptual framework to develop the interview topics. Existing literature indicates that some overlap in perspectives on counterfeiting, namely context, legal company, and illegal counterfeiter is needed to capture the phenomenon. Recognizing this point, the interview guide explored these three key sections. As data collection and data analysis are a simultaneous process in qualitative research (Marshall/Rossman 2006), we tested our questions with representatives of associations. During conducting the first interviews and while analyzing the transcripts, we recognized that differences in perceptions of counterfeiting could exist between the informants and that there is information which is not covered in the literature. Addressing these problems, we redesigned the interview guide and added questions to help the interviewees think about what they know about counterfeiting. We created slightly different of the interview guide for the interviewer and the interviewee. Both included the same questions but the interviewer had possible keywords in their versions to make sure that they could ask further questions if necessary whereas the interviewees could only see open questions to avoid a limitation in answering the questions. After a few revisions, we prepared the three main sections besides the heading: First, we started with an ice-breaker question about the counterfeiting phenomenon in general. We inquired about how the typical counterfeiting management case in the experts' field could be characterized in terms of economic, consumer, geographical, legal, product, social, and supplier dimensions as external contextual factors. In the second and third section, we concentrated on anti-counterfeiting respectively counterfeiting efforts. The section about counterfeiting contained the topics, aims, competitive advantages, dynamic capabilities, competencies, strategies, instruments, processes, supply chain, and organizational structures. Depending on the answers, the interviewees and interviewers could emphasize one of the three sections to ensure that the informants speak freely, based on their best knowledge, and experience.

3.2.2 Interview procedure

The interview procedure was separated into three stages. Stage one included the preparation. As we wanted to avoid a possible researcher bias (Creswell 2009), we worked together with 40 interviewers and trained them in conducting and transcribing expert interviews, and using the interview guide. The informants received their version to days in advance of the appointment to be able to prepare themselves without having too much time to adjust the answers to organization policy. Together with the interview guide confidentiality agreements were signed. In stage two, the participants took part individually or with a colleague at their respective organization, their preferred location, or if unavoidable by telephone to ensure direct communication between the participants. Before the beginning of the interview, the interviewers asked the informant for permission to record the conversation to prevent data loss, facilitate easier transcription, and increase validity (Huberman/Miles 2002). Questions were open-ended and respondents were encouraged to enter into a dialogue so that they responded to the broad line of questioning in their own terms. Interviews took between one and two and a half hours. Informants were encouraged to discuss and reflect their present counterfeiting cases or one that is not older than two years from the interview appointment to avoid retrospective narratives. Thus, we tried to reduce inaccuracy due to hindsight as a potential validity threat when interviewees recall past events and subjectively modify them. To enhance reliability, each interview was attended by two interviewers. Stage three involved post-processing of the expert interview. All interviews were transcribed by the interviewers within two days after the appointment took place based on the audio transcription. Transcription rules stated, that no behavior should be added, that interview summaries according to the guide should be written, and that both interviewers have to agree on the transcript. After each completed interview, the summaries were sent back to the interviewees for verification. We recognized that this methodology suffered from potential weaknesses such as informants who had recall problems, alter answers, or provided normative rather than descriptive answers. Therefore, we sought to minimize any associated reliability issues by conducting follow-up telephone calls for clarification. In addition, 70 business cases were written to highlight, validate, or identify additional elements. x the confidential nature of the discussions, the audio transcriptions were erased afterwards.

3.3 Sample description

Facing the lack of literature and the problems in addressing counterfeiters directly, we aim to strengthen the knowledge about counterfeiting management that can support the debate in any organization, by focusing on a high level of comprehensiveness and generalizability. In total, 280 interviews have been conducted from August 2007 to July 2010. They have been reduced to 230 explorative interviews with 247 anti-counterfeiting experts of 183 companies and institutions.

We used the International Standard Industrial Classification of All Economic Activities, Revision 4 (ISIC) on a 3-digit-level (section, division, group). ISIC is a classification according to productive activity, and not a classification of goods and services. The activity carried out by a unit is the type of production in which it engages (UN 2008). Table 2 provides a data overview by ISIC Section. We started with German business associations (Section S), researchers, and service providers (both Section M) to acquire information about the relevance of our interview topics, to include the industry sector perspective, and to collect recommendations for industry experts. In can be seen that a particular emphasis – in terms of participating organizations – was put on companies belonging to the section manufacturing as this section is the main target of counterfeiters and the day-to-day business includes dealing with counterfeiting. Sections F, G, H, J and N interact with our focused Section C. The other sections were added as participants from these areas were recommended.

Table 2: Data structured by section

ISIC	*Section*	*N*	*Share (%)*
C	Manufacturing	105	57.1
F	Construction	7	3.8
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	1	0.5
H	Transportation and storage	8	4.3
J	Information and communication	15	8.2
M	Professional, scientific and technical activities	27	14.7

N	Administrative and support service activities	1	0.5
O	Public administration and defense; compulsory social security	2	1.1
P	Education	1	0.5
S	Other service activities	17	9.2
Total		184	100.0

Within Section C, we created a comprehensive sample of German companies or subsidiaries of foreign firms on group level. This study includes R&D intensive patent-based high technology groups from the industrial goods sector, trademark based groups that belong to the consumer goods sector, and generic as well as customized products of mainly multinational companies. We cover original equipment manufacturers as well as first and second tier companies. Table 3 shows Section C on 3-digit-level level.

Table 3: Manufacturing on group level

Group	*N*	*Share (%)*	*Average Sales (m EUR, global)*	*Average Employees (#, global)*	*Average R&D (m EUR, global)*	*Average Subsidiaries (#, global)*
Other n=1 (e.g. Beverages, Textiles)	6	5.7	8,477	25,619	442	28
Other n=2 (e.g. other non-metallic products, sports goods)	17	16.2	11,304	45,424	1,217	31
Other n=3 (accessories for motor vehicles, other manufacturing)	12	11.4	8,911	42,539	1,159	51
Electronic components and boards	4	3.8	455	1,928	not reported	50
Domestic appliances	4	3.8	2,000	12,441	not reported	37
Pharmaceuticals	7	6.7	15,908	44,012	1,891	208
Other fabricated metal products	7	6.7	1,815	6,225	16	35
Furniture	7	6.7	370	4,325	43	35
Medical and dental instruments and supplies	8	7.6	9,058	88,078	895	28
Special-purpose machinery	10	9.5	541	2,334	66	38
General-purpose machinery	23	21.9	4,600	25,385	632	79
Total/ Average	**105**	**100.0**	**5,767**	**27,119**	**707**	**56**

To gather experience from various actors and functions, this study includes experts from three main areas, namely manufacturing companies, service providers (e. g. lawyers, consultants, private investigators, etc.), business associations, and institutions like universities or governmental authorities. All of the experts had to meet one important criterion: They had to be directly linked to counterfeiting as part of their work, irrespective of the hierarchical level. We used the knowledge of 247 experts who represented a wide range of operating or corporate positions and hierarchical levels with relevant experience from three months up to 15 years. Counterfeiting is a topic from temporary project management up to permanent CEO level. For some experts, we were not allowed to report their function (no permission) as they belonged to governmental, private, or company prosecution functions. Table 4 provides a summary of the participating experts by function.

Table 4: Participating experts by function, *Notes:* “Other” includes Foreign Affairs, Statistics, Production/Manufacturing, Key Account Management, Informatics, Parts, Project Management

Function	*N*	*Percentage*
Management	38	15,4%
Law	36	14,6%
Anti-Counterfeiting	24	9,7%
IP Management	22	8,9%
R&D/TIM	20	8,1%
Academic Research	13	5,3%
Marketing	9	3,6%
PR/Communication	9	3,6%
Security	7	2,8%
Business Development	6	2,4%
Sales	6	2,4%
Product Management	4	1,6%
Quality Management	4	1,6%
Management Accounting	3	1,2%
Other	9	3,6%
No Permission	37	15,0%
Total	**247**	100,0%

3.4 Data Reduction and Data Analysis

After the end of data collection the large amount of data gathered poses a challenge to researchers. The data need to be reduced to allow the derivation of focused conclusions (Lee 1998). Nevertheless, data need to be rich and extensive enough to enable an adequate account of contextual information (Richards 2005). In this study, the transcripts contain more than 1,300 pages, the cases studies include 350 pages, and the internal documents add 300 pages.

Data analysis is based on the qualitative content analysis method. Originally developed in communication science, this methodological text analysis is based on theory reference, step models, category definition, and criteria of validity and reliability. Furthermore, inductive category development, summarizing, context analysis, and deductive category application are possible (Mayring 2000, 2002, 2008). We aimed at structuring the data for content filtering to deduce the elements of counterfeiting management. To achieve this goal, we started with defining anti-counterfeiting by companies, actions of counterfeiters, and the counterfeiting phenomenon as our objects for analysis. To make sense of the data, a category system for data coding is used, a process that connects keywords ("codes") to words, sentences, or paragraphs (Creswell 2009). We arranged the first category system based on the literature. For the three areas we set up the main-categories already mentioned in section 3.2.1. Open coding (defining new codes for interesting aspects that are identified while reading the documents) was used to create sub-categories to integrate the various dimensions of each main-category or to add main-categories. We revised it five times during data analysis by merging, adding, or separating the extracted passages. Interview transcripts were reviewed sentence by sentence for each new category system. Thus, as for the interview topics, the system of codes was created both deductively from literature and inductively from collected data. As only one person was responsible for the main coding, coding reliability could have emerged as a problem. To ensure reliability, we used peer discussions with the interviewers and colleagues.

In order to handle that amount of data, we used the qualitative data analysis software MAXQDA (VERBI 2011). This software allows the storage and organization of documents, category creation, coding, the retrieval of text passages and it includes memos.

3.5 Quality assessment

Validity and reliability are two basic criteria to evaluate empirical research (Field 2009). In qualitative research, their connotation differs from the established definitions (Creswell 2009). Qualitative reliability is assured if the researcher's approach is consistent across different researchers and different projects (Gibbs 2007). This criterion is often problematic for this type of research. Qualitative validity is a frequently discussed issue (Lincoln et al. 2011) and refers to the point that the researcher takes care for the accuracy of the findings by employing certain procedures (Gibbs 2007).

Qualitative reliability procedures include four elements: First, transcripts should be inspected for mistakes during transcription process. Second, the correct and precise use of the codes should be ensured by constantly comparing data with codes and by creating memos. Third, as far as team coding is concerned, coordinated communication is needed via regular documented meetings and analysis sharing. Fourth, if codes are developed by different researchers, independently derived coding results should be cross-checked (Gibbs 2007). Qualitative validity procedures consist of eight elements: First, the triangulation of different data sources and participants' perspectives support validity. Second, member checking in terms of interaction with the participants after the data collection should take place. Third, the findings should be described in a comprehensive way. Fourth, the researchers' role should be described. Fifth, negative and discrepant information from the research results should be addressed by presenting contradictory findings. Sixth, a prolonged time in the field strengthens an accurate handling of the research object. Seventh, peer debriefing by means of addressing a person who is familiar with the researcher or the project to review the qualitative study. Eight, if possible, an external auditor should review the entire project (Creswell 2009).

As quality procedures should include multiple elements that can occur throughout all steps in the process of qualitative research (Creswell 2009), we arranged Table 5 to sum up our way of quality assurance.

Table 5: Quality assurance of the study

Criteria		Research Design	Instrument Selection	Data Collection	Data Analysis	Results
Reliability	Trans-cripts	Transcription rules	Summary transcripts	Informant check; 2 inter-viewers; inter-viewer training	Researcher, peer discussion;	
	Codes			Memos	Coding rules; memos	
	Commu-nication	No team coding, research meetings for preliminary discussion				
	Cross-Checking	Process docu-mentation		Case study		
Validity	Triangu-lation	Multiple topics	Expert Interview, case study	Multiple actors, Indus-try sectors, functions	Category system	
	Member Checking			Interviewee approval; follow up calls		
	Descrip-tion	Literature review	Instrument description	Sample description	Instrument description	Result description
	Resear-cher Bias		Interviewer ≠ researcher	Interviewer ≠ researcher	codified research instrument	
	Discrepant Informa-tion			Two interview guides; follow-up calls; Case	Discussion	Discussion
	Time	business projects; long project duration				
	debriefing	Experts for qualitative methods, colleagues, presentations, expert talks				
	External auditor	Research meetings	Research meetings	Research meetings	Research Meetings	Conferences

4. Towards an understanding of Counterfeiting management

This section reports our findings for counterfeiting management and provides a framework for counterfeiter analysis. All findings refer to counterfeiting management as an opposite element to legal competition. We did not focus on the competition between counterfeiters. Interesting findings are presented in more detail. Each subsection provides one unit of analysis for counterfeiting management.

The experts delivered information about competitive (dis-)advantages and aims of counterfeiters, supply chain elements, strategy formulation, organizational structures, instruments, process, and competencies. Nevertheless, we have to state, that the existing knowledge about counterfeiting is very limited due to a lack of corporate resources to conduct in-depth analysis, missing knowledge about a corresponding framework, and the problem of counterfeiter related information availability. In addition, experts from large multinational companies were able to contribute more than experts from smaller companies. According to the experts, a generic framework that includes a management perspective is a good starting point for summarizing a company's knowledge about the issue and analyzing counterfeiters in more detail. Thus, a basic framework should take all possible elements into consideration to understand the way a counterfeiter is doing business. They position such a framework as a strategic tool rather than an operational instrument. Furthermore, an industry sector specific adoption is needed. After the introduction of the basic framework, we will present selected elements in more detail.

4.1 A basic framework for exploring counterfeiting management

Based on the results of the content analysis of the transcripts and the cross-case analysis we focus on a combination of a process and competence oriented view. As interview partner 136 (private investigator) explains: "*You can identify methods and aims from the modus operandi*."[3] The modus operandi of a counterfeiter can be divided into (1) primary and (2) supporting activities that enable a counterfeiter to establish, gain, defend, or prolong a counterfeiting competitive advantage.

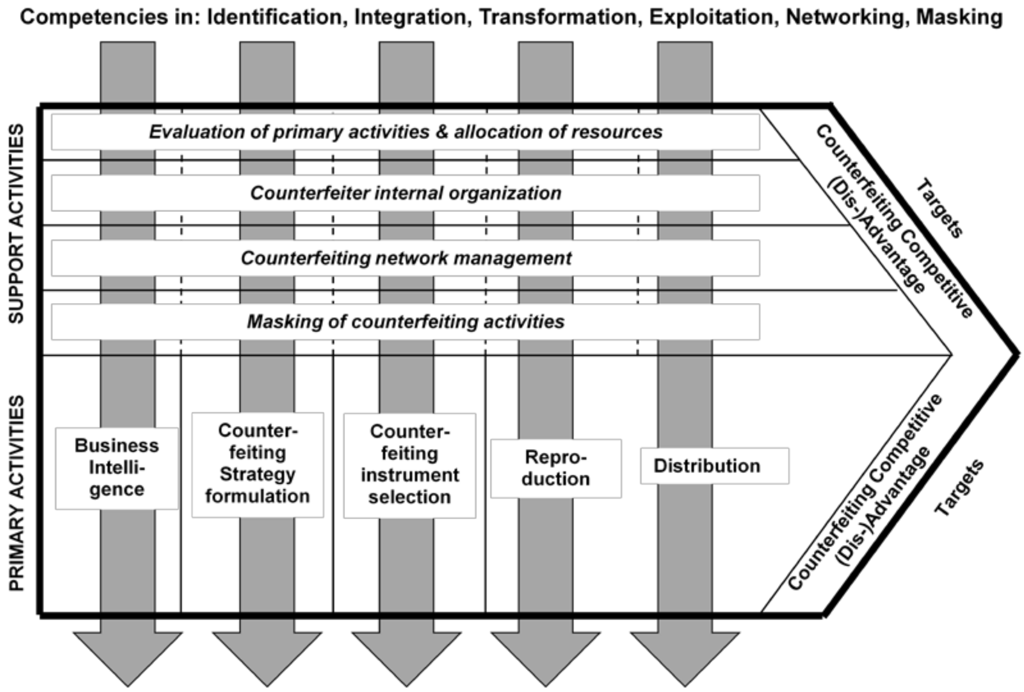
(1) The primary activities directly address the different stages of counterfeiting value creation. Like legal professional companies, counterfeiters have to generate business intelligence, formulate strategies, select instruments, start reproduction and disseminate the results of their activities.

(2) The supporting activities are not involved in the direct value creation process are not limited to one stage. These activities enable a counterfeiter to perform it's primary activities and include the masking of counterfeiting activities, counterfeiting network

[3] All translations made by the authors.

management, internal organization structure, and the evaluation of the activities as well as the allocation of specific resources to realized the counterfeiting business model.

Figure 1: A basic framework for counterfeiting management analysis



In addition, not only the primary and supporting activities may help to understand counterfeiting management but also the underlying competencies should be explored. As expert 138, a corporate security manager, specifies: *"Not only the physic counterfeits matter, counterfeiters need know-how and specific capabilities for development."* Thus, we could derive a competence setting from the transcripts that allows a more detailed analysis of counterfeiting management. It is important to note, that not all elements of the framework may be relevant or information is unavailable for one specific counterfeiter. That is the reason why we recommend to analyze existing corporate data, collaborate with legal supply chain members, service providers, and enforcement agencies to evaluate a counterfeiter.

4.2 Competitive (dis-)advantages and targets of counterfeiters

4.2.1 (Dis-)Economies of counterfeiting

The first step includes the analysis of a counterfeiter's competitive position and agenda. In general, counterfeiters in our study have several (dis-)advantages that can be divided into what we call Economies and Diseconomies of Counterfeiting. Economies of counterfeiting include free rider effects, economies of scale and scope, and the possibility for cost degression. Like in the OECD report (OECD 2008) counterfeiters can free-ride on the creative and economic efforts of legitimate companies' technology and market development

efforts. Economies of scope are possible in two ways: Counterfeiters can use their existing knowledge from legal activities for illegal production (e.g. factory overruns) or they can use their experience from one counterfeiting case for other illegitimate actions. For instance, we had one case that describes how a counterfeiter in Russia illegally imitated patent protected filters using the trademark of the original manufacturer. The company diversified it's business afterwards into trademark counterfeiting for engine oil which was never produced by the original company. Diseconomies of Piracy mark general disadvantages. These costs include investments for identifying suitable objects for counterfeiting (e.g. market analysis, bribery), knowledge acquisition, adoption and production. Moreover, counterfeiters have to take care of a risk premium for illegality and have to save reserves for confiscated products or lawsuits. Additional costs arise due to masking and securing the illegal supply chain. As specific competitive advantages the experts identified cost advantages, speed and flexibility, being unknown, and the utilization of legal uncertainty respectively illegality. Intentional illegality and cost advantages are the core elements of the business model. Although it is seen as important foundation for anti-counterfeiting, illegality allows a flexible strategy formulation and the utilization of legal uncertainty as well as the chance to take advantage of a low enforcement. Counterfeiters have a better cost position of avoiding investments associated with legal competition (e.g. preproduction costs, consumer and employee safety, taxes), and profiting from low labor costs by offshoring production. Speed and flexibility are seen as another competitive advantage as counterfeiters are mainly focusing on well established markets, a product's shape, not on functionality, lean production lines, less administration, and easily exchangeable workforce. Being unknown is seen as a temporary advantage that is based upon the often existing ignorance of original manufacturers, distributed production facilities, a high international division of value creation and a masking capabilities.
The overall motives for counterfeiting include five possible agendas. Besides having a profit motive and closing technological gaps, the experts reported three new motives: Some counterfeiters try to position themselves as suppliers for competitors of the original manufacturer. Companies also use counterfeiting as a way to become a legal competitor on global markets. Furthermore, counterfeiting is used as a well-directed instrument of governments to harm a legal company or strengthen and protect certain industry sectors.

4.2.2 Counterfeiting orientation

We also found information about four basic counterfeiting orientations which allow a more detailed analysis. Each actor can basically be characterized by a mixture of four basic positioning elements: (1) producing, (2) distributing, (3) financing, and (4) organizing.
(1) Production positioning refers to the direct production of counterfeited goods and can include all or only several stages of counterfeiting production. Production orientation leads to

technological learning and the ability to offer different combinations of quality and functionality. Due to mistakes in strategic management of intellectual property rights of original manufacturers concerning geographical filing, the additional use of utility patents etc., producers can avoid legal prosecution as enforcement of laws against unfair competition is hard to prove for agencies. In contrast, the signaling of production performance, investments in production facilities, and close networking with distribution partners are critical success factors. As a strong production orientation leads to investments into physical buildings, the ability to relocate production is important, too. Typically, counterfeiters with a high level of product orientation are located at some distance to the original manufacturer to avoid detection. All experts agree that the People's Republic of China is still the biggest manufacturing country. Other developing countries from Asia to Eastern Europe and South America regain market shares. Producers are coming from industrialized countries, too.

(2) Distribution position specifies the engagement of a counterfeiter in offering distribution and logistics services depending on market knowledge, distribution capabilities, and the potential addressable market. Market knowledge includes information about well-known original products, target markets of original manufacturers, important distribution channels, and consumer behavior. The distribution capabilities refer to the possible direct and indirect channel options for creating, using, or managing a channel system among the counterfeiters, between counterfeiters and consumers, and the infiltration of legal distribution channels on all stages of the supply chain. The potential addressable market refers to national, regional, and global distribution. Counterfeiters that focus on the distribution function also have to conduct consumer analysis to understand deceptive and non-deceptive consumer behavior. Target customers can be both, individuals or private companies. It seems that depending on the level of acceptance of counterfeiting the intensity and number of customer contacts is designed. Advantages of distribution orientation are counterfeiting market power, a relative low level of fixed costs, flexibility in choosing partners, market related learning, and a good chance to avoid detection on national and regional level as long as they do avoid markets of original manufacturers. Linked to this orientation, specific disadvantages arise, too. The majority of anti-counterfeiting activities are directed at counterfeit distributors as importers in strong enforcement systems are the easiest target for legal protection activities. Price pressure can be a problem if the distributors are collaborating with procurement agents of established companies (e.g. retailers in the consumer goods industry or parts procurement in the capital goods sector) in industrialized countries. Counterfeit distributors have to direct the channel system and are responsible for customer contact. Thus, they have to invest into various channel instruments or, especially in the capital goods industry, have to establish face-to-face communication to acquire companies or react to their offers. As a distribution function, supply with counterfeits depends on the relationship to producers. Without a broad

network of possible producers, a distributor is very likely to be unable to satisfy demand. If established mainly legal acting retailers or importers take part in the illegal distribution, negative image effects can also occur.

The next positioning elements, organizing and financing, are discussed very controversial by the experts. (3) The organizing positioning refers to background elements that are superior to production and distribution. They could be either called the true managers of counterfeiting as they manage and direct the whole value creation process and integrate the relevant actors, or private service providers as they serve as connecting elements between the counterfeiters in the supply chain. For both, networking and masking capabilities as well as organizational, product related, and market oriented know-how are the core elements that describe the organization orientation. Depending on the internal structure, this orientation leads to a high level of masking capability, flexibility in bringing together or directing counterfeiters, and mainly low fixed-costs for maintaining the network. Some experts also mentioned a high level of fixed-costs because of the ownership of production equipment, for instance, moulds or special tools, that is only provided on demand for limited time to counterfeit producers. Disadvantages arise from the dependence on the availability of production and distribution counterfeiters. Organizers in terms of counterfeiting managers need to take care, that they have lots of counterfeiters to address in order to avoid supply shortages. Serving parties need contact to a great variety of counterfeiters to fulfill their role of connecting party. That is why counterfeiting managers or services providers establish a multi-actor production and distribution system. Organizers also have to take care of quite a lot of knowledge creation regarding production, distribution, and the market. In addition, interaction with enforcement or governmental agents is crucial to their business success.

(4) The financing positioning refers to monetary flows that underlie counterfeiting. This element could not be described in more detail by the experts due to missing insights into the illegal finance sector. The experts could only mention high profits combined with a low level of prosecution. Depending on the size of the counterfeiter and the combination of the other three orientations, it seems as there are counterfeiters which focus on this element or combine one of the other functions with financing the operation.

Depending on these four orientation parameters, the importance and the position of a counterfeiter in the supply chain can be estimated by the original manufacturer.

Table 6 provides a summary of the criteria for the four basic orientations that we could identify in our study.

Table 6: Basic functional positioning

Orientation	Dimension	Advantages	Disadvantages
Production	- Ease of knowledge acquisition - Production capacity - Production know-how - Deliverable quality and functionality level - Boundness to physical production sites	- Cost structure - Technological Learning - Distance to original manufacturer - IP-mistakes of original manufacturers	- Dependence on other counterfeiting functions - Performance signaling
Distribution	- Market know how - Distribution capacity - Potential addressable market	- Market power - Low level of fixed costs - Market oriented learning effects - Ease of vanishing	- Price pressure - Customers have to be acquired - First target of enforcement - Dependence of production - Negative public relations
Organization	- Level organizational, production and market related knowledge - Network capability - Integration capability - Service provision for other orientations	- Strong background in organized crime - High profit margins - Low level of fixed costs - High flexibility - Ease of vanishing	- Dependence of other functions - Strong network dependence
Financing	- Level of monetary support	- High profit margins - Very unlikely to detect	- Investment risks

4.3 Primary activities

4.3.1 Business intelligence

Any counterfeiting activity is based on the detection of signals of emerging trends. This environmental scanning is captured in our model in the category business intelligence and has four elements. First, counterfeiters gather information about markets, products, and customers. Second, the evaluating of the counterfeiting environment is conducted. Third, counterfeiters try to identify, evaluate, and approach possible collaborators. Forth, legal and illegal direct information acquisition from original manufacturers was reported from the experts. Table 7 provides a summary.

Table 7: Sources for Business Intelligence

Level	Element	Object	Relevant Information
1	Market	Public information portals, trading, portals, trade fairs, industry reports, other counterfeiters	Market structure, price, volume; market development
	Customer	public chatting sites, Industry reports, other counterfeiters	Consumer behavior; willingness to pay; key buying factors, attitudes,

			acceptance of counterfeiting
	Product, process, packaging	Product and process documentations, photos, patent documents, operating manuals, buying or stealing products and packaging material, service level agreements, customer visits, public product presentations, product tests, scrap, other counterfeiters	Product features and shape, ingredients, complexity, handling, production processes;
2	Environ-ment	Patent documents, newspapers, governmental contacts, research reports, other counterfeiters,	Danger of IP infringements, available distribution channels, behavior of governmental authorities, counterfeiting clusters, available workforce
3	Collabo-rators	Consultants, customers, suppliers, distributors or competitors of the original manufacturer, wholesalers and retailers, governmental authorities (enforcement agents, audit or certification agencies), other counterfeiters, former employees of the original manufacturer	Production, distribution, organization, masking, knowledge and product acquisition, components, raw materials, blue-prints, scrap
4	Original manu-facturer	Joint-Ventures, contract based and outsourcing activities (R&D, supply, production, distribution), present or future permanent or temporary employees of the original manufacturer,	Present and future Product types, variants, and parts offered, distribution system, level of anti-counterfeiting, supply chain structure, target markets, pricing, level of factory surveillance, training material, scrap

4.3.2 Strategy formulation

From a strategic point of view, counterfeiting strategy formulation in our study consists of seven elements that can be found in Table 8. Besides the already in section 6.2 mentioned (1) positioning possibilities, counterfeiter strategy formulation shows several specifc characteristics. (2) The level of (non-)deceptiveness includes the basic decision for open or masked operations regarding business partners and customers that affects all primary activities. Counterfeiters that use open operations for business partners try to use their competitive advantages to interact with competitors of original manufacturers and counterfeiting friendly retailers or counterfeit producers. They sell their products to consumers that accept counterfeits due to lower prices or contact customers that are willing to share information about original product features. Masked operations are used to act as pretended original manufacturer, supplier, or industrial customer in order to facilitate counterfeiting. Closely linked to (2) are (3) targeted counterfeit and (4) pricing differentiation, and (5) specialization. Target counterfeit differentiation refers to a counterfeit's shape, quality, and functionality. Pricing strategies include low- and high price strategies as well as dynamic pricing according to customer demand and the pricing of the original product. The specialization is determined by product range and the use of non proprietary intellectual property rights (IP-infringement). Counterfeiters concentrate on one, a few, or multiple products of one or more original manufacturers from one or more industry sectors. In addition, the accepted IP-infringement (patent, trademarks etc.) can be divided into either product or trademark related counterfeiting and a mixture of both. The experts reported several combinations. For instance, the counterfeit producer specialized on one product without trademark infringement, specialized packaging counterfeiters added trademarks and the distributors offered blank and trademark products. (6) Operation range describes a counterfeiter's internationality and conflict potential. Geographical differentiation includes national, regional, or global activities. National activities concentrate on one country, whereas regional or global activities enlarge the operation range to two or more countries. Furthermore, the conflict potential in operating in home, host, or third party countries needs to be decided. A home country is the one the counterfeiters is coming from, original manufacturer are coming from host countries, and third party countries cannot be attached to any of them.

Table 8: Parameters for counterfeiting strategy formulation

Strategic element	Dimension	Elements
Positioning	Production, Distribution, Financing, Organization	The mixture describes a counterfeiter in general
(Non-)Deceptiveness	Open/masked operations	Business partners Customers
Counterfeit focus	Product Differentiation	Shape, quality, functionality
Pricing differentiation	Pricing differentiation	High, low, dynamic pricing
Operating Range	Internationality	National/regional/global
	Conflict potential	Home/Host/Third party country
Counterfeiter behavior	Activity level	Active vs. reactive
	Relevance	Dominating/complementing
Specialization	Product range	One, a few, multiple products/original manufacturers/industry sectors
	IP-Infringement	Product vs. trademark counterfeiting, both

Derived from both dimensions, counterfeiters can define their operation range. For instance, national home country counterfeiters produce and serve one single market to avoid anti-counterfeiting and to be able to achieve counterfeiting learning effects. Counterfeit distributors in the industrial goods sector often focus on third party countries and counterfeiters belonging to organized crime establish networks for global counterfeiting supply. (7) Counterfeiter behavior describes the role of a company. Counterfeiting can either be the dominating or the complementing part of a company's business model. Dominating means that a company is nearly completely relying on counterfeiting whereas other companies use counterfeiting to complement their legitimate product portfolio. In our study, complementing can be observed from well-established manufacturers, suppliers, or distributors. They have the advantage, that they often are able to use original material for third shift production or to complement their own product offerings. The second element of counterfeiter behavior is the activity level. Active counterfeiters search for opportunities, collaborators, or new business models to sell, distribute, finance, or organize counterfeiting. Reactive counterfeiters are engaged in counterfeiting only on demand. Initiators are counterfeiters (e.g. producers, distributors, or organizers), retailers or wholesalers from other countries, and competitors or customers of original manufacturers.

4.3.3 Instrument selection

The experts reported that counterfeiters do not rely on one but use multiple instruments to conduct their business. We arranged them according to the source or function within a company into political, technical/technological, legal and management oriented instruments in Table 9. Legal Instruments focus on possible IP-related actions of counterfeiters to combat original manufacturers. They aim at securing or prolonging counterfeiting activities. Management-oriented measures refer to the handling of the counterfeiting process and can be found at all stages. Political instruments support counterfeiting activities and are directed at governmental authorities or other counterfeiters. Technological solutions are directly linked to the counterfeit.

Table 9: Counterfeiting instruments

Source	Instruments
Legal	*Underlying IPRs:* Patent, trademark, utility patent, design patent, law against unfair competition *Legal instruments:* Pre- or counterfiling of existing IPRs of original manufacturers in “IPR-free”, home, or host countries; illegal use of existing IPRs; pre- or additional filing of “free” IPRs around the IPRs of the original manufacturer, alteration of existing trademark or patent application elements;
Manage	*Business Intelligence:*

ment oriented	Document analysis (IPRs, standards, on- and offline manuals, cata-logues etc.), trade, suppliers, vendors fair investigation, pretended meetings and offerings, human intelligence (competitors, suppliers, distributors, customers, employees of the original manufacturer); espionage, enforcement evaluation; online and offline technical espionage *Human Resources*: Bribery, headhunting, pressure on employee, decrease labor costs, individual relationship management, incriminating evidence, loyalty assessment, expatriate program, infiltrate the original manufacturer's workforce *General management:* Network management, collaboration (Joint-Ventures, fake contracts, production co-operations, knowledge and machinery exchange) betray other counterfeiters; permanent relocation, clustering vs. small scale sites; preference for regions with a low level of governmental surveillance, lobbying, relationship management, management of the illegal supply chain, little separated freight quantities *Logistics:* penetration of or intrusion into legitimate supply chain, low level of storage, changing of distribution routes, use of a hub-system, transportation (from cars to airplanes) *Marketing:* Market analysis, image creation, pricing, online marketing on private auction homepages, alteration of product names, provision of promotional material, manuals and product catalogues *Technology and Intellectual Property Management*: IP-Infringement analysis, combination of legal instruments, recommended alterations for counterfeits, life cycle analysis, "brand management" *Procurement:* Acquisition of parts, test samples, product properties, packaging, pre-products, complete counterfeits; pretended procurement talks, *Production:* machinery, manual labor, refilling of original packaging, quality and functionality management, level, on demand production, low or no storage, no-name products, repacking; sharing of production elements and machinery. *Sales/Distribution:* - Legal system: Intrusion into the legal system; bribing of drivers, blue-collar workers, storekeepers, retailers, or free trader; attendance of fairs; legal internet platforms - Illegal direct system: counterfeit internet platforms, addressing competitors, suppliers, or customers of the original manufacturer, fake labeling - Illegal indirect system: Street vendors, contact to counterfeit wholesalers and retailers, fake labeling, street markets, *R&D:* reverse engineering (based on products, pictures, patent; product adoption the reduce legal anti-counterfeiting
Political	*Governmental authorities:* Bribery, illegal cooperation, success sharing during raids; anti-counterfeiting information sharing; fake certifications, shipping documents, and toll

	registration numbers; illegal technology transfer *Private sector:* networking; joint lobbying, anti-counterfeiting information sharing
Techno-logical	Use of fake trademarks, certificates, registration numbers, combination: fake trademarks and packaging, fake manuals, color variation, use of the same overt technological/technical anti-counterfeiting solutions as fakes, combination of legal and illegal elements,

4.4 Support activities

4.4.1 Masking of counterfeiting activities

Derived from the expert interviews and the case studies, the masking of counterfeiting activities is one of the two major functions in supporting the counterfeiting process. Masking is at the core of business objectives as counterfeiting seems not to be possible until a company is able to select, use, and combine the instruments in section 6.3.3 accordingly. Thus, masking is directed at all possible stakeholders. The main instruments are production, sales/distribution, and logistics. All strategies do at least contain one element of masking. Without it, legal prosecution measures of anti-counterfeiting are easily applicable. That is the reason why, companies with a high degree of organizing and financing functions concentrate their efforts on masking their activities. Counterfeiters only abandon their secrecy to some extent if a non deceptive behavior leads to more profit. Anyhow, they only disclose less important parts of the front end of their activities that are close to customers. The relevance of masking in our study ends as soon as counterfeiters are established competitors with own intellectual property rights.

4.4.2 Network management of the supply chain: Structure and Actors

Network management is the second important supporting function. Counterfeiting is a highly divided illegal supply chain that is strongly relying on network structures and specialized actors. The actors and the structure are similar to the legal supply chain. On the first level, counterfeiters act as producers or procurement operators for low to medium quality materials. To reduce costs, they infringe process patents, use low-quality ingredients, and do not take care of environmental or health issues. On the second stage, counterfeiters are responsible for semi-finished goods. These goods range from technological components (e.g. casting molds) to the provision of ready-to-use counterfeited trademarks for the next stage. They violate all sorts of intellectual property rights, for instance copyright based software and packaging material and infiltrate legal supply chains, too. The third stage refers to system integration. A counterfeiter can have a “traditional” OEM position. The company produces it’s stage-specifc part, integrates the previous elements, and interacts with the subsequent stages. Up to this point the production oriented counterfeiter types of Staake/Fleisch 2008 could be applied. The experts report of another possibility for this stage: assembling points act as integration hubs for previous stages without management duties.

On the market oriented stages of the supply chain, counterfeiters as logistics providers care for delivery to target markets on stage four. They are important if distribution and market countries differ geographically. Counterfeit smugglers can also be found on this level. All kinds of illegal wholesalers, retails or street vendors can be found on stage five. On all stages, counterfeiters can act for both, legal and illegal supply chain partners of all industry sectors.

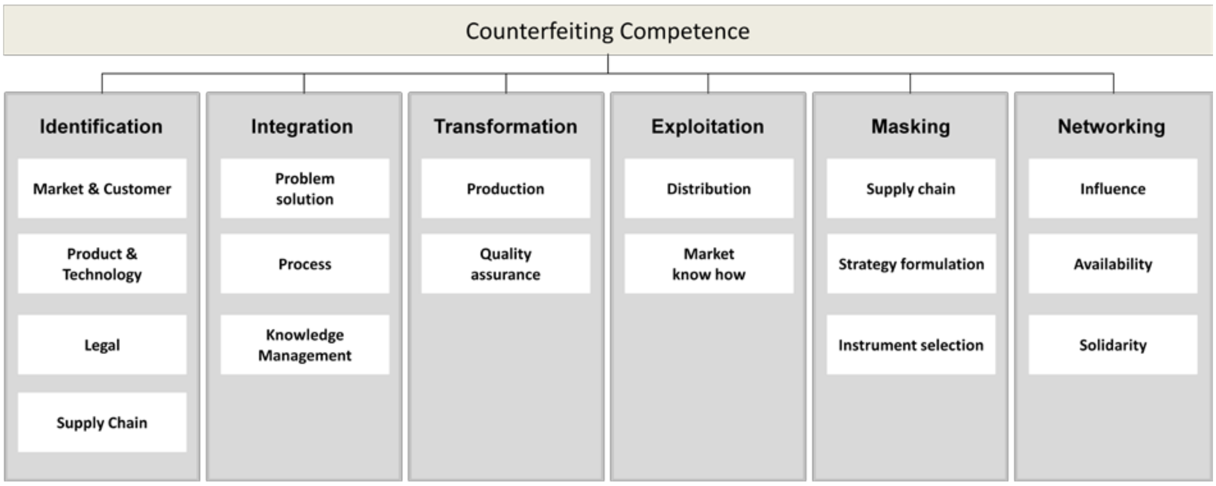
4.5 Competencies of counterfeiting management

Based on section 4.1 and the results in the subsequent sections, we argue that counterfeiting strategies and instruments alone cannot explain counterfeiting success. Moreover, the underlying counterfeiting competence enables a counterfeiter to achieve specific objectives. From a process oriented view, counterfeiters develop their own type of absorptive capacity. First, they have to create the potential for counterfeiting. This includes the creation of the potential for counterfeiting, precisely identifying and assimilating external know how. Second, the potential is realized by transforming and exploiting it. Third, masking protects a counterfeiter. Forth, networking refers to the interaction with all possible partners.

Besides the core competencies, we identified three dynamic capabilities of counterfeiters that are similar to the existing RBV literature for legal competition. (1) Adoptability refers to the reconfiguration, renewal, or removal of primary and supporting activities. The illegitimate companies have to change them in order to react to or influence a country's appropriability regime, or anti-counterfeiting efforts of original manufacturers. Facing increasing costs, the loss of counterfeiting collaborators, and limited instrument durations, the ability to adopt the system allows the protection or extension of the counterfeiting business model and the prevention of anti-counterfeiting. (2) Due to the dynamic character of the legal and illegal competition, the learning capability is the second element that is responsible for the business success of counterfeiter. They can improve their ongoing primary and secondary activities, acquire new knowledge, reduce technological disadvantages, shape or redirect their business model (e.g. from a high level of production function to a stronger focus on organizing), and can emerge as new legal competitors at least in the long run. (3) Reorganization refers to the integration, change, or deletion of organizational structures. Counterfeiters have to reorganize illegal supply chains, external networks, and internal organizational structures.

Figure 2 shows the competence based framework to evaluate counterfeiters. Each capability consists of two to four elements according to which the maturity of counterfeiting competence can be estimated. For each element four maturity levels have been identified. They make it possible to assess the proficiency of a counterfeiter in each capability element and can help for situation analysis in anti-counterfeiting. Higher levels represent a higher capability.

Figure 2: A framework for Counterfeiting Competence Assessment



4.5.1 Identification

As counterfeiters aim at profiting from the efforts of original manufacturers, they have to identify existing business opportunities to determine the risks and chances of counterfeiting. Market and consumers represent the demand side of the business opportunity. Product and technology refer to a technical evaluation of the original product. Legal aspects determine the risks of legal prosecution. Supply chain shows the understanding of the legal production and distribution system. We could identify the levels in Table 10.

Table 10: Levels of identification

Element	Level 1	Level 2	Level 3	Level 4
Market & Customer	Market scanning for sales figures	Market and customer scanning	Segmenting markets and customers	Identify the most important market and customer segments
Product / Technology	Using public available information about the product	Acquire product information from reverse engineering	Collaborate with stakeholders to enlarge product and technological know how	Active information acquisition from original manufacturer
Legal	No legal analysis	Identify important IP elements	Analyze legal consequences	Analyzing mistakes, gaps, and weak points
Supply chain	No supply chain analysis	Understand the general structure	Understand the core elements of the distribution channel system	Analyzing weak points and intrusion opportunities

4.5.2 Integration

Integration refers to the ability of counterfeiters to integrate the knowledge into their organizational structures. According to the experts, the degree of problem solution and the available processes should be used to estimate the integration capacity of a counterfeiter. Problem solution is associated with the development of possible solutions for all important issues which emerged during the identification. Knowledge management indicates the level of information exchange to support the integration. Process refers to the type of integration efforts. Table 11 shows the levels of integration.

Table 11: Levels of integration

Element	Level 1	Level 2	Level 3	Level 4
Problem solution	Providing solutions for one element	Providing solutions for two elements	Providing solutions for three elements	Providing solutions for four elements
Process	No process at all	Some procedures exist	A lot of procedures are used	Standard operating procedures
Knowledge Manage-ment	No knowledge management	Information exchange a few core collaborators	Information exchange within the counterfeiting network	Information exchange with all relevant stakeholders

4.5.3 Transformation

The transformation capability refers to the creation of counterfeits. Production reflects the similarity between the original product and the counterfeit. Quality assurance indicates if the counterfeiter is able to produce counterfeits on a constant level. Table 12 portrays the transformation levels.

Table 12: Levels of transformation

Element	Level 1	Level 2	Level 3	Level 4
Production	Only non deceptive counterfeits	Product shape	Product shape and basic functionality	Slavish imitations
Quality assurance	Permanent differences	Differences in the majority	Differences are observed seldom	Very little to no differences

4.5.4 Exploitation

Exploitation refers to the commercialization of counterfeits. Distribution describes the channel system. Market know how indicates the segmentation efforts to address specific customers. An overview can be found in Table 13

Table 13: Levels of exploitation

Element	Level 1	Level 2	Level 3	Level 4
Distribution	National single channel system	Regional single channel system	Regional multi channel system	Global multi channel system

Market know how	No specific segmentation	Concentration on the largest segment	Specialized counterfeits for several segments	Specialized counterfeits for each segment

4.5.5 Masking

Masking refers to the capability of keeping counterfeiting elements secret. Supply chain reflects the available information about the structure and the actors of the counterfeiting supply chain to the original manufacturer. Strategy formulation describes the capability of formulating adequate counterfeiting strategies. Instrument selection indicates the instrument application of a counterfeiter. Table 14 provides an overview.

Table 14: Levels of masking

Element	Level 1	Level 2	Level 3	Level 4
Supply chain	Structure and actors are known	Several stages and actors are known	A few stages and actors are known	Supply chain is unknown
Strategy formulation	No strategy formulation	A strategy can be observed	Strategy formulation based on several dimensions	Multidimensional strategy formulation
Instrument selection	Only the most necessary instruments are used	A few instruments are used	Instruments from different sources are used without coordination	Instruments from different sources complement each other

4.5.6 Networking

Networking refers to the complexity and the connections of a counterfeiter. Influence indicates if a counterfeiter is able to set an agenda for a network. Availability indicates if a counterfeiting network can provide all relevant elements for counterfeiting. Solidarity describes the level of mutual trust and understanding. Table 15 includes the different levels.

Table 15: Levels of networking

Element	Level 1	Level 2	Level 3	Level 4
Influence	The counterfeiter has no influence	The counterfeiter can participate in the agenda setting process in a minor way	The counterfeiter can set an agenda together with other strong members	The counterfeiter is the strong leader of the network
Availability	Only a few elements are available	The major relevant elements are available	All relevant elements are available.	All relevant elements are available several times
Solidarity	Network members cooperate loosely	Network members depend on each other in some areas	The network follows a strict agenda	The network belongs to organized crime

5. Discussion and conclusions

5.1 Discussion

The basic framework in section 4.1 and the subsequent sections reflects many primary and supporting activities. This process oriented view allows a comprehensive view on counterfeiting management. The general (dis-)advantages and targets presented in section 4.2 capture a differentiated picture for the engagement in counterfeiting. Contrary to the existing literature, we identified multiple targets of counterfeiters. Although the intention to realize profits is a dominant target, we found other motives like the reduction of technological disadvantages or the well-directed attack on original manufacturers. Depending on the counterfeiting orientations, counterfeiters appear to prioritize the relevant activities and highlight counterfeiting as a multi-actor phenomenon. Most of the experts in this study described both basic orientations as the major source to create profits. Especially counterfeiters as organizers strongly belong to networks of organized crime syndicates, mainly Mafia and Triads, or, in fewer cases, to radical political parties (e.g. Hezbollah) respectively terrorist organizations like Al-Qaeda. A few experts do not mention these two orientations or, if asked for, consider them as less important or as a part of production and distribution. As shown in section 4.3 counterfeiting strategies are related to a variety of elements and can be based on several sources of information. For the implementation of these strategies, counterfeiters can use a complex system of legal, political, technological, and management oriented instruments. From the supporting activities, the experts stressed the importance of masking and networking as most important supporting activities to organize counterfeiting in section 4.4. They could not provide insights into internal organization structures, evaluation, or resource allocation due to the limited access to counterfeiters as participating experts.

For successful counterfeiting management, counterfeiters have to develop specific competencies. Drawing on the resource/competence based view of the firm, we were able to identify different capabilities which represent counterfeiting competence as described in section 4.5. To explore them in more detail, we used the concept of absorptive capacity as starting point and adopted it to our research object to create a framework for analyzing counterfeiters in more detail. Due to the explorative design of this study the elements and levels should not be regarded as a closed tool but as an open instrument that could be rearranged or supplemented with additional elements for analyzing a counterfeiter’s management competence.

Based on our study, we argue that counterfeiters have developed from small scale backyard production to a professional industry with a high degree of labor division and specialized actors. Counterfeiters are able to achieve competitive advantages compared to legal competitors but they also have to face disadvantages. Therefore, counterfeiting management has to follow this development to secure the competitive position. Dierickx and Cool 1989 identified several barriers to asset stock accumulation which make corporate learning more difficult (Dierickx/Cool 1989). Counterfeiters seem to be able to overcome these barriers to some extent. They can position themselves as followers to reduce uncertainty and ambiguity. As they accept IP infringements, they can acquire product and process knowledge very fast. Additional costs for testing new concepts do not exist as long as they concentrate on simple counterfeits. Due to their networking capability they do not face critical resources. Thus, counterfeiting can be seen as a foundation for the realization of learning effects for the development of companies in addition to innovation and imitation.

5.2 Implications

5.2.1 Implications for anti-counterfeiting in practice

The experts in our study are all engaged in the field of (anti-)counterfeiting practice or research. Anti-counterfeiting depends on the knowledge about the counterfeiters to successfully develop a protection system. Up to now, counterfeiting is regarded as some type of black-box. With this study, we add an explorative collection of a wide variety of possible starting points for the analysis of counterfeiting management. We have shown that counterfeiting strategy formulation consists of several factors which can reveal a counterfeiter’s focus. Counterfeiters act in complex and international networks which consist of various specialized actors. Counterfeiting instruments can be found in various functions, among them production, sales/distribution, and logistics seem to be most important to mask activities. Counterfeiters are not all alike, they can be evaluated by analyzing their capabilities. Future anti-counterfeiting efforts should take these findings into consideration as emerging counterfeiting management demands professional anti-counterfeiting solutions.

5.2.3 Implications for (anti-)counterfeiting research

From a conceptual point of view, we found several elements in an explorative study, which describe counterfeiting management in more detail. The investigation of the supply side of counterfeiting management can provide valuable insights into counterfeiters as competitors of legitimate innovating and imitating companies. With this study we sum up the existing literature to present relevant research contributions. We present a process and competence oriented framework of counterfeiting management. Our approach demonstrates the potential of a qualitative research design with multiple methods for exploring less investigated field. This study identifies the elements of counterfeiting management as promising research gap in innovation and intellectual property management literature.

5.3 Limitations and further research

Given the very limited literature about counterfeiting management and the difficulties in addressing counterfeiters, we have used an indirect and explorative qualitative design that combines a multi-industry and a multi-actor perspective to investigate the supply side of counterfeiting. The expert interviews and case studies provided insightful information about the different topics. Although we put emphasis on the quality assurance in section 3.5, this research design is limited to some extent. (1) An explorative design aims at creating and not reducing information. (2) A qualitative approach reflects subjective information and cannot provide objective insights into counterfeiting management. For these two reasons, quantitative instruments have to be added to improve the knowledge about the elements of counterfeiting management. (3) This study was designed to explore the topic from a general perspective. To identify country or industry sector specific elements, the sample should be adjusted accordingly. In addition, future research should try to (4) create a more direct approach or using mixed-methods to analyze counterfeiting management, (5) link strategies and instruments to different types of counterfeiters, and (6) analyze the relationship between anti-counterfeiting and counterfeiting in more detail.

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References

Arundel, A., 2001. The relative effectiveness of patents and secrecy for appropriation. Research Policy 30, 611-624.

Baldwin, W.L., Childs, G.L., 1969. The fast second and rivalry in research and development. Southern Economic Journal 36, 18-24.

Barney, J.B., 1991. Firm resources and sustained competitive advantage. Journal of Management 17, 99-120.

Berman, B., 2008. Strategies to detect and reduce counterfeiting activity. Business Horizons 51, 191-199.

Buggie, F.D., 1982. Strategies for new product development. Long Range Planning 14, 22-31.

Bush, R.F., Bloch, P.H., Dawson, S., 1989. Remedies for product counterfeiting. Business Horizons 32, 59-65.

Cassell, C., Symon, G., 2009. Essential guide to qualitative methods in organizational research. Sage Publications, Thousand Oaks.

Chaudhry, P.E., 2006. Changing levels of intellectual property rights protection for global firms: A synopsis of recent U.S. and EU trade enforcement strategies, Business Horizons 40, 463-472.

Chaudhry, P.E., Walsh, M.G., 1996. An assessment of the impact of counterfeiting in international markets: The Piracy Paradox persists. The Columbia Journal of World Business 31, Issue 3, 34-38.

Chaudhry, P.E., Zimmerman, A., 2009. The economics of counterfeit trade – Governments, consumers, pirates and intellectual property rights. Springer Verlag, Berlin.

Cohen, W.M., Levinthal, D.A., 1989. Innovation and learning: The two faces of R&D. The Economic Journal 99, 569-596.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly 35, 128-152.

Connor, K.R., 1988. Strategies for product cannibalism. Strategic Management Journal 9, 9-26.

Cooper, R.G., 1981. The components of risk in new product development – Project NewProd. R&D Management 11, 47-54.

Cordell, V.V., Wongtada, N., Kieschnick, R., 1996. Counterfeit purchase intentions: Role of lawfulness attitudes and product traits as determinants. Journal of Business Research 35, 41-53.

Creswell, J. W., 2009. Research design. Qualitative, quantitative, and mixed-methods approaches (3rd ed.). Sage Publications, Thousand Oaks.

Creswell, J.W., Miller, D., 2000. Determining validity in qualitative inquiry. Theory into Practice 39, 124-130.

D'Aveni, R. A., 1994. Hypercompetition: Managing the dynamics of strategic maneuvering. Free Press, New York.

Denzin, N.K., Lincoln, Y.S. (Eds), 2011: The Sage handbook of qualitative research (4th ed.). Sage Publications, Thousand Oaks.

Dierickx, I., Cool, K., 1989. Asset stock accumulation and sustainability of competitive advantage. Management Science 35, 1504-1513.

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic Capabilities: what are they? Strategic Management Journal 21, 1105-1121.

Field, A., 2009. Discovering statistics using SPSS (3rd ed.). Sage Publications, London.

Ethiraj, S.K., Zhu, S.H., 2008. Performance effects of imitative entry. Strategic Management Journal 79, 797-817.

Frontier – Frontier Economics, 2011. Estimating the global economic and social impacts of counterfeiting and piracy - A Report commissioned by Business Action to Stop Counterfeiting and Piracy (downloaded on 20 August 2011 from http://www.iccwbo.org/uploadedFiles/BASCAP/Pages/Global%20Impacts%20-%20Final.pdf).

Gibbs, G.R., 2007. Analyzing qualitative data. Sage Publications, London.

Grant, R.M., 2008. Contemporary strategy analysis (6th ed.). Blackwell Publishing, Oxford.

Green, R.T., Smith, T., 2002. Executive insights: Countering brand counterfeiters. Journal of International Marketing 10, Issue 4, 39-106.

Harabi, N., 1995. Appropriability of technical innovations. An empirical analysis. Research Policy 24, 981-992.

Harvey, M.G., 1987. Industrial product counterfeiting: Problems and proposed solutions. The Journal of Business and Industrial Marketing 2, 5-13.

Harvey, M.G., Ronkainen, I.A., 1985. International counterfeiters: Marketing success without the cost and the risk. Columbia Journal of World Business 20, Issue 3, 37-45.

Helfat, C.E., Finkelstein, S., Mitchell, W., Peteraf, M.A., Singh, H., Teece, D.J., Winter, S.G., 2007. Dynamic capabilities. Understanding strategic change in organizations. Blackwell Publishing, Oxford.

Hopkins, D.M, Kontnik, L.T., Turnage, M.T., 2003. Counterfeiting exposed: Protecting your brand and customers. John Wiley & Sons, Hoboken, New Jersey.

Huberman, A.M., Miles, M.B., 2002. The qualitative researcher's companion. Sage Publications, Thousand Oaks.

Hung, C.L., 2003. The business of product counterfeiting in China and the post-WTO membership environment. Asia Pacific Business Review 10, 58-77.

ICC – International Chamber of Commerce, 2007. Global survey on counterfeiting and piracy. Survey findings report 2007 (downloaded on 1 December 2010 from http://www.iccwbo.org/uploadedFiles/BASCAP/Pages/BASCAP%20Survey_%20Final%20Report_29%20January07.pdf).

Johns, A., 2009. The intellectual Property Wars from Gutenberg to Gates. The University of Chicago Press, Chicago and London.

Keupp, M.M., Beckenbauer, A., Gassmann, O., 2009. How managers protect intellectual property rights in China using de facto strategies. R&D Management 39, 211-224.

Keupp, M.M., Beckenbauer, A., Gassmann, O., 2010. Enforcing intellectual property rights in weak appropriability regimes. Management International Review 50, 109-130.

Levin, R.C., Klevorick, A.K., Nelson, R.R., Winter, S.G., 1987. Appropriating the returns from industrial research and development. Brooking Papers on Economic Activity, Brookings Institution, Washington D.C.

Levitt, T., 1966. Innovative Imitation. Harvard Business Review 44, Issue 5, 63-70.

Lieberman, M.B., Montgomery, D.B., 1988. First-mover advantages. Strategic Management Journal 9, 41-58.

Lincoln, Y.S., Lynham, S.A., Guba, E.G., 2011. Paradigmatic controversies, contradictions, and emerging confluences, revisited, in: Denzin, N.K., Lincoln, Y.S. (Eds.): The Sage Handbook of Qualitative Research (4th ed.). Sage Publications, Thousand Oaks, 97-128.

Liu, K., Li, J.A., Wu, Y., La, K.K., 2005. Analysis of monitoring and limiting of commercial cheating: a newsvendor model. Journal of the Operational Research Society 56, 844-854.

Lee, H., Smith, K.G., Grimm, C.M., Schomburg, A., 2000. Timing, order and durability of new product advantages with imitation. Strategic Management Journal 21, 23-30.

Lee, T., 1998. Using qualitative methods in organizational research. Sage Publications, Thousand Oaks.

Lybecker, K.M., 2007. Ex roulette – Combating counterfeiting in developing nations. Managerial and Decision Economics 28, 509-520.

Mansfield, E., Schwartz, M., Wagner, S., 1981. Imitation costs and patents: An empirical study. The Economic Journal 91, 907-918.

Markides, C.C., Geroski, P.A., 2005. Fast second. How smart companies bypass radical innovation to enter and dominate new markets. Jossey-Bass, San Francisco.

Marshall, C., Rossman, G.B., 2006. Designing qualitative research (4th ed.). Sage Publications, Thousand Oaks.

Mayring, P. (2008):Qualitative Inhaltsanalyse, Grundlagen und Techniken. Beltz, Weinheim and Basel.

Mayring, P., 2002. Qualitative content analysis. Research instrument or mode of interpretation?, in: Kiegelmann, M. (Ed.): The role of the researcher in qualitative psychology. Ingeborg Huber, Tübingen, 139-148.

Mayring, P., 2000. Qualitative content analysis. Qualitative Social Research 1, Issue 2, Art. 20 (downloaded on 25 August 2011 from http://www.qualitative-research.net/index.php/fqs/article/view/1089/2386).

Minagawa, T., Trott, P., Hoecht, A., 2007. Counterfeit, imitation, reverse engineering and learning: Reflections from Chinese manufacturing firms. R&D Management 37, 445-467.

Naim, M., 2005. Illicit. William Heineman, London.

Nelson, R.R., Winter. S.G., 1982. An evolutionary theory of economic change. Harvard University Press, Cambridge, Mass.

OECD – Organisation for Economic Co-operation and Development, 2008. The Economic Impact of Counterfeiting and Piracy. OECD Publications, Paris.

OECD – Organisation for Economic Co-operation and Development, 2009. Magnitude of counterfeiting and piracy of tangible goods: an update (downloaded on 21 July 2011 from http://www.oecd.org/dataoecd/57/27/44088872.pdf).

Paradise, P.R., 1999. Trademark counterfeiting, product piracy, and the billion dollar threat to the U.S. Economy. Quorum Books, Westport.

Phillips, T., 2007. Knockoff: The deadly trade in counterfeit goods. Kogan Page, London.

Porter, M.E., 1980. Competitive strategy: Techniques for analyzing industries and competitors. Free Press, New York.

Porter, M.E., 1985. Competitive advantage: Creating and sustaining superior performance. Free Press, New York.

Prahalad C.K., Hamel, G., 1990. The core competence of the corporation. Harvard Business Review 68, Issue 3, 79-91.

Richards, L., 2005. Handling qualitative data: A practical guide. Sage Publications, Thousand Oaks.

Rubin, H.J., Rubin, I.S., 2005. Qualitative interviewing: The art of hearing data. Sage Publications, Thousand Oaks.

Sattler, H., 2003. Appropriability of product innovations: An empirical analysis for Germany. International Journal of Technology Management 26, 502-516.

Schnaars, S.P., 1994. Managing imitation strategies. How later entrants seize markets from pioneers. The Free Press; New York.

Schumpeter, J.A., 1934. The theory of economic development. Harvard University Press, Cambridge, MA.

Schumpeter, J.A., 1950. Capitalism, socialism and democracy. Harper, New York.

Shultz, C.J., Saporito, B., 1996. Protecting intellectual property. Strategies and recommendations to deter counterfeiting and brand piracy in global markets. Columbia Journal of World Business 31, Issue 1, 18-28.

Staake, T.R., Fleisch, E., 2008. Countering counterfeit trade. Illicit market insights, best-practice strategies, and management toolbox. Springer Verlag, Berlin and Heidelberg.

Staake, T.R., Thiesse, F., Fleisch, E., 2009. The emergence of counterfeit trade: A literature review. European Journal of Marketing 43, 320-349.

Stumpf, S.A., Chaudhry, P.E., 2010. Country matters: Executives weight in on the causes and counter measures of counterfeit trade. Business Horizons 53, 305-314.

Teece, D.J., 2000. Strategies for managing knowledge assets: The role of firm structure and industrial context. Longe Range Planning 33, 35-54.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18, 509-533.

Trott, P., Hoecht, A., 2007. Product counterfeiting, non-consensual acquisition of technology and new product development - An innovation perspective. European Journal of Innovation Management 10, 126-143.

UN – United Nations, 2008. International Standard Industrial Classification of All Economic Activities Revision 4. Statistical papers, Series M No. 4/Rev.4, United Nations Publication, New York.

VERBI – VERBI Software. Consult. Sozialforschung. GmbH, 2011. What is MAXQDA? (downloaded on 11 August 2011 from http://www.maxqda.com/products/maxqda).

Wernerfelt, B., 1984. A resource-based view of the firm. Strategic Management Journal 5, 171-180.

WIPO – World Intellectual Property Organization, 2005. WIPO Intellectual Property Handbook: Policy, Law and Use. WIPO Publication No. 489 (E). World Intellectual Property Organization, Geneva.

Yang C.H., Kuo N.F., 2008. Trade-related influences, foreign intellectual property rights and outbound international patenting. Research Policy 37, 446-459.

Yang, D., Sonmez, M., Bosworth, D., 2004. Intellectual property abuses: How should multinationals respond? Long Range Planning 37, 459-475.

Yin, R.K., 2008. Case study research: Design and method (4^{th} ed). Sage Publications Thousand Oaks.

Zahra, S.A., George, G., 2002. Absorptive capacity: A review, reconceptualization, and extension. Academy of Management Review 27, 185-203.

A New Typology of Governance of Universities' Technology Transfer Processes

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ABSTRACT

Since the early eighties, when the Bayh-Dole Act was passed in the U.S., universities have gradually started to put in place technology transfer processes. Prior research had its focus on the determinants of efficiency and effectiveness of technology transfer. However, studies on the governance of universities' technology transfer are scarce at best. The objective of this paper is to contribute to fill this gap. The adopted methodology consists in analyzing the diversity of organizational models, both theoretically and empirically. Theoretically, the paper presents a discussion on which combinations of organizational characteristics should yield viable configurations. Empirically, the paper relies on sixteen case studies of universities located in six European countries. The results provide both a conceptual understanding and an empirical overview of how universities organize their technology transfer and IP management.

Keywords: Technology transfer offices; organizational structure; governance, academic patents

1. INTRODUCTION

Commercialization of new knowledge created by universities gained in importance among scholars, university managers and policy makers over the last 30 years (Geuna & Muscio 2009). One of the reasons for this change was the adoption of the Bayh-Dole Act in 1980 and the rising number of university-to-industry technology transfer agreements in the U.S. The European Commission's Lisbon Strategy in 2000 confirmed the importance of creation and exploitation of knowledge of universities to foster regional economic development. In addition, newly implemented policies at various universities as well as public initiatives emerged to promote technology transfer activities. The abolishment of the so called "professor's privilege"[1] in several European countries (e.g. Denmark and Germany) is one example of a major change of university policies. Many national and regional governments supported universities efforts to establish so called Technology Transfer Offices (TTOs).[2] These changes contributed to a surge in academic patenting and formal university-to-industry technology transfer. They are accompanied by the need for systematic and professional knowledge and intellectual property management (Mowery et al. 2001; Mowery & Sampat 2005; van Zeebroeck et al. 2008).

On that basis a large body of literature emerged analyzing the phenomenon of technology transfer and the factors that determine the productivity of universities' TTOs (Thursby & Kemp 2002; Siegel et al. 2003a; Chapple et al. 2005; Belenzon & Schankerman 2007; Lach & Schankerman 2008).

The technology produced by the university, characteristics of the university itself, TTO characteristics, and the demand for technology were identified as important determinants of the number of licensing agreements and royalties generated (Conti & Gaulé 2009). Since TTOs are functioning as intermediaries that transmit new technological developments from universities to industry they are increasingly recognized in the literature as key factor to effective and efficient technology transfer. Several studies identified the number of TTO staff and the age of the TTO as impact factors on technology transfer performance (e.g. Thursby &

[1] According to the professor's privilege researchers rather than the universities own the intellectual property. In Sweden and Italy the professor's privilege is nowadays in place. Italy introduced, opposed to the overall trend, the inventor ownership model in 2005.

[2] The initiative "Signo" of the German federal ministry of Economics and Technology to support technology transfer activities is one prominent example therefor.

Kemp 2002; Chapple et al. 2005)[3]. Conti & Gaulé (2009) investigated differences of technology transfer performance in the U.S. and Europe. They find that not the number of licenses but the amount of licensing revenues differs between European and US TTOs. The difference is related to organizational practices and staffing of TTOs. Moreover, Siegel et al. (2003a) and Markman et al. (2005), among others, have shown that organizational practices and institutional factors influence the effectiveness of technology transfer. The work by Bercovitz et al. (2001) is, to the best of our knowledge, the first attempt to analyze performance implications of TTO's organizational forms, inter alia, the flexibility in budget management, in the U.S. context.[4]

In short, prior literature noticed the importance of different organizational aspects in the context of university-industry transfer. However, a study of the differences in the organizational integration (concerning, e.g., the degree of centralization of technology transfer activities), particularly in the European context, is missing so far. The objective of this paper is precisely to fill this gap by analyzing the diversity of organizational models of technology transfer and management activities. To this end, in a first stage, five key dimensions of organizational structure and their characteristics are identified. The various combinations of these dimensions do not always lead to viable configurations. As a result, taking into account only the viable configurations, a typology of organizational models of TTOs is put forward. Second, this typology is tested with sixteen case studies of TTOs located in six European countries.[5]

This qualitative analysis presents new evidence on the diversity of the governance of technology transfer processes. TTO models can be classified into four groups: The *classical TTO* exclusively serves one university and is integrated into its administrative structure. The *autonomous TTO* essentially has a higher degree of autonomy. The highest degree of autonomy is however achieved when the TTO is independent from the university's

[3] See Siegel et al. (2007) for a more detailed overview of key studies on TTO effectiveness.

[4] See Section 2.1 for a more detailed discussion.

[5] Despite the fact that the terms knowledge and technology transfer constitute two very different concepts they are often used interchangeably. As Landry et al. (2007, p. 563) state: "In fact, technology and knowledge differ significantly in four aspects: purpose, degree of codification, type of storage and degree of observability. Technology refers to tools for changing the environment, while knowledge embodies theories and principles helping us to understand the relationships between causes and effects. Technology refers to codified information stored in publications, software and blueprints, whereas knowledge tends to have a tacit component and is stored in people's heads. Technology is tangible and the impact of its use is precise, while knowledge can be less tangible and the impact of its use is more amorphous." In the following we use the term technology transfer according to this definition. In reality these two concepts are far from being distinct, as a licensing deal often requires the contribution of the academic inventor, who implicitly relies on a wide tacit knowledge.

administration, especially with respect to budget allocation and human resource management, and does not have to report directly to the Vice Rector of Research (or similar authorities). The *centralized Technology Transfer Alliance* (TTA) serves the technology transfer activities of several universities. This type of TTO is organized outside the university's administrative structure. The *decentralized TTA*, finally, is focused on one academic discipline, e.g. life sciences or engineering. Like the centralized TTA, the decentralized TTA serves several universities.

It is obvious that no general best practice for organizing university-to-industry technology transfer exists. Rather, universities must take their own goals and characteristics as well as environmental factors into account when organizing their technology transfer. As a consequence, the findings indicate that a comparison of universities with different goals and concomitant organizational models regarding technology transfer can be misleading. For the measurement of relative efficiency and effectiveness the identified structural variables should be taken into account. On a management level, the results of this paper provide guidance to support universities in designing the organizational structure of their technology transfer activities.

The paper is structured as follows. The next section provides a brief overview of the literature on university technology transfer processes, especially on their governance and organizational structure. This first section helps to identify the relevant structural variables. Section 3 is devoted to the analysis of the combinations of organizational characteristics that should be viable and suggests a typology of organizational models of TTOs. The case studies are presented and classified in Section 4. The final section is devoted to concluding remarks.

2. LITERATURE REVIEW AND DIMENSIONS OF TTO'S GOVERNANCE

2.1. University-to-industry technology transfer

The key function of a TTO is to act as an intermediary between the university and the industry. However, technology transfer is a complex phenomenon, which may be embodied in a variety of channels. There is no generally accepted model of technology transfer processes. TTOs can be involved in three main dimensions: (1) Research funding and services; (2) IP management; (3) Spin-out services (Clarysse et al. 2005; Debackere & Veugelers 2005; Siegel & Phan 2005; Meyer & Tang 2007; Macho-Stadler & Pérez-Castrillo 2009; Van Looy et al. 2011). The literature on TTOs and university-to-industry technology transfer mainly focuses on TTO activities related to IP management and spin-out services. A broader definition should however be adopted, including research services such as research contract negotiation and promotion of European research projects into the list of technology transfer activities. The reason for broadening the definition is that the organizational unit responsible for patents and licensing activities is in many cases simultaneously responsible for research services and/or spin-out services (Debackere & Veugelers 2005; Mathieu et al. 2008). Furthermore, the outcomes of research services, IP management, and spin-out services are dependent on each other, for example, as Van Looy et al. (2011) and Mathieu (2011) showed, there is a significant and positive relationship between contract research, patents, and spin-out activity.

The increasing importance of technology transfer for universities, industry and policy makers raises the question of which factors influence the success of such activities. The following determinants of TTO productivity (measured by the number of licenses, license revenues, or the number of spin-outs) have been identified: (1) characteristics of the TTO, (2) quality and type of the technology produced by the academic institution, (3) quality of the research institution, and (4) regional demand for technology (e.g. Franklin et al. 2001; Thursby & Kemp 2002; Di Gregorio & Shane 2003; Siegel et al. 2003a; Arora & Ceccagnoli 2004; Chapple et al. 2005; Lockett et al. 2005; Lockett & Wright 2005; O'Shea et al. 2005; Belenzon & Schankerman 2007; Lach & Schankerman 2008; Van Looy et al. 2011). Given the focus of the present paper, the literature review will specifically address the first determinant, i.e., characteristics of the TTO, in relation to organizational factors.

Siegel et al. (2003a) provide evidence showing that deviations from the production frontier of TTO's cannot completely be explained by institutional (e.g. public or private status of the university) and environmental (e.g. state-level economic growth) factors. They assume that relative performance is also determined by organizational practices. They identify the following critical organizational factors: Compensation and staffing practices in the TTO, faculty compensation scheme, and actions taken by administrators to reduce barriers between universities and firms. Licensing activity is supposed to be higher if an incentive scheme for TTO personnel is implemented. Moreover, they argue that a TTO staffed with a mix of scientists and entrepreneurs/businessmen perform better in spin-out services and in marketing the inventions.

Bercovitz et al. (2001) examine the relationship of organizational structure and performance of U.S. universities' TTOs based on the theoretical work by Chandler (1962, 1977, 1990) and Williamson (1975, 1985). They analyze four different organizational forms: the functional form, the multidivisional form, the holding form, and the matrix form. The functional form is a "(…) centralized, functionally departmentalized structure in which decision-making and coordination responsibilities lie with a small team of executives (…)" (Bercovitz et al. 2001, p. 22). Organizations decomposed into semi-autonomous divisions with a strong central office are organized in a multidivisional form. The holding form is very similar to the multidivisional form, but has a weak central office. The organizational form where two organizational dimensions are combined is denoted matrix form. Each form has specific attributes—information processing capacity, coordination capability, and incentive alignment—determining the technology transfer efficiency. Firstly, the authors hypothesize that TTOs organized in a matrix form have a higher overlap of industry partners in research contracts and licensing agreements than in the other organizational forms. Secondly, the number of invention disclosures, licenses, and patents per full-time equivalent are assumed to be highest in the multidivisional and holding form. Thirdly, they hypothesize that the matrix form is most suitable to leverage licensing fees against sponsored research dollars. The three hypotheses are tested and confirmed on the basis of three U.S. universities.

Markman et al. (2005) analyze, based on 128 interviews with TTO directors in the U.S., the relationship between organizational structure on the one hand and licensing strategies and new venture formation on the other. Based on interviews they identify three types of organizational structure, which differ according to the autonomy granted at the institutional level: (1) traditional university structure, (2) nonprofit research foundation, (3) for-profit private extension. TTOs under a traditional university structure are organized as department and are tightly supervised by the vice president of the university. TTOs denoted as nonprofit research foundations are organized as separate legal entity with a board chaired by the university president. The last type is a TTO created as a separate for profit legal entity. Type 1 has the lowest, type 3 the highest degree of autonomy. They find that TTOs with a traditional structure are more likely to license in exchange for sponsored research. The opposite is true for nonprofit structure. Licensing strategies inducing new venture creation are more often observed in the traditional and in the for-profit TTO structure.

Despite the growing interest in and research on university-to-industry technology transfer, little is known about how technology transfer activities are organized in European universities (Clarysse et al. 2005). To the best of our knowledge only a few studies are dealing with TTO's organizational structure in Europe.

Debackere & Veugelers (2005) identify the TTO of K.U. Leuven as a benchmark case in Europe and discuss organizational practices along this case in detail. Furthermore, they compare its structure with TTOs of eleven European universities and find strong parallels. They suggest, from an organizational viewpoint, that governance structures have major impact on university-to-industry relations. Incentive management and the pooling of critical resources are seen as important structural variables. They argue that the involvement of research groups via a matrix structure is critical for the technology transfer success.

Meyer & Tang (2007) analyze the influence of various IP management practices on measures of patent value in the U.K. university context. The observed difference regarding the TTO set-up are related to structural integration, level of collaboration with university research services, and the degree of specialization (either by disciplines and technology fields or by technology transfer functions). Since the focus of the paper is on IP management processes and the relationship on indicators for patent value, the authors do not discuss the various organizational structures in detail.

The expert group on knowledge transfer of the European Commission (2009) describes in their final report different models of TTOs. The structural variables taken into account are: The level of autonomy granted to the TTO, the ownership of the TTO, and if the TTO is established by a group of universities. They qualified the department, the subsidiary, and the independent organization type.

The literature review points out that the majority of studies examine the functioning of TTOs in the U.S. However, the European context is quite different from the U.S. In the words of the European Commission (2007, p. 7): "Compared to North America[6], the average university in Europe[7,8], generates far fewer inventions and patents. That is largely due to a less

[6] AUTM survey – http://www.autm.net/FY_2004_Licensing_Survey.htm

[7] ASTP survey 2006 – http://www.astp.net/Survey/Final%20ASTP%20report%20June%2014%202006.pdf

systematic and professional management of knowledge and Intellectual Property by European universities." Not only university culture differs between the two continents, but also the corporate culture is quite different in respect to university-to-industry technology transfer. The TTO, as intermediary between industry and university, has to adapt to these environmental factors. The transfer of research results on U.S. TTOs to European TTOs is consequently not straightforward. Furthermore, the variation of national and cultural context in Europe is far greater than in the U.S., providing the opportunity to study contingencies in much more detail.

In a nutshell, the contributions reviewed in this section provide many insights. However, they typically focus on selected aspects of the organizational structure of TTOs and are only partially based on theoretical foundations. The present paper addresses this gap by theoretically deriving a typology of university TTOs and juxtaposing it to case studies of European universities.

2.2. Relevant dimensions of TTOs' governance

This section reviews the literature on the formal structure of organizations and derives structural variables that should be considered in the context of industry-university technology transfer.

The present paper is based on the implicit assumption that the governance, or the organizational structure of technology transfer organizations does matter. Or, as Williamsons (1985, p. 274) puts it: "Organization form matters." The contingency theory has the basic assumption that the formal organizational structure has a major impact on the efficiency of organizations, but an organizational structure which is universally efficient does not exist. Since giving a complete overview of the extensive organizational literature would go beyond the scope of this paper, it concentrates on the theory directly related to formal organizational structures. The focus on organizational models of European technology transfer allows to adapt the dimensions used by the organizational literature to this special case.

Empirical analysis and comparisons of organizational structures require definitions of the dimensions relevant for the study and the operationalization of these dimensions (Pugh et al. 1968). However, organizations are institutionally complex by their very nature and have a large number of characteristics and dimensions. Therefore the trade-off between precision and complexity with increasing dimensions has to be taken into account. For certain research

[8] ProTon survey – http://ec.europa.eu/research/era/docs/en/others-11.pdf

questions, only some of these dimensions and characteristics are relevant. Consequently, it is essential to select the relevant dimensions and characteristics out of the possible ones (Meyer et al. 1993).[9]

The derivation of relevant dimensions of a formal organizational structure is based on the idea of the bureaucracy model put forward by Max Weber (1947).Weber's uni-dimensional concept of organizational structure was further developed by many researchers, among (e.g., Pugh et al. 1968; Child 1972). The structural variables most widely discussed by these authors are specialization, centralization, standardization, formalization, and configuration. In this study the structural variables specialization, centralization, and configuration are used to characterize the organizational structure of TTOs.[10] The dimension configuration describes the role structure of the organization, expressed in the organizational chart.

Two additional dimensions discussed in the literature on university technology transfer are added: the degree of exclusivity and the ownership status (Debackere & Veugelers 2005; Markman et al. 2005; European Commission 2007).

The advantages and disadvantages of each dimension and their characteristics will be assessed along the following criteria: (1) relationship between TTO and academics as well as relationship between TTO and industry partners; (2) exploitation of economies of scale and synergies; and (3) conflicts of interests and concomitant communication and coordination costs. Table 1 summarizes the strengths and weaknesses of these dimensions.

(a) *Degree of centralization*: Centralization is defined as the locus of authority to make decisions affecting the organization (Pugh et al. 1968; Pugh & Hickson 1976). The more decisions are delegated to the subunit, the lower the degree of centralization and vice versa (Mackenzie 1978, p. 200). The degree of centralization must be seen as a continuum from the lowest (*fully decentralized*) to highest hierarchical level (*fully centralized*). In the context of universities' technology transfer and in this paper decentralization means that decisions regarding technology transfer are taken on the department (or faculties) level. In a decentralized structure the TTO is focused on one specific scientific discipline. In contrast, a

[9] For a comprehensive analytic framework one might suggest to take all dimension into account, however, this would make the analysis very complex. From a scientific point of view it is crucial to reduce complexity.

[10] Standardization and formalization are not considered for the following reasons. The structural dimension standardization describes to what extend activities are fixed. Since the technology transfer process is already fixed in most of its dimensions, this structural dimension does not help to differentiate between types of TTO's organizational structure. The structural dimension formalization denotes to which extent organizational rules are written down and filed.

centralized TTO structure implies that decisions about technology transfer activities are taken at the institutional level with the same rules and processes for all the departments or faculties.

The strength and weaknesses of a decentralized (vs. centralized) system can be gauged through coordination costs, fair processes within the university and the competencies of TTO officers. Decision makers in a decentralized system may not have all the necessary information to take the best decision. And even if they do, conflicts of interests may lead to decisions that are suboptimal for the organization (Nohria 1991). It is not clear if their decisions are in line with the strategic goals of the university. In addition, academic researchers are most likely to be treated differently across faculties regarding the new valuation of the new knowledge they create, generating room for frustrations.

On the more positive side of a decentralized structure is the scientific specialization and industrial relationship of TTO officers. They are likely to be best informed about the technological dimension of the invention. Developing relations with industry partners or using already existing partnerships is also easier in a decentralized structure. One reason for this is the specialized knowledge in the area of research and more direct and personal contacts of TTO officers to relevant industry partners. Furthermore, the relationship TTO-researcher is more intense and trustful.

In other words, a decentralized approach favors technological specialization, a more trustful relationship with academic researchers and better contacts with the industry. However, it increases coordination costs within the university, benefits from less synergies between technology transfer activities performed in different departments (decentralized TTO structure are less efficient with respect to the exploitation of common resources across departments), might lead to unfair treatment of inventors across faculties, and could fail to reach the minimum threshold to benefit from economies of scale.

(b) *Degree of horizontal specialization*: The degree of horizontal specialization defines the distribution of tasks within the organization. By specifying the degree of specialization the area of responsibility is determined (Mackenzie 1978). Similar to the degree of centralization the degree of specialization can be gradually varied on a continuum from generalization (or full integration) to specialization. For example, a low degree of specialization would mean that the TTO is responsible for all technology transfer activities.

As discussed in Section 2.1, activities related to technology transfer can be grouped into (1) research services (i.e., support services for privately-funded research projects), (2) IP management, and (3) spin-off services (i.e. incubators). The management of a university's patent portfolio is regarded as central activity for all TTOs. A *fully integrated* TTO is responsible for all three activities within one organizational unit. When the activities related to research services and IP management are executed by the TTO, it is *backward integrated*. A *forward integrated* TTO would be responsible for IP management and spin-out services.[11] Specialization on IP management (*IP-specialized*) denotes the highest degree of specialization. Specializations on other activities than IP management would probably not be referred to as TTOs and thus are beyond the scope of this paper.[12]

One advantage of an IP specialization is that the employees are specialized in one of the technology transfer activity—here IP management. The focus on one activity induces a learning effect which improves the quality and the quantity of work. Disadvantages associated with specialization are higher communication and coordination costs, which can reduce the productivity gains precisely generated by the specialization(Nohria 1991). Furthermore, IP specialization might deteriorate the relationship of the TTO with its stakeholders. Researchers and industry partners have higher search and coordination costs since they have to coordinate with different organizational units. The disadvantage of IP specialization and at the same time the advantage of lower degree of specialization is the exploitation of synergies. A forward integrated TTO can exploit synergies for commercialization; the backward integrated TTO generates synergies for research funding. The fully integrated TTO can exploit synergies in both directions. In sum, exploitation of synergies would be higher in fully-integrated TTOs.

(c) *Level of autonomy*: Markman et al. (2005) address the influence of different levels of autonomy granted to the TTO on new venture creation and licensing strategies. They show that autonomy granted to the TTO is an important dimension of the organizational structure. The organizational form with the lowest degree of autonomy is more likely to license in exchange of sponsored research. Licensing inducing new venture creation, however, is less often observed in organizational forms in nonprofit research organizations.

A *dependent* TTO has to report directly to the universities administration (e.g. Office of the Provost or Vice Rector for Research) and has a reduced decision-making autonomy with respect to budget, incentives and human resource management.

[11] Since the process model of research services starts with acquiring projects and ends with transferring the research results to the industry, we are talking of *backward* integration. In contrast to this, the process of spin-out services activities starts from research results and ends with the incorporation of a spin-off company. It is therefore called *forward* integration.

[12] Organizational units specialized on research services are mostly named research service centers, organization units specialized on spin-out services are known as incubators.

One important aspect of the degree of autonomy granted is how flexibly the TTO can manage their budget and to what extent it is self-determined regarding the remuneration and incentive scheme of its employees. The importance for technology transfer efficiency of the ability of universities to attract and remunerate TTO personnel is well recognized in the literature (e.g. Siegel et al. 2003a; Siegel et al. 2003b; Markman et al. 2005; Belenzon & Schankerman 2007).[13] The quality of TTO personnel and the turnover rate are both identified as key determinants of technology transfer efficiency.

Another aspect of the degree of autonomy granted refers to the exploitation of synergies. In the case of an independent TTO vertical synergies cannot be exploited, for example by sharing supporting functions of the university like financial services. Central service functions like administration and financing have to be created within the TTO. This induces higher costs. The relationship between TTO and industry as well as between TTO and academics is less affected by this organizational variable, although incentive mechanisms could well take into account the creation of networks within the industry.

(d) *Degree of exclusivity*: This structural variable indicates whether an organizational unit serves more than one customer (or university), as opposed to an exclusive relationship. A low degree of exclusivity denotes an *exclusive* organizational structure. Transferred to the context of TTOs, this implies that the TTO was established by one university and only serves it. In contrast, a high degree of exclusivity implies that the TTO is established by and is responsible for more than one university (*non-exclusive*).

In the case of a non-exclusive structure, higher coordination costs between the university and the TTO prevail. Moreover, competition effects between the universities relying on its services have to be taken into account. The other weaknesses associated with the non-exclusive TTO are less intensive contacts with researcher and a lower probability of being integrated in a university culture. On the other hand, the search costs for industry are decreased by a non-exclusive organizational structure. Industry partners have one contact point even if they are collaborating with several universities. Therefore, the relationship between the non-exclusive TTO and the industry is probably more intense than with exclusive TTOs; but the reverse is true regarding the relationship with the researchers. The higher economies of scale induced by a larger invention and patent portfolio argue in favor of the non-exclusive TTO.

[13] Siegel et al. (2003a) expect a direct (positive) impact of the compensation scheme for technology licensing officers on the licensing activity. Belenzon & Schankerman (2007) find that the license income increases due to incentives schemes by 40%.

(e) *Ownership status*: The ownership status is an additional important dimension to consider in the governance of TTOs. If the TTO is organized as a department of the university, it is considered to be fully owned by the university. A legally independent TTO can be owned by only one university (*full ownership*) or by several shareholders. The organizational setting where one university is not the majority shareholder of the TTO is called *shared ownership*. TTOs under a shared ownership model are by definition organized as separate legal entities.

TTOs with a shared ownership are in most cases more market orientated and face higher pressure to generate profits. However, the visibility of the TTO for researchers is lower and the university has less control of technology transfer activities. Furthermore, a shared TTO implies, on average, lower strategic fit with the overall strategy of the university. The exploitation of economies of scale and synergies is not affected by the ownership status.

[INSERT Table 1 AROUND HERE]

Drawing on the above discussion of the five of structural variables that contribute to shape the governance of university technology transfer, the next section investigates the feasible combinations of those variables.

3. TYPOLOGY OF TTO'S ORGANIZATIONAL STRUCURE

3.1. Non-feasible combinations of organizational dimensions

This section addresses the issue compatibility between various dimensions of TTOs' governance.

The previous section presents five dimensions along which the organization of university technology transfer can be characterized. Four of these can take on two possible values, while one can take on four values. Thus, the number of combinations of values of two dimensions equals $4 \cdot (2 + 2 + 2 + 2) + 2 \cdot (2 + 2 + 2) + 2 \cdot (2 + 2) + 2 \cdot 2 = 56$ (see Table 2). It is on the level of these combinations that the feasibility of configurations are investigated, where a "configuration" is a combination of values of all five dimensions. There are $4 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 64$ configurations, which represent the entirety of potential organizational structures of TTOs. It is assumed that the university's management aims at maximizing TTO's efficiency and effectiveness as well as minimizing its costs.

1) Decentralization is not compatible with full integration.

The first dimension that can be taken into account is the *degree of centralization*. Inefficiencies associated with low economies of scale and low synergy exploitation due to a decentralized structure are intense in combination with a fully integrated TTO. In particular, executing activities related to research services on the faculty level could lead to inefficient resource exploitation and loss of horizontal synergies (e.g. between different faculties). Consequently, this combination should rarely be observed.

2) Decentralization is not compatible with a strong IP specialization.

Decentralized TTOs specialized on IP management should also be rarely observed because the interdependencies between IP management and other technology transfer activities are intense. Consequently, the coordination and communications costs would strongly increase, intensified by decentralization, and in most cases exceed the advantages associated with efficiency gain due to a better relationship of the TTO and its stakeholders.

3) Decentralization is not compatible with a dependent organization.

The drawbacks of a decentralized structure are lower resource efficiency and higher coordination costs due to potential conflicts of interest. This drawback can be worsened if associated with a *dependent (or non-autonomous)* organizational structure. Managers on the department level optimize their strategy depending on local goals. (Bercovitz et al. 2001). As a result, university administration has to install mechanisms aligning deviating objectives to university technology transfer strategy, for several faculties, increasing administrative costs for the university. It logically follows that this combination is to be avoided; TTOs organized within university administration are rarely decentralized and should not be.

4) Decentralization is not compatible with exclusivity.

The inefficiencies due to lower economies of scale and less synergy exploitation observed in a decentralized structure are perceived as too strong to be compensated by a single university. As a conclusion, the combination of exclusivity and decentralization should rarely be observed.

In a nutshell, we conjecture that a decentralized TTO will not at the same time be dependent, fully integrated, IP specialized, and exclusive. But the decentralized TTO is compatible with non-exclusivity and autonomy. The next focus is on the degree of specialization.

5) An IP specialized TTO is not compatible with dependency.

The *degree of specialization* should also be compatible the level of autonomy granted. Under a dependent, IP-specialized organizational setting monitoring costs are increased, due to the need for simultaneous control of different organizational units by university administration. Moreover, the exploitation of synergies between different organizational units is more difficult and concomitant overhead costs are increased. Therefore, IP-specialization and dependency is likely to be an inefficient configuration.

6) An IP specialized TTO is not compatible with exclusivity.

TTOs specialized on IP management serving exclusively one university should be rarely observed for the following reason. Specialization is associated with lower potential for synergy exploitation between the technology transfer activities, since they are executed in different organizational units. In an exclusive organizational structure this disadvantage of specialization is serious, because the effect cannot be compensated by, for example, a strong pooling of inventions.

7) & 8) Full integration and backward integration is not compatible with non-exclusivity.

Fully integrated TTOs are responsible for all technology transfer activities, by definition. This, in turn, implies that the combination with a non-exclusive organizational structure is not feasible. The main argument here is that universities compete with respect to research services (especially privately-funded research contracts), which require intense and trustful collaboration between the TTO personnel and researchers. A non-exclusive organizational structure means that universities are sharing the services of one TTO. The concomitant competition effect could lead to a distrust of researchers towards the TTO officers. Consequently, fully integrated or backward integrated organizational structures would not be a compatible combination with a non-exclusive organizational structure. In other words, a non-exclusive TTO would not be responsible for research services.

9) Non-exclusivity is not compatible with dependency.

The combination of dependency and non-exclusivity is perceived as not being feasible, for the following reason. Dependency and non-exclusivity can often contradict each other. If the TTO was established and its services are used by more than one university, it is unlikely that it is integrated into the administrative structure of one single university. From the perspective of the other participating universities this combination is associated with high coordination costs and negatively affected relationship between TTO and researcher. The next focus is on the ownership status.

10) Full ownership is not compatible with non-exclusivity.

The combination full ownership and non-exclusivity is not viable because non-exclusive TTOs serve several universities which, in turn, should be direct or indirect shareholders of the TTO. Otherwise one university has to bear the risk for all the universities involved in the network.

11) Shared ownership is not compatible with full integration.

Full integration and shared ownership would be an inefficient combination. In the case of shared ownership, the university is not the majority shareholder of the TTO, and consequently the university has to transfer a large share of its decision-making authority with regard to technology transfer, and especially research services, to third parties. The associated risk for the university within this setting leads to increasing coordination and communication costs. Moreover, the relationship between TTO and academics as well as with industry partners could be negatively affected due to potential distrusts of the participating parties.

12) Shared ownership is not compatible with dependency.

A TTO shared by several shareholders, organized as separate legal entity, is in most cases not dependent on university administration. The advantages of shared ownership and especially of the separate legal entity, e.g. higher market orientation, would not be exploited to full extent within a dependent organizational structure.

Table 2 summarizes the discussion. The combinations discussed above are marked in grey. The combinations not marked are feasible combinations.

13) Shared ownership is not compatible with exclusivity.

The TTO under a shared ownership model has in most cases less intense contact with researchers. Furthermore, the university has less control of the TTO because it is not the majority shareholder. Consequently, for a university operating alone the shared ownership has no advantages.

[INSERT Table 2 AROUND HERE]

3.2. "Feasible" organizational structures

The exclusion of non-feasible combinations of structural variables reduces the number of TTO configurations from 64 to 9. These organizational models are shown in Table 3.

[INSERT Table 3 AROUND HERE]

Four general types of TTO organizational models can be identified, whereby each type differs with respect to the degree of specialization.

The first type is best described with the term *classical TTO* (I). It is centralized, dependent, fully owned, and solitary. The TTO is responsible for all technology transfer activities (fully integrated (1)), for IP management and research services (backward integrated (2)), or for IP management and spin-out services (forward integrated (3)).

The second type is denoted *autonomous TTO* (II). The autonomous and the classical TTO model differ in terms of the level of autonomy granted. As the classical TTO, the autonomous TTO model can be fully integrated (4), backward integrated (5), or forward integrated (6).

The third type is the *centralized Technology Transfer Alliance* (III) (centralized TTA). In contrast with the other two types, it serves more than one university. It is organized outside of universities' administrative structures and the decision-making authority is centralized at the institutional level. This TTO model is compatible with either forward integration (7) or IP-specialization (8). It should be noted, that universities using the services of a centralized TTA generally keep an internal university-specific TTO, with a reduced size.

The last model is the *decentralized Technology Transfer Alliance* (IV) (decentralized TTA). In contrast to the centralized TTA, the degree of centralization is low (i.e., it focuses on one discipline) and it is specialized on IP management and spin-out services (forward integrated (9)).

4. CASE STUDIES

The various combinations of TTO governance dimensions, and the typology presented in the previous section, should be compared with real cases in order be assessed and validated. The 16 case studies presented in this section are based on in-depth interviews with key-personnel of the TTOs. The semi-structured interviews were conducted face-to-face with the interviewees during the period from January 2009 to November 2010 and last about 90 minutes on average. To reduce social desirability and to improve the willingness to participate in the interviews, the interviewees' anonymity was secured.

To enrich the information gained from the interviews additional information was gathered from secondary sources, mainly TTO's and universities' website as well as official university reports, and proceeded with data triangulation (Eisenhardt 1989; Yin 2003). To validate the collected information, the interviewees were asked to check the information.

4.1. Classification of the cases

Key figures of the sample are presented in Table 4.[14]

[INSERT Table 4 AROUND HERE]

Despite the growing interest in university technology transfer empirical evidence about specific characteristics and performance measures of European TTOs is still scarce. The ProTon 2009 Europe Survey[15], the CEMI Survey 2008[16] and the ASTP Survey 2007[17] are, to the best of our knowledge, the most recent large-scale empirical projects in Europe regarding university technology transfer offices. According to the CEMI Survey 2008,[18] 60% of the European TTOs were founded after 1998, 23% between 1988 and 1997, and 17% before 1988. The average age of TTOs in our sample in 2008 is 14.8 years, whereby 50% were founded after 1998. The size of the TTOs, as measured with the average number of FTEs per

[14] Since TTAs (case K and L) are serving more than one university, figures related to the university are not specified.

[15] Available at: http://www.interface.ulg.ac.be/docs/Proton21052010.pdf

[16] Available at: http://cemi.epfl.ch/files/content/sites/cemi/files/shared/research/CEMI-TTO-survey-2008.pdf

[17] Available at: http://www.astp.net/Survey/Summary_2007_ASTP_report.pdf

[18] In order to achieve comparability, the CEMI Survey was chosen; since the other two surveys also included in the target population other Public Research Organizations. The survey was conducted in summer 2008 and in total 211 answers (59,4% respond rate) were obtained from TTOs located in Western Europe.

institution, is much larger with the current sample than with the average in Europe (18.7 vs. 10.8[19]).

In terms of geographical coverage, the TTOs come from six different countries within Europe: Belgium, Switzerland, France, Germany, UK, and the Netherlands.[20] According to the Shanghai academic ranking of world universities, published by the Institute of Higher Education of Shanghai Jiao Tong university, six TTOs are part of universities ranked among the top 100, five among the top 200, three among top 300 or more.[21]

In the next subsections, each case study is classified with respect to the new typology. First, each case was classified along the dimensions degree of centralization, level of autonomy, degree of exclusivity, ownership status, and degree of specialization. Second, the configuration of each case was matched to the typology. The result can be found in Table 5 and is discussed in the following.

[INSERT Table 5 AROUND HERE]

4.1.1. Classical TTO

The classical TTO is characterized by the configuration centralized, dependent, solitary, and fully owned. The value of the degree of specialization can be fully integrated, backward integrated, or forward integrated. Four out of the sixteen case studies (A, B, D, and E) match this configuration.

The cases have all in common that the TTO is responsible for the transfer of research results regardless of inventor's academic discipline. Moreover, all four TTOs are organized as department within the university. The university is the sole owner of the TTO.

The degree of autonomy granted is operationalized along three criteria: 1) reporting directly or not to the Vice Director of Research/Innovation or to the Office of Provost; 2) being independent from universities administration regarding budget management; and 3) enjoying decision-making authority with respect to human resource management (e.g. specification of incentive schemes for TTO personnel and decision regarding staff hiring).

[19] This number refers to the year 2007.

[20] All TTOs in our sample are located in countries where institutional ownership system is in practice. Institutional ownership denotes the situation where results of public-funded-research are owned by the institution and not by the inventor. In several European countries the system changed from the inventor ownership (also known as professor's privilege) to institutional ownership system. In Germany the change took place in 2002, in the Netherlands in 1995.

[21] Available at: http://www.arwu.org/.

All four TTOs have to report directly to the Vice Director of Research/Innovation and have no decision-making authority regarding human resource management. Except one, all TTOs are dependent on universities administration regarding their budget management. The exception in respect to the last criterion is case E. However, the interviewee told us that the integration in the university and the administrational control is very strong. This interview evidence leads us to classify the TTO as dependent.

The TTOs serve exclusively their founding university and do not collaborate substantially with other universities or technology transfer institutions. Consequently, the cases fulfill the requirements to fit the classical TTO type.

The last dimension, degree of specialization, determines the kind of the classical TTO. Out of the four cases three are backward integrated (case B, D, and E), and one is forward integrated (case A).

In contrast to the backward integrated TTOs, the forward integrated TTO (case A) is involved in activities to foster spin-out creation but not in activities related to research services.

4.1.2. Autonomous TTO

The autonomous TTO differs from the classical TTO type in respect to the degree of autonomy granted. Six out of the sixteen case studies are classified as autonomous TTO (cases C, F, G, H, I, and J). The autonomous TTO serves exclusively the founding university and is responsible for all scientific fields.

The degree of autonomy granted to the TTO, operationalized along the three criteria, varies between the case studies. Four cases (case C, F, I, and J) can be classified as independent along all three criteria. Case G is independent in respect to their budget and human resource management. However, they have to report directly to university administration. The decision to code them still as independent is based on interview evidence. The informants put emphasis on the fact that their TTO can decide on strategic aspects independent of university administration. The interviewee of case G explicitly stressed this dimension as one important factor, which makes the TTO successful. Case H is independent from university administration with regard to human resource management but not with regard to budget management.

Furthermore, the cases reveal information regarding the organizational integration of the two TTO types. All classical TTOs were integrated as a department. Four of the six cases classified as independent are organized as a subsidiary, fully owned by the university (cases F, H, I, and J). However, two TTOs (case C and G) are organized as a department within the university and are concurrently independent. This leads to the assumption that the organizational integration as subsidiary is most likely to correspond with an independent configuration, but the organizational integration as department can match with both - a dependent and an independent configuration.

The last dimension considered is the degree of specialization. Four out of the six cases classified as autonomous TTOs are forward integrated (case F, H, I, J). Case C is backward integrated and case G is fully integrated. Research services in all four forward integrated TTOs are executed by a research service center, integrated as department in the organizational structure of the university. The two TTOs, which are also responsible for research services, are organized as department.

This leads to the conclusion that TTOs organized as subsidiary are not likely to be responsible for research services and are independent.

4.1.3. Centralized TTA

The centralized TTA is characterized by the configuration centralized, independent, non-exclusive, and shared ownership. According to the typology, the TTO used by all universities can be forward integrated or IP specialized. All universities engaged in the network can however operate a *university-specific TTO*, a TTO exclusively serving the founding university. The university-specific TTO is necessary if the universities in the alliance are not obliged to automatically disclose their inventions to the *centralized TTA*.

Case K is classified as a centralized TTA, serving 28 universities. To improve our understanding of the TTA model four university executives were next to TTA executives interviewed (cases K_a-K_d). In the first step, we describe and classify the centralized TTO (case K). In the second step, we analyze the university-specific TTOs (case K_a-K_d).

Since the centralized TTA is responsible for all disciplines represented in the universities it is classified as centralized. It was founded as private company by two non-profit organizations and all universities in the alliance are members of one of these founding organizations. The two non-profit organizations again are members of the centralized TTA board and represent the interests of the universities. Consequently, the ownership status of the centralized TTA is classified as shared.

The centralized TTA is categorized as autonomous with respect to the criteria: human resource and budget management. It does not have to report directly to the Vice Director of Research or Innovation of one university. Technology transfer activities of the TTA are restricted to the management of universities patent portfolio. Consequently, we can classify this case as independent and IP-specialized.

The four cases (case K_a-K_d) of university-specific TTOs are organized as centralized and dependent TTO. The university-specific TTO is in all cases fully owned by the university and is integrated as department in the organizational structure of the university. Consequently, the four cases are classified as classical TTO. Three out of the four cases are forward integrated (case K_a , K_c, and K_d) and one is backward integrated (K_b). A central research office is responsible for research services in the cases of forward integrated TTOs. In the case of the backward integrated TTO spin-out services are outsourced to an associated institute. In a nutshell, the university-specific TTOs in TTA structure are all classified as centralized, administrated, and fully owned.

4.1.4. Decentralized TTA

The last type, the decentralized TTA, is characterized by the configuration: decentralized, independent, non-exclusive, shared ownership, and forward integrated. This is the case, where one TTO is active in technology transfer activities for research results of one academic discipline and serves several universities. In this case, it is most likely that the university operates a university-specific TTO since the decentralized TTA serves only one discipline.

Case L belongs to this category. The non-profit, autonomous research institute has departments, labs and research facilities in four universities in the field of life sciences. A central service function of this research institute - the decentralized TTA - is responsible for IP management and spin-out activities. The TTA is only in charge of inventions which result from basic research of the labs and departments located at different universities and connected to the institute. It can therefore be classified as forward integrated, non-exclusive and decentralized. The research institute is independent in every aspect and is governed by a Board of Directors, composed of representatives of the networked universities, of the government, and of the industry. No university in the network is major shareholder of the research institute. Consequently, the TTO can be classified in the category shared ownership.

Similar to the centralized TTA model, in the decentralized TTA model each university still has a university-specific TTO.

4.2. Differences between the TTO models

Drawing on the above classification of the sixteen case studies, implications of the different types for the technology transfer governance process can now be analyzed, especially regarding IP related transfer activities, which include the following steps: invention disclosure, early economic assessment, deciding if the invention should be patented, filing the patent, searching for licensees, negotiating the contract conditions (with industry partner or spin-out companies), and royalty monitoring.

4.2.1. Differences between the classical and the autonomous TTO model

One of the most important input factors for technology transfer processes is the number and quality of inventions disclosed to the TTO. To foster invention disclosure, two formal activities can be performed: technology "scouting" and raising awareness towards researchers about technology transfer. The first interesting finding from the case studies is that only one of the dependent TTOs is active in internal technology "scouting". However, three out of six autonomous TTOs (case H, I, and J) are actively scouting for possible inventions (e.g., regular and systematic visits of the departments). Regarding "awareness", the common channel to inform academic researchers is to give classes to Ph.D. students. However, case I and H perform a novel approach to increase the number of invention disclosures. They trained selected researchers on technology transfer activities. Those researchers are acting as the first informal contact point for their colleagues. No formal causality can be deduced from this observation, but it gives a hint that autonomy leads to more innovative approaches. Nothing would preclude classical TTOs to do so, but they probably have less explicit or implicit incentives. Indeed, more classical TTOs are often at least backward integrated and hence might have other priorities, like the private funding of academic research.

Deciding which invention to patent and finding exploitation partners are the next process steps. Differences in regard to who is making the decision about patenting as well as differences in the inventor involvement could not be found between the autonomous and the classical TTO type. The decision about patenting is either made by one TTO employee, who is responsible for the invention, or a committee, generally composed of the TTO team. It is worth mentioning that only two TTOs (case E and F) explicitly involve the inventor in the decision about patenting and only three TTOs systematically involve the inventor in the contract negotiations. The inventor acts in all cases as an information source to find potential exploitation partners. Next to using the inventor as information source, the most frequent activities to identify licensees are: networking and advanced marketing techniques.

Regarding the licensing strategy, autonomous TTOs are all taking equity in spin-out companies. However, only one classical TTO (case E) is allowed to take equity in spin-outs. Licensing for equity is associated with financial flexibility for the licensee. This flexibility is supposed to allow spin-outs to bring the technology more quickly to the market (Markman et al. 2005). From this we may conclude that an autonomous organizational structure is more likely to actively support spin-outs. Bray and Lee (2000) have shown that taking equity in start-ups compared to average cash-license agreement produces in most cases greater rate of return in the long run. However, taking equity is not always the most profitable approach, especially considering technologies with very high market potential.

The final process steps, after the conclusion of the contract, are royalty splitting and royalty monitoring. Regarding the latter, we do not identify differences between the two TTO types. Though, in respect to revenue splitting we identify two different systems used by the TTOs. The first system is based on constant shares for the inventor, department/laboratory/university, and/or the TTO.[22] In the second system the share for the inventor decreases with an increase in the royalties. All classical TTOs use the first system and three autonomous TTOs (case C, G, and I) have the second system in practice. Siegel et al. (2003a) as well as Debackere and Veugelers (2005) identified the compensation scheme for university researchers as one success factor for university-to-industry technology transfer. This result is consistent with the outcome of the interviews. The interviewees stated that the second system gives additional incentive to researchers and helps spin-out companies in the early start-up phase. This is also in line with the finding that autonomous TTOs are more actively involved in spin-out support.

Taken as a whole, the case studies reveal differences between the classical and autonomous type especially regarding how the TTO is raising awareness, which licensing strategy they perform, and which system is used to compensate faculty.

4.2.2. Differences between the TTO and TTA model

The first step of the technology transfer process in a TTA, as in the traditional TTO model, is the invention disclosure by the researcher. The recipient of the invention disclosure is the university-specific TTO. The TTO controls the invention disclosure form for correctness and completeness and decides to forward it or not to the TTA. All activities related to awareness and information diffusion is under the responsibility of the university-specific TTO. The monitoring of the relationship inventor-TTO and confidence-building measures are two of the major tasks of the university-specific TTO. This is in line with the argument that a non-exclusive organizational structure implies less intensive relationship between TTA officers and researchers (cf. Section 2.2). University-specific TTOs, however,

[22] Inventor’s share varies from 25% to 85%.

reduce this negative effect: the main issue to address is to keep a degree of confidence for the researchers.

The decision about patenting is made by two employees of the TTA. The result of the decision has to be communicated to the university-specific TTO. In the case of a positive decision, the university has to agree to the invention is to be patented. This is necessary because the university is the actual owner of the invention. In the case of a negative decision, the university-specific TTO has the option to patent the invention itself. In comparison with the TTO type, the coordination and communication costs in this process step are much higher.

The next step, searching for exploitation partners, is executed by the TTA in close collaboration with the university-specific TTO and the inventor. The TTA plans this process step in a more systematic way than most of the TTOs organized as classical or autonomous TTO type. One example for this is that the TTA has institutionalized a regular meeting concerning the marketing approach for the inventions. This is not the case in classical or autonomous TTOs in our sample. No difference between the two types can be found regarding the involvement of the inventor during the negotiation phase. In the two types the inventor is normally not explicitly involved. .

The TTA also takes responsibility for royalty control. However, interview evidence revealed that it is not able to fulfill the task in the desired scope. This is equivalent to the results for the autonomous TTOs.

Regarding the royalty splitting, the TTA obtains the highest share of all TTOs in the sample. The university-specific TTO, however, is not obliged to transfer the invention to the TTA. If the university-specific TTO decides to keep the invention in house they have to bear the costs and the risks. The share for the researcher(s) though remains the same. It is obvious that the TTA faces the risk that the university-specific TTO only transfers inventions with low prospects of success. The benefits of relying on the TTA have to outweigh these costs. This is possible due to e.g. pooling of inventions, greater visibility, and higher bargaining power of the TTA.

To conclude, the most prevailing difference between the TTO and the centralized TTA model relates to the division of labor and task specialization: information diffusion about technology transfer and marketing of the inventions. The university-specific TTO is, in respect to the IP management, more an intermediary between inventor and TTA than a real transfer agent. Moreover, the TTA type is more specialized on marketing activities than the TTO type. This specialization can enhance the efficiency and effectiveness of technology transfer. However, the positive effect is decreased by higher coordination and communication costs. Furthermore, the TTA model pools inventions from several universities and can consequently exploit economies of scale, has higher visibility for industry partners and researchers, as well as more bargaining power. This effect is most interesting for universities with a smaller patent portfolio.

5. DISCUSSION AND CONCLUSION

This paper presents an analysis of how European universities have set the governance of technology transfer activities and provides a new typology of organizational models. Four types of TTOs are identified: The classical TTO, the autonomous TTO, the centralized TTA, and the decentralized TTA. This typology is applied to sixteen case studies of European universities.

The seemingly bewildering diversity of TTO models across Europe can be reduced due to theoretically discussing viable configurations of organizational characteristics. The qualitative analysis provides rich insights of TTO's organizational structure and the implications for the technology transfer process. The TTA type has several advantages for the technology transfer process. The pooling of inventions leads to larger patent portfolios and higher bargaining power. It enables small universities to take an active part in university-to-industry technology transfer. However, the case studies reveal that in a centralized TTA structure university-specific TTOs are needed for "boundary spanning" between the TTA and the researchers. Moreover, the TTA model implies higher coordination and communication cost. However, also the TTO type has positive effects on the technology transfer process. The relationship between TTO staff and academics is more intense. Moreover, the university is able to align strategic goals of the TTO to those of the university and the direct competition between universities can be prevented.

Consequently, rather the strategy and goals of each university have to be taken into account in order to find the right governance model. The findings suggest that universities interested in spin-out creation should evolve towards an autonomous TTO. The universities more interested in the private funding of their research activities would prefer the classical TTO model.

The typology and qualitative analysis presented in this paper lead to the conclusion that comparing universities with different goals and governance models for technology transfer can be misleading. Performance measurement of TTOs without taking into account the governance characteristics identified in this paper may result in wrong implications. Studies measuring the effectiveness and efficiency of TTOs based on e.g. the output variable number of spin-out companies, do not take into account that this output measure is not appropriate for IP-specialized and backward integrated TTOs, for instance. Not differentiating between the different types of TTO induces a risk to compare "apples to oranges".

Altogether, this study contributes to theory in several ways. First, there is currently no theoretical framework for organizational integration in the European context. Existing research focused only on TTOs exclusively serving one university (Bercovitz et al. 2001; Debackere & Veugelers 2005; Markman et al. 2005). This study extends the stream of research by analyzing the TTA organizational model and provides rich insights on the current technology transfer process in Europe. Second, the results provide important implications for the measurement of the efficiency and effectiveness of TTOs in Europe. Evaluating all TTO types based on the same output variables without taking the governance structure into account may result in biased perception of the TTO performance. Third, the typology and qualitative analysis presented in the paper provide analytical support for university management in designing the organizational structure of technology transfer activities.

Future studies could analyze the quantitative impact of different TTO types on the efficiency and effectiveness of technology transfer activities. In particular, a quantitative assessment of the performance differences of TTOs with varying degrees of specialization would provide valuable information for practitioner, policy makers, and researchers. At the country level of the university, a more detailed analyzes of variables influencing the choice of a specific TTO type and restructuring decisions would allow for a more detailed assessment of appropriate TTO types in certain situations.

Table 1. Strengths and weaknesses of five options for TTOs governance

	High Centralization ***(vs. Decentralization)***	**Weak specialization** ***(vs. high specialization)***	**Weak autonomy** ***(vs. high autonomy)***	**Exclusive** ***(vs. Non-exclusive)***	**Fully ov** ***(vs. shared o***
Relationship between TTO and academics	Less intensive	-	-	More intensive	More inte
Relationship between TTO and industry partners	Less intensive	-	-	Less intensive	-
Exploitation of economies of scale	Higher	Higher	-	Lower	-
Exploitation of synergies	Higher	Higher	Higher	Lower	-
Conflicts of interest and concomitant coordination and communication costs	Lower	Lower	-	Lower	Lowe
Further strengths	-	· Lower search costs for researcher and industry partners	-	· Less competition effects between universities · Higher probability of being integrated in the university culture	· Better control o transfer activities university · Higher strategic overall university
Further weakness	· Less technological specialization	· Less specialized in one of the technology transfer activity	· Less flexible ragrding remuneration and incentive scheme	· Higher search costs for industry partners	· Less market ori · Lower pressure profits

Table 2. Values of structural dimensions – 56 possible combinations

Dimension	*Description of dimension*		*Values*		a_1	a_2	b_1	b_2	b_3	b_4	c_1	c_2	d_1	d_2	e_1	e_2
Degree of centralization	*Location of authority regarding technology transfer activities*	*University level*	**Centralized**	a_1												
		Faculty level	**Decentralized**	a_2			1			2		3	4			
Degree of specialization	*Technology transfer activities performed by the TTO.*	*Research services, IP management, and spin-out services*	**Fully integrated**	b_1										7		1
		IP-management and spin-out services	**Forward integrated**	b_2												
		Research services and IP-management	**Backward integrated**	b_3										8		
		IP-management	**IP specialized**	b_4								5	6			
Level of autonomy	*Dependency of the TTO on university administration*	*TTO is independent of university administration in regard to budget and human resource management. TTO has not to report directly to university administration.*	**Independent**	c_1												
		TTO is dependent of university administration in regard to budget and human resource management. TTO has to report directly to university administration.	**Dependent**	c_2										9		1
Degree of exclusitvity	*One common TTO serves several universities*	*TTO serves exclusively one university*	**Exclusive**	d_1												1
		TTO serves several universities	**Non-exclusive**	d_2											10	
Ownership status	*Ownership of TTO*	*100% owned by one university*	**Full ownership**	e_1												
		No university is majority shareholder	**Shared ownership**	e_2												

non feasible combinations

Table 3. Typology

(a) Degree of centralization	Centralized								Decentralized
(c) Level of autonomy granted	Dependent			Independent					
(d) Degree of exclusivity	Exclusive						Non-exclusive		
(e) Ownership status	Full ownership						Shared ownership		
(b) Degree of specialization	Fully integrated	Backward integrated	Forward integrated	Fully integrated	Backward integrated	Forward integrated	Forward integrated	IP specialized	Forward integrated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TTO Type	**I. Classical TTO**			**II. Autonomous TTO**			**III. Centralized TTA**		**IV. Decentralized TTA**

Table 4. Key figures

Variables	Mean (Median)	Std. dev.
Number of Students	40,591 (26,000)	65,843
Number of Researcher	5,343 (3,906)	5,919
Age of TTO (in 2008)	14.8 (11.0)	10
Number of FTEs	18.7 (15.0)	15
Sample size	**16**	

Table 5. Typology and cases

	Fully integrated	Backward integrated	Forward integrated	Fully integrated	Backward integrated	Forward integrated	Forward integrated	IP specialized	Forward integrated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TTO Type	**I. Classical TTO**			**II. Autonomous TTO**			**III. Centralized TTA**		**IV. Decentralized TTA**
Cases		B D E K_b	A K_a K_c K_d	G	C	F H I J		K	L
Average (Median) # students		21,700 (24,500)	22,210 (28,700)	37,000 (37,000)	15,000 (15,000)	26,577 (25,500)		274,926 (274,926)	
Average (Median) # researchers		4,865 (4,300)	2,649 (3,258)	5,321 (5,321)	3,000 (3,000)	4,964 (5,177)		26,055 (26,055)	1,200 (1,200)
Average (Median) # FTE		19.8 (18.5)	9.9 (10.0)	52.0 (52.0)	6.5 (6.5)	22.9 (21.0)		15.0 (15.0)	15.0 (15.0)
Average (Median) age		16.0 (16.0)	21.5 (22.0)	39.0 (7.0)	12.0 (12.0)	16.0 (16.0)		4.0 (4.0)	15.0 (15.0)

REFERENCES

Arora, A., Ceccagnoli, M. (2004): Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. *SSRN eLibrary*.

Belenzon, S., Schankerman, M. (2007): *Harnessing Success: Determinants of Universitytechnology Licensing Performance* STICERD - Economics of Industry Papers, Suntory and Toyota International Centres for Economics and Related Disciplines, LSE.

Bercovitz, J., Feldman, M., Feller, I., Burton, R. (2001): Organizational Structure as a Determinant of Academic Patent and Licensing Behavior: An Exploratory Study of Duke, Johns Hopkins, and Pennsylvania State Universities. *Journal of Technology Transfer* 26, p. 21-35.

Bray, M. J., Lee, J. N. (2000): University Revenues from Technology Transfer: Licensing Fees Vs. Equity Positions. *Journal of Business Venturing* 15(5/6), p. 385.

Chandler, A. (1962): *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. The M.I.T. Press, Cambridge, MA.

Chandler, A. (1977): *The Visible Hand: The Managerial Revolution in American Business*. Harvard University Press, Cambridge, MA.

Chandler, A. (1990): *Scale and Scope: The Dynamics of Industrail Capitalism*. The Belknap Press of Harvard University Press, Cambridge, MA.

Chapple, W., Lockett, A., Siegel, D., Wright, M. (2005): Assessing the Relative Performance of U.K. University Technology Transfer Offices: Parametric and Non-Parametric Evidence. *Research Policy* 34(3), p. 369-384.

Child, J. (1972): Organizational Structure, Environment and Performance: The Role of Strategic Choice. *Sociology* 6(1), p. 2-22.

Clarysse, B., Wright, M., Lockett, A., Van de Velde, E., Vohora, A. (2005): Spinning out New Ventures: A Typology of Incubation Strategies from European Research Institutions. *Journal of Business Venturing* 20(2), p. 183-216.

Conti, A., Gaulé, P. (2009): *Are the Us Outperforming Europe in University Technology Licensing: A New Perspective on the European Paradox* CEMI-Workingpaper,

Debackere, K., Veugelers, R. (2005): The Role of Academic Technology Transfer Organizations in Improving Industry Science Links. *Research Policy* 34(3), p. 321-342.

Di Gregorio, D., Shane, S. (2003): Why Do Some Universities Generate More Start-Ups Than Others? *Research Policy* 32(2), p. 209-227.

Eisenhardt, K. M. (1989): Building Theories from Case Study Research. *Academy of Management Review* 14(4).

European Commission (2007): Improving Knowledge Transfer between Research Institutions and Industry across Europe: Embracing Open Innovation -Implementing the Lisbon Agenda. *Communication to the Council, the European Parliament, the European Economic and Social Committee and the Comittee of the Regions*. Brussels.

European Commission (2009): Expert Group on Knowledge Transfer. Brussels.

Franklin, S. J., Wright, M., Lockett, A. (2001): Academic and Surrogate Entrepreneurs in University Spin-out Companies. *The Journal of Technology Transfer* 26(1-2), p. 127-141.

Geuna, A., Muscio, A. (2009): The Governance of University Knowledge Transfer: A Critical Review of the Literature. *Minerva* 47, p. 93-114.

Lach, S., Schankerman, M. (2008): Incentives and Invention in Universities. *RAND Journal of Economics (Blackwell Publishing Limited)* 39(2), p. 403-433.

Landry, R., Amara, N., Ouimet, M. (2007): Determinants of Knowledge Transfer: Evidence from Canadian University Researchers in Natural Sciences and Engineering. *Journal of Technology Transfer* 32, p. 561-592.

Lockett, A., Siegel, D., Wright, M., Ensley, M. D. (2005): The Creation of Spin-Off Firms at Public Research Institutions: Managerial and Policy Implications. *Research Policy* 34(7), p. 981-993.

Lockett, A., Wright, M. (2005): Resources, Capabilities, Risk Capital and the Creation of University Spin-out Companies. *Research Policy* 34(7), p. 1043-1057.

Macho-Stadler, I., Pérez-Castrillo, D. (2009): *Incentives in University Technology Transfers* UFAE and IAE Working Papers, Unitat de Fonaments de l'Anàlisi Econòmica (UAB) and Institut d'Anàlisi Econòmica (CSIC).

Mackenzie, K. D. (1978): *Organizational Structures*. AHM Publishing Corporation, Illinois.

Markman, G. D., Phan, P. H., Balkin, D. B., Gianiodis, P. T. (2005): Entrepreneurship and University-Based Technology Transfer. *Journal of Business Venturing* 20(2), p. 241-263.

Mathieu, A. (2011): *University-Industry Interactions and Knowledge Transfer Mechanisms: A Critical Survey* ULB -- Universite Libre de Bruxelles.

Mathieu, A., Meyer, M., Van Pottelsberghe de la Potterie, B. (2008): Turning Science into Business: A Case Study of a Major European Research University. *Science and Public Policy* 35(9), p. 669-679.

Meyer, A. D., Tsui, A. S., Hinings, C. R. (1993): Configurational Approaches to Organizational Analysis. *Academy of Management Journal* 36(6), p. 1175-1195.

Meyer, M., Tang, P. (2007): Exploring the “Value” of Academic Patents: Ip Management Practices in Uk Universities and Their Implications for Third-Stream Indicators. *Scientometrics* 70(2), p. 415-440.

Mowery, D. C., Nelson, R. R., Sampat, B. N., Ziedonis, A. A. (2001): The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980. *Research Policy* 30(1), p. 99-119.

Mowery, D. C., Sampat, B. N. (2005): The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other Oecd Governments? *The Journal of Technology Transfer* 30(1), p. 115-127.

Nohria, N. (1991): Note on Organization Structure. *Harvard Business School Note 491-083*.

O'Shea, R. P., Allen, T. J., Chevalier, A., Roche, F. (2005): Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities. *Research Policy* 34(7), p. 994-1009.

Pugh, D. S., Hickson, D. J. (1976): *Organizational Structure in Its Context: The Aston Programme I*. Saxon House, Westmead, Farnborough, Hants.

Pugh, D. S., Hickson, D. J., Hinings, C. R., Turner, C. (1968): Dimensions of Organization Structure. *Administrative Science Quarterly* 13(1), p. 65-105.

Siegel, D. S., Phan, P. H. (2005): Analyzing the Effectiveness of University Technology Transfer: Implications for Entrepreneurship Education. In: Libecap, G. D. (Ed.), *University Entrepreneurship and Technology Transfer (Advances in the Study of Entrepreneurship, Innovation & Economic Growth, Volume 16)*. Emerald Group Publishing Limited, p. 1-38.

Siegel, D. S., Veugelers, R., Wright, M. (2007): Technology Transfer Offices and Commercialization of University Intellectual Property: Performance and Policy Implications. *Oxford Review of Economic Policy* 23(4), p. 640-660.

Siegel, D. S., Waldman, D., Link, A. (2003a): Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study. *Research Policy* 32(1), p. 27-48.

Siegel, D. S., Waldman, D. A., Atwater, L. E., Link, A. N. (2003b): Commercial Knowledge Transfers from Universities to Firms: Improving the Effectiveness of University-Industry Collaboration. *Journal of High Technology Management Research*. 14**:** 111.

Thursby, J. G., Kemp, S. (2002): Growth and Productive Efficiency of University Intellectual Property Licensing. *Research Policy* 31(1), p. 109-124.

Van Looy, B., Landoni, P., Callaert, J., van Pottelsberghe, B., Sapsalis, E., Debackere, K. (2011): Entrepreneurial Effectiveness of European Universities: An Empirical Assessment of Antecedents and Trade-Offs. *Research Policy* 40(4), p. 553-564.

van Zeebroeck, N., van Pottelsberghe de la Potterie, B., Guellec, D. (2008): Patents and Academic Research: A State of the Art. *Journal of Intellectual Capital* 9(2), p. 246-263.

Weber, M. (1947): *The Theory of Socail and Economic Organization*. The Free Press, New York, NY.

Williamson, O. E. (1975): *Markets and Hierarchies: Analysis and Antitrust Implications*. The Free Press, New York, NY.

Williamson, O. E. (1985): *The Economic Institutions of Capitalism*, New York.

Yin, R. K. (2003): *Case Study Research: Design and Methods*, California, 3 Edition.

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Bringing EU Trademark Protection Back Into Shape – Lessons to Learn From Keyword Advertising

In recent years, the Court of Justice of the European Union (CJEU) has continuously expanded the scope and reach of trademark protection in the EU. With the challenges arising in the digital environment, however, this expansionist approach becomes more and more questionable. The current problems arising from keyword advertising shed light on areas of overbroad, excessive trademark protection created by the Court. Moreover, inconsistencies in the Court's system of infringement criteria clearly come to the fore. Against this background, the present analysis explores ways out of the dilemma.

After a short introduction of basic notions of trademark law (section 1), the problematic expansion of trademark protection in recent years (sections 2 and 3), and current problems arising in the digital environment (section 4), will be analysed in more detail. Addressing potential solutions, it will be argued that in spite of current difficulties, it would be naive to assume that the Court is prepared to restrict the scope of EU trademark law to traditional protection against confusion with only minor extensions concerning dilution (section 5). Instead, the need for an appropriate, more flexible limitation infrastructure will be emphasized (section 6 and concluding section 7).

1. Basics

According to traditional trademark theory, trademarks primarily serve the purpose of indicating the commercial origin of goods and services offered in the marketplace.[1] The CJEU refers to

> "the essential function of the trade mark, which is to guarantee the identity of the origin of the trade-marked product to the consumer or final user by enabling him to distinguish without any possibility of confusion between that product and products which have another origin."[2]

To enable trademarks to fulfil the essential origin function, trademark law offers enterprises the opportunity to establish an exclusive link with a distinctive sign. As a result, the protected sign is rendered capable of functioning as a source identifier in trade. In this way, trademark law guarantees market transparency. It ensures fair competition, protects consumers against confusion and contributes to the proper functioning of market economies by allowing consumers to clearly express their preference for a particular product or service. From an

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[1] For an overview of trademark functions, pointing out this traditional focus on identification and distinction functions and potential extensions with regard to communication, investment and advertising functions, see R. Keim, Der markenrechtliche Tatbestand der Verwechslungsgefahr, Baden-Baden: Nomos 2009, 37-61.

[2] For an early use of this formula, see CJEU, 3 December 1981, case C-1/81, Pfizer vs. Eurim-Pharm, para. 8. As to the reappearance of the same formula in later judgments, see particularly CJEU, 12 November 2002, case C-206/01, Arsenal/Reed, para. 48. Cf. I. Simon Fhima, How Does "Essential Function" Doctrine Drive European Trade Mark Law?, International Review of Intellectual Property and Competition Law 36 (2005), 401.

economic perspective, it can be added that the clear indication of the commercial origin of goods and services reduces consumers' search costs.[3]

To enable trademarks to fulfil this essential origin function, rather defensive[4] protection is sufficient. As long as the trademark owner is capable of preventing other traders from using identical or similar signs for identical or similar goods or services, the clear identification of the commercial source of goods and services can be guaranteed. As highlighted by the CJEU, the protection of trademarks as identifiers of commercial source aims at the exclusion of "any possibility of confusion". Accordingly, this protection is to be granted only if use of a conflicting sign is likely to cause confusion.[5] In cases of double identity (an identical sign used for an identical product), this risk of confusion may be deemed so obvious that it can be presumed.[6] However, this presumption must not be misunderstood as a departure from the general requirement to show that confusion is likely to arise from the use at issue.

Given these clear conceptual contours of traditional trademark protection against confusion, it is not surprising that agreement on this limited scope of protection could be reached in the European Union. By virtue of Art. 5(1) of the Trademark Directive (TMD),[7] the grant of this basic protection is mandatory in all EU Member States. It gives trademark owners limited control over communication concerning their marks – control that only covers the identification and distinction of the goods or services they offer in the marketplace. According to the CJEU, the condition of a likelihood of confusion may be satisfied where the public confuses the sign and the mark in question (direct confusion), or where the public makes a connection between the proprietors of the sign and those of the mark and confuses them (indirect confusion).[8] Moreover, trademarks with a particularly distinctive character may give

[3] With regard to the search costs argument, see J. Griffiths, A Law-and-Economic Perspective on Trade Marks, in: L. Bently/J. Davis/J.C. Ginsburg (eds.), Trade Marks and Brands – An Interdisciplinary Critique, Cambridge: Cambridge University Press 2008, 241; M. Strasser, The Rational Basis of Trademark Protection Revisited: Putting the Dilution Doctrine into Context, Fordham Intellectual Property, Media & Entertainment Law Journal 10 (2000), 375 (379-382). With regard to questions arising in the digital environment, see S.L. Dogan/M.A. Lemley, Trademarks and Consumer Search Costs on the Internet, Houston Law Review 41 (2004), 777.

[4] This protection is defensive in the sense that it aims at the prevention of confusing use and is not concerned primarily with the exploitation of brand value as an enterprise's intellectual property asset. Cf. M.R.F. Senftleben, The Trademark Tower of Babel – Dilution Concepts in International, US and EC Law, International Review of Intellectual Property and Competition Law 40 (2009), 45 (47), online available at http://ssrn.com/abstract=1723903.

[5] Apart from the introduction of 'absolute protection' in cases of sign and product identity (which will be dealt with below), this basic requirement is clearly reflected in Recital 11 of the EU Trademark Directive: "The likelihood of confusion, the appreciation of which depends on numerous elements and, in particular, on the recognition of the trade mark on the market, the association which can be made with the used or registered sign, the degree of similarity between the trade mark and the sign and between the goods or services identified, should constitute the specific condition for such protection."

[6] At the international level, this concept of presuming a likelihood of confusion in cases of double identity is clearly reflected in Art. 16(1) TRIPS: "The owner of a registered trademark shall have the exclusive right to prevent all third parties not having the owner's consent from using in the course of trade identical or similar signs for goods or services which are identical or similar to those in respect of which the trademark is registered where such use would result in a likelihood of confusion. In case of the use of an identical sign for identical goods or services, a likelihood of confusion shall be presumed."

[7] Directive 2008/95/EC of the European Parliament and of the Council of October 22, 2008, to approximate the laws of the Member States relating to trade marks (codified version) (OJ 2008 L 299, 25), which entered into force on November 28, 2008, and repealed the earlier Directive 89/104/EEC of the Council of December 21, 1988.

[8] See CJEU, 11 November 1997, case C-251/95, Puma/Sabel, para. 16-26. For an overview of the EU approach to anti-confusion protection, see G. Würtenberger, Risk of Confusion and Criteria to Determine the Same in

rise to a greater likelihood of confusion.[9] The EU concept also covers post sale confusion that might arise after the place of purchase with a clear notice concerning the commercial origin of goods has been left.[10]

2. Extensions

In all these cases, EU protection against confusion can be understood to serve the rather defensive purpose of preventing competitors from use that would interfere with the basic communication of information about the commercial origin of goods and services offered by the trademark owner. It is this prevention of confusing use that constitutes the core rationale of protection.[11] Nonetheless, the exclusive rights necessary for ensuring protection against confusion can be used strategically by the trademark owner to realize additional benefits. To allow trademarks to convey reliable information on the commercial origin of goods or services, it is indispensable to reserve use of the trademark exclusively for the trademark owner in all market segments where use of identical or similar signs could lead to confusion.[12] As a result, the trademark owner obtains an exclusive channel of communication in several areas of the market. In principle, only the enterprise holding trademark rights is entitled to convey information to consumers via the trademark in this protected area.[13]

Through investment in advertising, the trademark owner can easily use this exclusive communication channel to add messages that are unrelated to the underlying objective of ensuring accurate information about the commercial source of goods or services. In particular, an enterprise can start advertising campaigns to teach consumers to associate a certain attitude or lifestyle with the trademark.[14] The moment a trademark "speaks" to consumers about a

European Community Trade Mark Law, European Intellectual Property Review 2002, 20. For critical comments on the need for additional anti-dilution protection, see J.T. McCarthy, Dilution of a Trademark: European and United States Law Compared, The Trademark Reporter 94 (2004), 1163 (1170-1172), online available at http://ssrn.com/abstract=1350045.

[9] CJEU, ibid., para. 24. The degree of distinctiveness is one of the factors to be considered in the framework of the infringement analysis. See CJEU, 29 September 1998, case C-39/97, Canon/Cannon; CJEU, 22 June 1999, case C-342/97, Lloyd/Loint's.

[10] See CJEU, 12 November 2002, case C-206/01, Arsenal/Reed, para. 57, with regard to cases of double identity.

[11] For an alternative view, emphasizing the attention devoted to the trademark owner's interest in exploiting brand value in the context of protection against confusion, see T. Cohen Jehoram/H. Van Helden, Bekend, bekender, bekendst: Goodwill-bescherming van merken, in: Benelux Office for Intellectual Property (ed.), In Varietate Concordia? National and European Trademarks Living Apart Together, The Hague: Benelux Office for Intellectual Property 2011, 111; M. Buydens, Pouvoir distinctif de la marquee et risque de confusion: larvatus prodeo?, in: Benelux Office for Intellectual Property, ibid., 33; A.A. Quaedvlieg, Verwaterd of verward, een kwestie van bekendheid?, in: D.J.G. Visser/D.W.F. Verkade (eds.), Een eigen, oorspronkelijk karakter – Opstellen aangeboden aan prof. mr. Jaap H. Spoor, Amsterdam: DeLex 2007, 275.

[12] In the case of collective trademarks, this exclusive reservation of a sign concerns an association of enterprises who use the trademark in trade. The basic mechanism, however, remains unchanged. The information coveyed via the trademark, by contrast, will focus on certain product characteristics rather than one particular commercial origin. Cf. A. Peukert, Individual, Multiple and Collective Ownership of Intellectual Property Rights – Which Impact on Exclusivity?, in: A. Kur/V. Mizaras (eds.), The Structure of Intellectual Property Law: Can One Size Fit All?, Cheltenham: Edward Elgar Publishing 2011, online available at http://ssrn.com/abstract=1563990.

[13] As in other fields of intellectual property protection, it is indispensable to set certain limits to the exclusive rights of trademark owners. The principle of an exclusive communication channel, therefore, is limited in several respects. See the general limitations set forth in Art. 6 TMD. With regard to comparative advertising, see CJEU, 12 June 2008, case C-533/06, O2/Hutchison, para. 45; CJEU, 18 June 2009, case C-487/07, L'Oréal/Bellure, para. 54.

[14] Cf. R.S. Brown, Advertising and the Public Interest: Legal Protection of Trade Symbols, Yale Law Journal 108 (1999), 1619 (1619-1620); K.H. Fezer, Entwicklungslinien und Prinzipien des Markenrechts in Europa –

particular image that can be associated with the trademarked product, consumers no longer simply buy products from a particular source. They also buy the respective "trademark experience" and "brand image".[15]

Inevitably, the exclusive rights necessary to ensure protection against confusion, therefore, also protect the investment made in the creation of a favourable trademark image. Basic protection against confusion safeguards the exclusive link between an enterprise and its trademark. In this way, it also offers legal security for substantial investment in the evocation of brand-related associations in the minds of consumers. The WTO Panel dealing with EC protection for trademarks and geographical indications for agricultural products and foodstuffs described this protection reflex as follows:

> "The function of trademarks can be understood by reference to Article 15.1 [TRIPS] as distinguishing goods and services of undertakings in the course of trade. Every trademark owner has a legitimate interest in preserving the distinctiveness, or capacity to distinguish, of its trademark so that it can perform that function. This includes its interest in using its own trademark in connection with the relevant goods and services of its own and authorized undertakings. Taking account of that legitimate interest will also take account of the trademark owner's interest in the economic value of its mark arising from the reputation that it enjoys and the quality that it denotes."[16]

The WTO Panel was not called upon to discuss the protection of trademark reputation and brand image in more detail. It could content itself with the indication of a connection between the protection of trademark distinctiveness and trademark repute. The delicate question to be answered in advanced trademark protection systems, such as the EU system, however, is whether – in addition to the described protection reflex inherent in basic protection against confusion – the creation of a brand image should additionally be rewarded with enhanced protection covering cases of dilution.[17] In other words: does the marketing effort made by the trademark owner justify an additional layer of protection against dilution besides the basic protection against confusion?

Auf dem Weg zur Marke als einem immaterialgüterrechtlichen Kommunikationszeichen, Gewerblicher Rechtsschutz und Urheberrecht 2003, 457 (461-462); S. Casparie-Kerdel, Dilution Disguised: Has the Concept of Trade Mark Dilution Made its Way into the Laws of Europe?, European Intellectual Property Review 2001, 185 (185-186); M. Lehmann, Die wettbewerbswidrige Ausnutzung und Beeinträchtigung des guten Rufs bekannter Marken, Namen und Herkunftsangaben – Die Rechtslage in der Bundesrepublik Deutschland, Gewerblicher Rechtsschutz und Urheberrecht International 1986, 6 (14-17).

[15] See J.E. Schroeder, Brand Culture: Trade marks, Marketing and Consumption, in: Bently/Davis/Ginsburg, supra note 3, 161.

[16] See WTO Panel, 15 March 2005, WTO Document WT/DS174/R, para. 7.664, based on a complaint by the US. A second and almost identical report, WTO Document WT/DS290/R, deals with a parallel complaint by Australia. The reports are online available at www.wto.org. For a discussion of the reports, see M.R.F. Senftleben, Towards a Horizontal Standard for Limiting Intellectual Property Rights? – WTO Panel Reports Shed Light on the Three-Step Test in Copyright Law and Related Tests in Patent and Trademark Law, International Review of Intellectual Property and Competition Law 37 (2006), 407, online available at http://ssrn.com/abstract=1723871.

[17] With regard to the basis of this discussion in trademark law, see F.I. Schechter, The Rational Basis of Trademark Protection, Harvard Law Review 40 (1927), 813. With regard to current problems, see Casparie-Kerdel, supra note 14; McCarthy, supra note 8; Senftleben, supra note 4; G. Bonet, La protection de l'image de la marquee dans la jurisprudence de la Cour de Justice, in: C. Geiger/J. Schmidt-Szalewski (eds.), Les défis du droit des marques au XXIe siècle, Strasbourg: Litec 2010, 105; G.B. Dinwoodie/M.D. Janis, Dilution's (Still) Uncertain Future, Michigan Law Review First Impressions 105 (2006), 98.

The problem with this additional layer of protection is that the creation of a brand image is a selfish endeavour. When a trademark triggers a whole bundle of lifestyle messages and positive associations, the trademark experience itself becomes an independent product for which consumers are willing to pay. Realizing the economic potential of the trademark, the brand owner will seek protection for the brand image as such.[18] Once sufficient protection is acquired, the marketing and commercialization of the brand can easily be extended to additional products. The owner of a prestigious clothing brand, for instance, may consider also selling jewellery and perfume under the trademark or decide to grant licenses for this purpose. Through product diversification of this type, the revenue accruing from the creation of a powerful brand can be maximized.[19]

As a result of these marketing strategies, trademark rights lose their defensive nature. Seeking enhanced protection against dilution, the brand owner asks for control over the use of the trademark across all markets and regardless of whether there is a likelihood of confusion. This brings anti-dilution rights close to exploitation rights. However, unlike other intellectual property owners enjoying exploitation rights, such as inventors and authors, the brand owner cannot validly claim to have created intellectual property that furthers science or art. The trademark does not even fall into the public domain after a limited period of time. By contrast, brand protection is protection of investments that are made to improve an enterprise's market position. It is not evident that this selfish investment decision also furthers the overall welfare of society.

Against this background, it is unclear why trademark law should offer brand exploitation rights.[20] Typical rationales underlying the grant of exploitation rights in intellectual property law, such as the incentive rationale and the reward rationale, are inapplicable in this context. It is not obvious that the extra incentive of brand exploitation rights is needed to spur investment in brand creation. In fact, there is little evidence of any need for brand image creation in society that would justify the invocation of this rationale and an extra incentive for brand image creators.[21] By contrast, it may be argued that seductive lifestyle messages

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[18] See the position taken by the US Supreme Court, Moseley vs. V Secret Catalogue ("Victoria's Secret"), 537 US 418 (2003): "[u]nlike traditional infringement law, the prohibitions against trademark dilution are not the product of common-law development, and are not motivated by an interest in protecting consumers."

[19] The result of these marketing efforts, however, is "self-dilution". As the trademark owner herself engages in the establishment of links with additional products, she could hardly care less about the immediate association of the mark with a specific product in the minds of consumers. Cf. S. Stadler Nelson, The Wages of Ubiquity in Trademark Law, Iowa Law Review 88 (2003), 731.

[20] For a detailed analysis of potential justifications, see W. Sakulin, Trademark Protection and Freedom of Expression – An Inquiry into the Conflict between Trademark Rights and Freedom of Expression under European Law, The Hague/London/New York: Kluwer Law International 2010, 35-67, who also casts doubt upon the justificatory basis of protection against dilution. Proponents of brand image protection in the framework of trademark law particularly point to the effort and financial expenses made by the brand owner. For instance, see A. Breitschaft, Intel, Adidas & Co – Is the Jurisprudence of the European Court of Justice on Dilution Law in Compliance with the Underlying Rationales and Fit for the Future?, European Intellectual Property Review 2009, 497 (499). Considering the costs for society involved in the grant of brand image protection – in particular restrictions of freedom of expression and freedom of competition – this fact alone, however, can hardly be deemed sufficient for the grant of broad exclusive rights.

[21] See D. Scott/A. Oliver/M. Ley-Pineda, Trade Marks as Property: a Philosophical Perspective, in: Bently/Davis/Ginsburg, supra note 3, 285 (296-297), who consider product differentiation, facilitation of consumer choice and incentives to purchasing and, nevertheless, reject utilitarian arguments. Cf. M.A. Lemley, The Modern Lanham Act and the Death of Common Sense, Yale Law Journal 108 (1999), 1687 (1694-1696); R.S. Brown, Advertising and the Public Interest: Legal Protection of Trade Symbols, Yale Law Journal 108 (1999), 1619 (1622-1634).

conveyed by a trademark distract from a product's genuine qualities, thereby rendering consumers' buying decisions less objective and depriving the trader with the objectively best offer of corresponding market success.[22] Potential economic arguments, such as the facilitation of competition in mature markets and the enhancement of product popularity, are outweighed by social and cultural concerns about the privatization of words and phrases.[23]

The reward argument hardly offers stronger support.[24] Admittedly, it is the trademark owner who spent time and money on the creation of a particular brand image. Feelings of rightness and justice, therefore, suggest that the result of these efforts be due to her. Comparing brand image with other intellectual creations, however, it becomes doubtful whether the trademark owner deserves this reward. Whereas works and inventions contribute to mankind's treasury of cultural expression and technical knowledge once they fall into the public domain, a trademark carrying a particular brand image can be monopolized *ad infinitum* by the trademark owner by constantly renewing registration. As emphasized above, the investment in the creation of a brand image remains an individual, selfish marketing decision for which the trademark owner cannot necessarily expect a reward from society as a whole.[25]

With classical rationales being unavailable in the case of brand exploitation rights, law and policy makers in the field of trademark law should be cautious with regard to the extension of trademark protection beyond the traditional field of protection against confusion. Not surprisingly, the legal framework set forth in the EU Trademark Directive includes several safeguards against inappropriately broad protection in this area. For EU Member States, the grant of enhanced protection against dilution is optional under Art. 5(2) TMD. If the provision is implemented into national law,[26] the brand owner still has to surmount several hurdles to obtain protection. Besides the obligation to satisfy the general protection requirements of use in the course of trade and use in relation to goods or services, the brand owner must show that her trademark has a reputation, and that a conflicting sign is used in a way that takes unfair advantage of, or is detrimental to, the distinctive character or the repute of the trademark. Moreover, Art. 5(2) TMD provides for a flexible defence of "due cause" to counterbalance the grant of anti-dilution protection.

With these safeguards, the EU trademark system seems unlikely to succumb to the temptation of granting unjustified brand exploitation rights. The phalanx of infringement criteria clearly indicates that the mere use of a sign similar to a mark with a reputation is not intended to give

[22] See Brown, supra note 21, 1635-1637, who points out that "[t]he classical economists who enthroned the consumer never dreamed that he would make his decisions under a bombardment of stupefying symbols." However, see also the economic analysis conducted by R. van den Bergh/M. Lehmann, Informationsökonomie und Verbraucherschutz im Wettbewerbs- und Warenzeichenrecht, Gewerblicher Rechtsschutz und Urheberrecht International 1992, 588 (589-593).

[23] See Strasser, supra note 3, 389-390 and 412-414, on the one hand, and Lemley, supra note 21, 1694-1698; R. Cooper Dreyfuss, We Are Symbols and Inhabit Symbols, so Should we be Paying Rent? Deconstructing the Lanham Act and Rights of Publicity, Columbia-VLA Journal of Law & Arts 20 (1996), 123 (128), on the other hand.

[24] For an analysis of Lockean justification models, see Scott/Oliver/Ley-Pineda, supra note 21, 297-305; Sakulin, supra note 20, 63-66.

[25] Cf. B. Beebe, A Defense of the New Federal Trademark Antidilution Law, Fordham Intellectual Property, Media & Entertainment Law Journal 16 (2006), 1143 (1159), stating that a court "should not grant antidilution protection to reward – i.e., to promote – spending on advertising, just as it should not grant such protection in recognition of something like the plaintiff's good faith in trying as hard as it can to make its mark famous."

[26] In fact, all EU Member States implemented Art. 5(2) TMD in their national trademark laws. On the basis of this provision, anti-dilution protection is thus available throughout the European Union.

rise to an infringement action based on dilution. Anti-dilution protection should not readily be awarded whenever a sign calling to mind a mark with a reputation is used in some area of the market. Otherwise, the brand owner would obtain an exclusive right that, *de facto*, can be equated with exploitation rights conferred in copyright and patent law. Instead, the conditions laid down in Art. 5(2) TMD call upon EU courts to embark on a careful case-by-case analysis to ascertain whether the individual circumstances of the case brought before them justify anti-dilution protection.[27]

3. Excesses

The CJEU, however, is reluctant to follow this cautious approach. Instead of seeking to give individual meaning to the various protection requirements, the Court seems determined to systematically lower the threshold for anti-dilution protection and cut up the safety net of infringement criteria that was tied to prevent overbroad brand image protection. Step by step, the Court has relaxed the applicable protection requirements in recent years. As a result, anti-dilution rights in the EU come closer and closer to unjustified brand exploitation rights. Brand owners may soon be able to invoke anti-dilution protection to control any use of signs similar to a mark with a reputation in trade.

Under the aegis of the CJEU, the general protection requirements of use in the course of trade[28] and use in relation to goods or services do not constitute substantial hurdles for trademark owners seeking protection. In particular, the requirement of use in relation to goods or services is applied flexibly by the CJEU. In principle, this general prerequisite for protection could be understood to require "use as a trademark". It may be applied to confine the scope of trademark rights to instances where another's trademark is employed as an identifier of commercial source with regard to one's own goods or services.[29] Following this approach, access to trademark protection could be contained from the outset.[30] The entrance requirement of trademark use would already serve as a filter to exclude claims that are unrelated to the identification and distinction of goods and services. Nonetheless, this notion of trademark use would cover instances of dilution where harm to a mark with a reputation

[27] For a more detailed discussion of an approach avoiding an unjustified protection automatism in EU trademark law, see Senftleben, supra note 4, 59-64.

[28] Use of a trademark constitutes use in the course of trade in the EU where it occurs "in the context of commercial activity with a view to economic advantage and not as a private matter." See CJEU, 23 March 2010, cases C-236/08-238/08, Google/Louis Vuitton et al., para. 50; CJEU, 12 November 2002, case C-206/01, Arsenal/Reed, para. 40.

[29] CJEU, 25 January 2007, case C-48/05, Opel/Autec, para. 24, pointed in this direction. The course adopted in this judgment, however, was not followed in further decisions. Cf. P.J. Yap, Essential Function of a Trade Mark: From BMW to O2, European Intellectual Property Review 2009, 81 (86-87).

[30] With regard to similar proposals in the US, see S.L. Dogan/M.A. Lemley, The Trademark Use Requirement in Dilution Cases, Santa Clara Computer & High Technology Law Journal 24 (2008), 541 (542): "By maintaining the law's focus on misleading branding, the trademark use doctrine keeps trademark law true to its ultimate goal of promoting competitive markets." However, see also G.B. Dinwoodie/M.D. Janis, Confusion Over Use: Contextualism in Trademark Law, Iowa Law Review 92 (2007), 1597 (1657-1658), doubting that problems arising in the current "expansionist climate" could be solved by recalibrating the notion of trademark use: "Trademark use is simply too blunt a concept, no matter how defined, to capture the full range of values at play in these debates." For a summary of the debate, see M. Davison/F. Di Giantomasso, Use as a Trade Mark: Avoiding Confusion When Considering Dilution, European Intellectual Property Review 2009, 443. With regard to the EU, see A. Kur, Confusion Over Use? Die Benutzung "als Marke" im Lichte der EuGH-Rechtsprechung, Gewerblicher Rechtsschutz und Urheberrecht International 2008, 1 (11), who warns of limiting trademark protection from the outset on the basis of a restrictive notion of trademark use, in particular with regard to Community trademarks.

flows from a conflicting sign used by a third party as a source identifier. In the landmark Claeryn/Klarein decision of the Benelux Court of Justice, for instance, use of the sign "Klarein" as a source identifier for a cleaning detergent gave rise to an infringement action based on dilution because it was similar to the well-known gin trademark "Claeryn" and encroached upon that trademark's "potential for raising a desire to buy".[31]

Instead of sharpening the conceptual contours of trademark use in this way, the CJEU has constantly weakened this general protection requirement. The Court found use for the purpose of informing the public about repair and maintenance services offered with regard to trademarked products to constitute relevant trademark use.[32] The CJEU also qualified use in comparative advertising as trademark use on the grounds that the advertiser made use of a competitor's trademark to distinguish her own products from those of the competitor.[33] As a result, the basic requirement of trademark use does not prevent trademark owners from asserting their rights against references to the trademark even though the public does not perceive these references as an indication of commercial source. By contrast, referential use is brought within the reach of the exclusive rights of trademark owners.

In the case of marks with a reputation, even decorative use that merely calls to mind the protected trademark may be held to constitute relevant trademark use on the basis of CJEU jurisprudence. The case "Lila Postkarte" of the German Federal Court of Justice, for instance, concerned the marketing of postcards that alluded ironically to trademarks and advertising campaigns of the chocolate producer Milka. On purple background corresponding to Milka's abstract colour mark, the postcard sought to ridicule the nature idyll with cows and mountains that is evoked in Milka advertising. It showed the following poem attributed to "Rainer Maria Milka":

"Über allen Wipfeln ist Ruh,
irgendwo blökt eine Kuh.
Muh!"[34]

Assessing this ironic play with Milka insignia, the German Federal Court of Justice confirmed the broad notion of trademark use evolving from the jurisprudence of the CJEU.[35] It held that

[31] See Benelux Court of Justice, 1 March 1975, case A74/1, "Claeryn/Klarein", published in Nederlandse Jurisprudentie 1975, 472; Ars Aequi 1977, 664; Bijblad bij de Industriële Eigendom 1975, 183. Cf. Casparie-Kerdel, supra note 14, 189-190. Cf. Opinion of Advocate General Jacobs, 10 July 2003, concerning CJEU, case C-408/01, Adidas/Fitnessworld, para. 38, stating that "the concept of detriment to the repute of a trade mark […] describes the situation where – as it was put in the well-known Claeryn/Klarein decision of the Benelux Court of Justice – the goods for which the infringing sign is used appeal to the public's senses in such a way that the trade mark's power of attraction is affected."

[32] See CJEU, 23 February 1999, case C-63/97, BMW/Deenik, para. 42. For an overview of the development of the trademark use requirement in CJEU jurisprudence, see Kur, supra note 30.

[33] See CJEU, 12 June 2008, case C-533/06, O2/Hutchison, para. 35-36. As to keyword advertising on the basis of services offered by a search engine, use of a competitor's trademark as a keyword for a sponsored link with one's own advertising has been found to constitute trademark use on similar grounds. See CJEU, 23 March 2010, cases C-236/08-238/08, Google/Louis Vuitton et al., para. 71.

[34] "It is calm above the tree tops, somewhere a cow is bellowing. Moo!" See German Federal Court of Justice, 3 February 2005, case I ZR 159/02, Gewerblicher Rechtsschutz und Urheberrecht 2005, 583, "Lila Postkarte", online available at www.bundesgerichtshof.de. Cf. C. Born, Zur Zulässigkeit einer humorvollen Markenparodie – Anmerkungen zum Urteil des BGH "Lila Postkarte", Gewerblicher Rechtsschutz und Urheberrecht 2006, 192.

[35] See the reference to CJEU, 23 October 2003, case C-408/01, Adidas/Fitnessworld, para. 39, in the decision "Lila Postkarte" of the German Federal Court of Justice, ibid., 584. With regard to the qualification of decorative use as relevant trademark use, see also Kur, supra note 30, 5-6.

for the use of Milka trademarks to constitute trademark use in the sense of Art. 5(2) TMD, it was sufficient that the postcard called to mind the well-known Milka signs.[36] Even though being decorative, the use in question, therefore, gave rise to the question of trademark infringement. Accordingly, the German Federal Court of Justice embarked on a scrutiny of the trademark parody in the light of the infringement criteria of detriment to distinctive character or repute, and the taking of unfair advantage. Weighing Milka's concerns about a disparagement of the trademarks against the fundamental guarantee of the freedom of art, the Court finally concluded that the freedom of art had to prevail in light of the ironic statement made with the postcard.[37] The use of Milka trademarks was found to have taken place with "due cause" in the sense of Art. 5(2) TMD.

Examples of this kind show that, with jurisprudence encouraging the inclusion of referential and decorative use in an elastic concept of trademark use, the CJEU has opened the doors to trademark protection widely.[38] Trademark rights become generally available when a protected sign is used in the context of presenting or discussing goods or services. This general control over communication involving a trademark paves the way for the extension of trademark rights to exploitation rights comparable to those conferred in copyright and patent law. The mere use of a trademark in some relation to goods or services is sufficient to lodge an infringement claim.[39] In the Milka case, for instance, the infringement action could not be stopped at an early stage by holding that the use did not constitute actionable trademark use. Instead, the parodist had to invoke the defence of due cause and argue the case in several instances until the German Federal Court of Justice took a final decision.

Admittedly, the CJEU need not necessarily employ the basic requirement of use in relation to goods or services as a means to draw clear boundary lines of trademark protection in the EU. The general requirement of trademark use is followed by several more specific conditions. As indicated above, a brand owner seeking protection under Art. 5(2) TMD must also show that her trademark has a reputation. This further protection requirement only applies in the specific context of anti-dilution protection. Therefore, it could be embraced by the CJEU as a tool to regulate access to this problematic enhanced layer of protection. With a nuanced concept of reputation, the Court could ensure that anti-dilution protection is awarded only if a trademark has a brand image that is likely to be harmed or unfairly exploited because of its particular value and attractiveness. The requirement of "having a reputation" could become an important eligibility criterion in the case of brand owners seeking protection against dilution.

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[36] See German Federal Court of Justice, ibid., 584.

[37] See German Federal Court of Justice, ibid., 584-585. For a further case in which freedom of speech prevailed over trademark protection, see German Federal Court of Justice, 11 March 2008, case VI ZR 7/07, Neue Juristische Wochenschrift 2008, 2110, "Gen-Milch", online available at www.bundesgerichtshof.de.

[38] The requirement of trademark use is even less relevant in EU Member States that, in line with Art. 5(5) TMD extend trademark protection to forms of use "other than for the purposes of distinguishing goods or services". In these Member States, not only the requirement of "use in the course of trade" but also the requirement of "use in relation to goods or services" does not apply in this area of extended protection. See Art. 2.20(1)(d) of the Benelux Treaty Concerning Intellectual Property. Cf. T. Cohen Jehoram/C.J.J.C. van Nispen/J.L.R.A. Huydecoper, Industriële eigendom – Deel 2: Merkenrecht, Deventer: Kluwer 2008, 366-367; C. Gielen, Merkenrecht, in: C. Gielen (ed.), Kort begrip van het intellectuele eigendomsrecht, Deventer: Kluwer 2007, 256 and 286-287.

[39] This risk of creating an automatism of property claims ("Eigentumslogik") is also pointed out by proponents of an elastic notion of trademark use. See Kur, supra note 30, 12. For similar concerns expressed against the background of developments in the US, see S.L. Dogan/M.A. Lemley, Grounding Trademark Law Through Trademark Use, Trademark Reporter 98 (2008), 1345.

Instead of establishing an appropriate test that regulates eligibility for anti-dilution protection, the threshold for assuming that a trademark has the necessary reputation is remarkably low in the EU. In "Chevy", the Court explained that "the market share held by the trade mark" and "the size of the investment made by the undertaking in promoting it" had to be taken into account in this context.[40] However, the Court also explained that

> "[t]he public amongst which the earlier trade mark must have acquired a reputation is that concerned by that trade mark, that is to say, depending on the product or service marketed, either the public at large or a more specialized public, for example traders in a specific sector."[41]

Moreover, the Court clarified that

> "[t]he degree of knowledge required must be considered to be reached when the earlier mark is known by a significant part of the public concerned by the products or services covered by that trade mark."[42]

This clarification shows that the Court considers knowledge among the individual target group of the product concerned sufficient, even though this target group may be a specialized public in the case of specific products or services. The Court favours a niche reputation approach. Further findings in the Chevy case confirm this conclusion. In respect of the necessary territorial expansion of the mark's reputation, the Court held the view that

> "[i]n the absence of any definition [in Art. 5(2) TMD] in this respect, a trade mark cannot be required to have a reputation "throughout" the territory of the Member State. It is sufficient for it to exist in a substantial part of it."[43]

Hence, the CJEU follows a niche reputation approach focusing on knowledge among a significant part of a potentially specialized public in a substantial part of an EU Member State. Introducing this low standard, the Court is far from exerting efficient access control on the basis of the reputation requirement. Instead of actively regulating access to enhanced protection against dilution, the door to anti-dilution rights is kept open widely.[44] Not only the general requirement of trademark use but also the specific eligibility criterion of "having a reputation" is virtually eroded instead of being employed to keep trademark protection within reasonable limits.

The erosion of a further prerequisite for protection seems inevitable in the context of anti-dilution protection. As pointed out above, traditional protection against confusion requires some likelihood of confusion. Protection against dilution, however, is not primarily concerned with the prevention of confusing use. It aims at preserving the particular distinctive character and the repute of marks with a reputation. A trademark's particular distinctive character or repute, however, may be harmed or unfairly exploited without causing a risk of confusion. The mere allusion to the mark with a reputation can be sufficient. Accordingly, the CJEU

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[40] See CJEU, 14 September 1999, case C-375/97, General Motors vs. Yplon ("Chevy"), para. 27.
[41] CJEU, ibid., para. 24.
[42] CJEU, ibid., para. 26.
[43] CJEU, ibid., para. 28. In respect of the territorial expansion required in the case of Community trademarks, see CJEU, 6 October 2009, case C-301/07, Pago/Tirolmilch, para. 29-30.
[44] Cf. the critique by F. Pollaud-Dulian, Marques de renommée: Histoire de la dénaturation d'un concept, Propriétés intellectuelles 2001, 43.

adopted an elastic association test in Adidas/Fitnessworld. In line with this ruling, enhanced protection against dilution becomes available when a competing sign calls to mind a mark with a reputation.[45]

After this erosion of safeguards against overbroad brand image protection, the seemingly robust edifice of EU infringement criteria is about to crumble. To obtain protection against dilution, however, the brand owner still must provide evidence that the conflicting use takes unfair advantage of, or is detrimental to, the distinctive character or the repute of the mark with a reputation. This remaining condition constitutes the last bastion against overbroad brand image exploitation rights. Against this background, the decision Intel/CPM gave hope that the CJEU would defend at least this remaining barrier. With regard to proof of detriment to the distinctive character of marks with a reputation, the Court required

> "evidence of a change in the economic behaviour of the average consumer of the goods or services for which the earlier mark was registered consequent on the use of the later mark, or a serious likelihood that such a change will occur in the future."[46]

From a practical perspective, one may wonder how the required "evidence of a change in the economic behaviour of the average consumer" can ever be produced.[47] Considering the need to balance protection, however, it is consistent to pose a difficult hurdle. With the general requirement of trademark use and the specific eligibility criterion of having a reputation being rendered meaningless, it is justified to set a high threshold when it comes to the final question of taking unfair advantage or causing detriment.

The Intel/CPM decision, however, was followed by the L'Oréal/Bellure judgment in which the CJEU lowered this final threshold substantially. Dealing with comparison lists concerning cheap imitations of well-known L'Oréal perfumes, the Court stated that a mere attempt to ride on the coat-tails of a mark with a reputation could be sufficient to assume that unfair advantage had been taken. It explained that

> "where a third party attempts, through the use of a sign similar to a mark with a reputation, to ride on the coat-tails of that mark in order to benefit from its power of attraction, its reputation and its prestige, and to exploit, without paying any financial compensation and without being required to make efforts of his own in that regard, the marketing effort expended by the proprietor of that mark in order to create and maintain the image of that mark, the advantage resulting from such use must be considered to be an advantage that has been unfairly taken of the distinctive character or the repute of that mark".[48]

The fundamental change with regard to the availability of anti-dilution protection becomes apparent the moment the relationship between the different final infringement criteria is

[45] See CJEU, 23 October, 2003, case C-408/01, Adidas/Fitnessworld, para. 29.
[46] See CJEU, 27 November 2008, case C-252/07, Intel/CPM, para. 77.
[47] Cf. A. Bouvel, Marques et renommée: À propos de l'arrêt "Intel" rendu par la Cour de justice des communautés européennes le 27 novembre 2008 (aff. C-252/07), in: Geiger/Schmidt-Szalewski, supra note 17, 123; A.A. Quaedvlieg, INTEL en verwatering: Economisch gedrag en juridisch bewijs, Bijblad bij de industriële eigendom 2009, 253; A.A. Quaedvlieg, Herkomst- en goodwillinbreuk in het merkenrecht na INTEL en l'Oréal, Ars Aequi 2009, 799; S. Middlemiss/S. Warner, The Protection of Marks with a Reputation: Intel v CPM, European Intellectual Property Review 2009, 326 (331-332).
[48] See CJEU, 18 June 2009, case C-487/07, L'Oréal/Bellure, para. 49.

considered. The three modes of infringement – detriment to distinctive character (blurring), detriment to repute (tarnishment), unfair advantage from distinctive character or repute (free-riding) – constitute alternative conditions in accordance with Art. 5(2) TMD. By setting a low standard for the taking of unfair advantage, the Court, thus, creates a loophole that can be used when a showing of detriment is impossible. The brand owner who does not succeed in providing "evidence of a change in the economic behaviour of the average consumer" can insist on the taking of unfair advantage instead. For this alternative basis of her claim, she merely has to argue that the defendant attempts (!) to ride on the coat-tails of the mark with a reputation.

With the creation of the coat-tail formula in L'Oréal/Bellure, the CJEU, therefore, abandoned the remaining bastion of final infringement criteria. Under Art. 5(2) TMD, brand owners seeking anti-dilution protection can benefit from an elastic entrance requirement of trademark use, encompassing referential and decorative use, a remarkably low eligibility criterion of having a reputation, an elastic association test of calling to mind the mark with a reputation and, finally, a flexible unfair advantage criterion that is already fulfilled the moment a third party attempts to ride on the coat-tails of the mark with a reputation. Surveying these broad, elastic and flexible conditions for protection against dilution, one can hardly deny that anti-dilution protection under Art. 5(2) TMD requires little more than a showing that a conflicting sign in some area of the market triggers an association with a mark with a reputation.[49] The CJEU, therefore, has brought anti-dilution rights very close to the exploitation rights offered in copyright and patent law.

In L'Oréal/Bellure, however, the Court did not content itself with this remarkable step in respect of Art. 5(2) TMD. It also transformed Art. 5(1)(a) TMD into a powerful instrument for brand image protection. The provision regulates protection in cases of double identity – a sign identical to the protected trademark used for identical goods or services. In this regard, the CJEU held that, besides the essential origin function, a trademark's quality, communication, investment and advertising functions enjoyed *absolute* protection under Art. 5(1)(a) TMD.[50] These functions, however, are typically fulfilled by marks with a reputation. As elaborated above, a strong brand is capable of conveying lifestyle messages that are the result of substantial investment in advertising. Protection of a trademark's communication, investment and advertising functions is thus protection of the investment in the creation of a favourable brand image and the brand communication based on this image.

In line with Recital 11 of the EU Trademark Directive, the CJEU assumes that the protection of these additional trademark functions under Art. 5(1)(a) TMD must be absolute. Indeed, the Recital stipulates that

[49] However, see also the practical considerations by C. Morcom, L'Oréal v Bellure – Who Has Won?, European Intellectual Property Review 2009, 627 (634-635): "The law reports include many cases which demonstrate that whatever the ECJ may rule, it may be dangerous to assume that a mark is so well-known that little evidence is needed in claims invoking art. 5(2) of the Trade Marks Directive and corresponding provisions elsewhere. Perhaps Intel provides an example." Nonetheless, the crucial point here is that the CJEU lowered the conditions for a showing of infringement under Art. 5(2) TMD substantially by providing the coat-tail formula as a vehicle to bypass the higher infringement standard developed in Intel. The practical difficulties with regard to sufficient evidence, therefore, have been reduced significantly.

[50] CJEU, ibid., para. 58. Cf. F. Hacker, Funktionenlehre und Benutzungsbegriff nach "L'Oréal", Markenrecht 2009, 333.

> "[t]he protection afforded by the registered trade mark, the function of which is in particular to guarantee the trade mark as an indication of origin, should be absolute in the case of identity between the mark and the sign and the goods or services."

However, this Recital must be seen in the context of the Directive's particular structure. The drafters intended protection against confusion under Art. 5(1) TMD to be mandatory, whereas protection against dilution under Art. 5(2) TMD remained optional. The statement about absolute protection in double identity cases falling under Art. 5(1)(a) TMD, therefore, only concerns mandatory protection against confusion. Including typical functions of marks with a reputation in this system of absolute protection, the Court trespassed this boundary line drawn in the Directive. As protection of marks with a reputation is optional under Art. 5(2) TMD, the protection of specific functions of these trademarks also remains optional. The protection of the specific functions of marks with a reputation under the mandatory Art. 5(1)(a) TMD encroaches upon the freedom left to EU Member States.

The *contra legem* inclusion of communication, investment and advertising functions in Art. 5(1)(a) TMD is a further step in the transformation of trademark rights into brand exploitation instruments. According to the Court, absolute protection under Art. 5(1)(a) TMD merely requires that one of the protected functions of a trademark is "adversely" affected by the use of an identical sign for identical goods or services.[51] It remains to be seen how the Court further develops this criterion of adverse effect.[52] Considering the continuous relaxation of infringement criteria in the field of Art. 5(2) TMD, it cannot be excluded that the threshold for a showing of adverse effect is fairly low.

An elastic test of adverse effect, however, would be even more problematic than a low threshold for anti-dilution protection under Art. 5(2) TMD. The flexible defence of "due cause" safeguards comparative advertising and parody under Art. 5(2) TMD. A similar balancing tool is sought in vain in Art. 5(1)(a) TMD.[53] Comparative advertising and parody almost inevitably interfere with brand communication, investment and advertising. A biting parody impacts deeply on the way in which consumers perceive the target trademark. It is likely to have a corrosive effect on a favourable trademark image that is the result of substantial investment in advertising and product control.[54] Harm to the investment and

[51] With regard to the requirement of adverse effect, see the explications given in CJEU, 23 March 2010, cases C-236/08-238/08, Google France and Google/Louis Vuitton et al., para. 75-79.

[52] It is doubtful whether the breathing space created in this way is sufficient to satisfy freedom of speech concerns. See A. Ohly, Keyword-Advertising auf dem Weg von Karlsruhe nach Luxemburg, Gewerblicher Rechtsschutz und Urheberrecht 2009, 709 (711-712); A. Kur/L. Bently/A. Ohly, Sweet Smells and a Sour Taste – the ECJ's L'Oréal Decision, Max Planck Institute for Intellectual Property and Competition Law Research Paper Series No. 09-12, online available at http://ssrn.com/abstract=1492032.

[53] See the critique by A. Ohly, Keyword Advertising auf dem Weg zurück von Luxemburg nach Paris, Wien, Karlsruhe und Den Haag, Gewerblicher Rechtsschutz und Urheberrecht 2010, 776 (780 and 782); Hacker, supra note 50, 337. Cf. also Max Planck Institute for Intellectual Property and Competition Law, Study on the Overall Functioning of the European Trade Mark System, Munich: Max Planck Institute 2011, online available at http://ec.europa.eu/internal_market/indprop/tm/index_en.htm, para. 2.260, stating that the present state of law is unsatisfactory because of absolute protection "in the sense that it does not depend on any balancing of interests, apart from a functional analysis."

[54] T-shirts or cartoons parodying the trademarked Mickey Mouse drawing can serve as an example of a parody falling under Art. 5(1)(a) TMD. See the international Madrid registration no. 296478 of Mickey Mouse relating, among various other products, to printed matter (class 16) and clothing (class 25). The particulars of the registration can be consulted online at <<http://www.wipo.int/ipdl/en/madrid/search-struct.jsp>>. In the copyright fair use case Campbell vs. Acuff Rose, the US Supreme Court solved the problem by stating that "when a lethal parody, like a scathing theater review, kills demand for the original, it does not produce a harm

advertising function of a trademark can also flow from comparative advertising that sheds new light on a trademark by informing consumers about better offers in the marketplace. As the product comparison interferes with the trademark communication initiated by the owner, affects prior investment in a favourable trademark image and reduces the trademark's advertising power, it is difficult to see how advertisers could escape a finding of adverse effect under Art. 5(1)(a) TMD. The verdict of infringement seems unavoidable.[55]

In L'Oréal/Bellure, the CJEU solved this dilemma by invoking the rules of the EC Comparative Advertisement Directive.[56] Using the criteria for permissible comparative advertising as an external balancing tool, the Court arrived at the conclusion that a case of infringement would only arise where a trademark was used for the purpose of comparative advertising without all the requirements stated in the Comparative Advertisement Directive being satisfied.[57] To add flexibility to its overbroad system of trademark function protection under Art. 5(1)(a) TMD, the Court, thus, had to resort to the rules on comparative advertising outside the Trademark Directive. Whether the Court will make similar efforts for parodists remains to be seen. In any case, the developments in the area of Art. 5(1)(a) TMD confirm the Court's intention to give brand owners rather general control over any communication involving their marks with a reputation. Besides flexible anti-dilution protection under Art. 5(2) TMD, they can rely on protection under Art. 5(1)(a) TMD that only requires a showing of adverse effect on brand communication, investment and advertising.

4. New Technologies

After this excessive broadening of brand protection, it is an open question how the CJEU will adapt trademark law to new technologies. The Internet, bringing along the challenge of keyword advertising, may have a mitigating effect on the further development of trademark protection in the EU. In particular, it allows the CJEU to reconsider the balance between trademark protection and fundamental freedoms, such as freedom of expression and freedom of competition.[58] It is obvious that the extension of trademark rights in recent years endanger artistic and commercial freedom of expression and information.[59] As explained above, the Court included referential and decorative trademark use in its flexible concept of trademark use. As a result, trademark rights can be asserted against mere references to a protected sign

cognizable under the Copyright Act." See Campbell vs. Acuff-Rose, 510 US 569 (1994), II D. A similar denial of "adverse effect" by the CJEU would be necessary to safeguard parody under Article 5(1)(a) TMD.

[55] The mere presumption of confusion in double identity cases would offer more flexibility. In cases of comparative advertising meeting the requirements stated in the EC Comparative Advertisement Directive, it could be concluded that the presumption has been rebutted.

[56] The Court dealt with the Misleading Advertisement Directive 84/450 of 10 September 1984, as amended by the Comparative Advertisement Directive 97/55 of 6 October 1997. These two Directives are now consolidated in the Misleading and Comparative Advertisement Directive 2006/114/EC of 12 December 2006.

[57] See CJEU, 18 June 2009, case C-487/07, L'Oréal/Bellure, para. 54 and 65.

[58] With regard to the mitigating effect of fundamental rights on intellectual property protection regimes, see C. Geiger, The Constitutional Dimension of Intellectual Property, in: L.C. Torremans (ed.), Intellectual Property and Human Rights, The Hague/London/New York: Kluwer Law International 2008, 101; L.R. Helfer, Toward a Human Rights Framework for Intellectual Property, University of California, Davis Law Review 40 (2007), 971, online available at http://ssrn.com/abstract=891303; T. Mylly, Intellectual Property and Fundamental Rights: Do They Interoperate?, in: N. Bruun (ed.), Intellectual Property Beyond Rights, Helsinki: WSOY 2005, 185; C. Geiger, Fundamental Rights, a Safeguard for the Coherence of Intellectual Property?, International Review of Intellectual Property and Competition Law 35 (2004), 268.

[59] With regard to the digital environment, cf. Dogan/Lemley, supra note 39, 1372-1373. See also R. Tushnet, Gone in Sixty Milliseconds: Trademark Law and Cognitive Science, Texas Law Review 86 (2008), 507, pointing out that even a minimalist anti-dilution statute is likely to impact deeply on freedom of speech.

even though these references are not perceived as an indication of commercial origin by the public. With this approach, references to trademarks in comparative advertising and parody have become actionable under EU trademark law. Given the elastic infringement tests applied by the Court in the context of Arts. 5(2) and 5(1)(a) TMD, they may easily amount to infringement. Under these circumstances, sufficient breathing space for freedom of speech and freedom of competition depends on appropriate defences that are scarce at least in the case of Art. 5(1)(a) TMD.

The Advocates General (AG) in keyword advertising cases openly address this dilemma in opinions concerning trademark use in the digital environment. The need to strike a proper balance between trademark protection and freedom of expression and competition has become a recurring theme. In his opinion in Google France, AG Poiares Maduro underlined the importance of appropriate counterbalances in the light of broad brand protection:

> "Nevertheless, whatever the protection afforded to innovation and investment, it is never absolute. It must always be balanced against other interests, in the same way as trade mark protection itself is balanced against them. I believe that the present cases call for such a balance as regards freedom of expression and freedom of commerce."[60]

Similarly, AG Jääskinen urged the Court in his opinion in L'Oréal/eBay not to forget

> "that the listings uploaded by users to eBay's marketplace are communications protected by the fundamental rights of freedom of expression and information provided by Article 11 of [the] Charter of Fundamental Rights of the EU and Article 10 of the European Convention on Human Rights."[61]

In his further opinion in Interflora/Marks & Spencer, Jääskinen again invites the Court to recalibrate the EU brand protection system in light of the need to reconcile trademark protection with competing fundamental rights. The case concerns an infringement action brought by Interflora on the grounds that Marks & Spencer bought the well-known Interflora trademark and several variants thereof as keywords for the advertising of its competing flower delivery service via the Google AdWords system. Addressing the coat-tail formula developed in L'Oréal/Bellure with regard to Art. 5(2) TMD, Jääskinen wonders why the Court did not make the existence of unfair advantage dependent on the conflicting use being detrimental to the trade mark proprietor. In L'Oréal/Bellure, the CJEU had awarded protection against the taking of unfair advantage even though the trademark owner had failed to demonstrate the existence of any harm, such as an impairment of sales or a loss of reward for the promotion and maintenance of the trademark.[62] With regard to freedom of competition, Jääskinen warns against this background of

> "a move away from a Pareto optimal situation. The situation of the trade mark proprietor would not improve as he by definition would not suffer any detriment because of the use, but the competitor's situation would worsen because he would lose

[60] See AG Poiares Maduro, opinion of 22 September 2009, cases C-236/08-238/08, Google France and Google/Louis Vuitton et al., para. 102.

[61] See AG N. Jääskinen, opinion of 9 December 2010, case C-324/09, L'Oréal/eBay, para. 49. For an overview of decisions concerning keyword advertising by online auction providers, see A.S.Y. Cheung/K.K.H. Pun, Comparative Study on the Liability for Trade Mark Infringement of Online Auction Providers, European Intellectual Property Review 2009, 559.

[62] See CJEU, 18 June 2009, case C-487/07, L'Oréal/Bellure, para. 30 and 43.

> a part of his business. Also the situation of the consumers who had not been misled by the ad but consciously preferred to buy the competitor's products would be impaired."[63]

Seeking to safeguard Marks & Spencer endeavours to present a commercial alternative to Interflora flower delivery services, Jääskinen proposes not to condemn the advertising simply because Marks & Spencer is taking advantage of the repute of Interflora's trade mark, but to focus on the fairness of that use instead. In Jääskinen's view, the purpose of presenting a commercial alternative to the goods or services protected by a mark with a reputation should count as due cause in the context of modern marketing relying on keyword advertising on the internet. Otherwise, keyword advertising using a third party's mark with a reputation would readily amount to prohibited free-riding. Such a conclusion, however, could not be justified in view of the need to promote undistorted competition and the possibilities of consumers to seek information about goods and services.[64]

Although Marks & Spencer neither compares its goods and services with those of Interflora, nor presents its goods as imitations or copies, or even expressly presents them as alternatives, the importance attached to freedom of competition and freedom of information prompts Jääskinen to conclude that the mere choice of Interflora keywords in search engine advertising implies a marketing message that Marks & Spencer offer an alternative service. Given this implied message, the keyword advertising, according to Jääskinen, does not constitute free-riding in the sense of the coat-tail formula developed by the Court in L'Oréal/Bellure.[65] Virtually, the Advocate General, therefore, calls upon the Court to drop the infringement automatism created in L'Oréal/Bellure and apply a strict test of unfairness instead. This proposal could pave the way for a more balanced approach to Art. 5(2) TMD after the continuous relaxation of infringement requirements in recent years.

It remains to be seen whether the Court will follow the lines of argument drawn by Jääskinen in his Interflora/Marks & Spencer opinion. The case is pending. The Court's first decisions in other keyword advertising cases, however, are promising.[66] In Google France and Google, the CJEU held that the search engine offering a keyword advertising service – in this case Google with its AdWords service – did not use affected trademarks in the sense of trademark law. It could not be inferred from the fact of creating the technical conditions necessary for the use of

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[63] See AG N. Jääskinen, opinion of 24 March 2011, case C-323/09, Interflora/Marks & Spencer, para. 94.

[64] See Jääskinen, ibid., para. 99. The need to further develop the condition of unfairness under Art. 5(2) TMD has also been pointed out by Kur, supra note 30, 6 and 10.

[65] See Jääskinen, ibid., para. 104-105.

[66] With regard to the development of jurisprudence concerning keyword advertising in the EU, cf. A. Ohly, supra note 53; M.R.F. Senftleben, Keyword advertising – Geldend Europees recht en daaruit volgende systematiek, Bulletin industriële eigendom 2010, 346; J. Cornthwaite, AdWords or Bad Words? A UK Perspective on Keywords and Trade Mark Infringement, European Intellectual Property Review 2009, 347; R. Knaak, Keyword Advertising – Das aktuelle Key-Thema des Europäischen Markenrechts, Gewerblicher Rechtsschutz und Urheberrecht International 2009, 551; C. Well-Szönyi, Adwords: Die Kontroverse um die Zulässigkeit der Verwendung fremder Marken als Schlüsselwort in der französischen Rechtsprechung, Gewerblicher Rechtsschutz und Urheberrecht International 2009, 557; G. Engels, Keyword Advertising – Zwischen beschreibender, unsichtbarer und missbräuchlicher Verwendung, Markenrecht 2009, 289; M. Schubert/S. Ott, AdWords – Schutz für die Werbefunktion einer Marke?, Markenrecht 2009, 338; O. Sosnitza, Adwords = Metatags? Zur marken- und wettbewerbsrechtlichen Zulässigkeit des Keyword Advertising über Suchmaschinen, Markenrecht 2009, 35; Ch. Gielen, Van adwords en metatags, in: N.A.N.M. van Eijk et al. (eds.), Dommering-bundel, Amsterdam: Cramwinckel 2008, 101; O. van Daalen/A. Groen, Beïnvloeding van zoekresultaten en gesponsorde koppelingen. De juridische kwalificatie van onzichtbaar merkgebruik, BMM Bulletin 2006, 106.

a trademark as a keyword, and receiving a payment for that keyword advertising service, that the search engine itself used the sign.[67] Given the flexible approach to trademark use in recent years, this ruling comes as a welcome surprise.[68] It places keyword advertising services offered by search engines beyond the direct control of trademark owners. Search engines may be held liable, however, for infringing advertising made by the users of the service, if they do not meet the requirements of the exemption for hosting in Art. 14 of the E-Commerce Directive.[69]

The Google France decision is also important with regard to the broad function theory governing Art. 5(1)(a) TMD after L'Oréal/Bellure. Discussing the liability of the advertiser using keyword advertising services, the Court held that using another's trademark as a keyword for one's own advertising did not encroach upon the advertising function of the affected trademark.[70] The CJEU comes to this conclusion by assuming that the website of the trademark owner would feature prominently among the natural search results, and that this prominent position would be sufficient to safeguard the advertising function.[71] This doubtful assumption[72] appears as a strategic argument to bypass the new function theory altogether – at least with regard to the functions of communication, investment and advertising that are typically fulfilled by marks with a reputation.[73] The fact that the Court does not even address the communication and investment function in Google France confirms this impression.

5. Back to Basics?

In an ideal world, these steps taken by the CJEU in Google France would herald a fundamental change in the Court's attitude towards brand image protection. They may be seen as an indication that the Court is determined to bring trademark protection back into shape after the excesses in recent years. With a further sharpening of the conceptual contours of the notion of trademark use,[74] a high threshold for assuming an adverse effect on newly protected trademark functions under Art. 5(1)(a) TMD, and a strict test of unfairness under Art. 5(2) TMD in line with the Interflora opinion of AG Jääskinen, the questionable protection of brand value would become subject to a careful case-by-case analysis again. A protection automatism that brings trademark rights close to exploitation rights could be avoided. Traditional

[67] See CJEU, 23 March 2010, cases C-236/08-238/08, Google France and Google/Louis Vuitton et al., para. 57.
[68] With regard to opposite developments in the US and a critique of these developments, see S.L. Dogan, Beyond Trademark Use, Journal on Telecommunication and High Technology Law 8 (2010), 135. However, see also Dinwoodie/Janis, supra note 30, 1629-1632, warning of an information overload that may result from widespread and unregulated sale of trademark-generated sponsored links.
[69] CJEU, ibid., para. 114. However, see the fundamental critique expressed by G.B. Dinwoodie/M.D. Janis, Lessons From the Trademark Use Debate, Iowa Law Review 92 (2007), 1703 (1717), who point out in the light of developments in the US that "the sale of keyword-triggered advertising and the manner of presentation of search results potentially create independent trademark-related harm, thus making it an appropriate subject of direct liability."
[70] CJEU, ibid., para. 98.
[71] CJEU, ibid., para. 97.
[72] See Ohly, supra note 53, 782, who rightly points out that the assumption becomes questionable in the case of "normal" trademarks not having a particular reputation. Webpages concerning these marks need not necessarily feature prominently among the natural search results. The argument even becomes invalid if the trademark owner does not have webpages.
[73] With regard to the essential origin function that is traditionally protected under Art. 5(1)(a) TMD, the Court did not hesitate to hold keyword advertising liable of having an adverse effect. See CJEU, ibid., para. 90.
[74] For an alternative concept focusing on contextual factors rather than the "wonder drug" of trademark use as a limiting theory, see Dinwoodie/Janis, supra note 30, 1657-1661.

protection against confusion could be brought into focus again. The risk of encroachments upon freedom of expression and freedom of competition could be reduced.

For several reasons, however, this return to trademark protection of less extravagant proportions is not very likely. First of all, it must not be overlooked that the Google France decision need not necessarily be interpreted as a radical departure from the expansionist course adopted by the Court in recent years. Besides the outlined cautious approach to the notion of trademark use and the protection of new trademark functions under Art. 5(1)(a) TMD, the decision also contains elements that point towards a further strengthening of protection. In particular, the CJEU imposed new obligations on advertisers with regard to the prevention of consumer confusion. As to the essential origin function traditionally protected under Art. 5(1)(a) TMD, the Court stated:

> "In the case where the ad, while not suggesting the existence of an economic link, is vague to such an extent on the origin of the goods or services at issue that normally informed and reasonably attentive internet users are unable to determine, on the basis of the advertising link and the commercial message attached thereto, whether the advertiser is a third party vis-à-vis the proprietor of the trade mark or, on the contrary, economically linked to that proprietor, the conclusion must also be that there is an adverse effect on that function of the trade mark."[75]

In the almost simultaneous BergSpechte decision, the Court extended this specific standard to Art. 5(1)(b) TMD.[76] Both the origin function analysis under Art. 5(1)(a) TMD and the likelihood of confusion test under Art. 5(1)(b) TMD, therefore, now include the test whether the advertising is too vague to exclude a potential risk of consumer confusion. This recalibration of protection against confusion is nothing less than a shift from proof of likely confusion by the trademark owner to an obligation on all third parties to secure market transparency when using keyword advertising services.[77] This change seems to corroborate the Court's efforts to overcome the rather defensive nature of traditional trademark rights. Instead of conceiving of trademark rights as instruments that shield trademarks from confusing use by third parties at the initiative of the trademark owner, the Court redefines protection against confusion as a positive obligation of third parties to keep a sufficient distance from the origin information conveyed via the trademark. Google France, therefore, does not necessarily put an end to the continuous broadening of trademark rights in recent years.

[75] See CJEU, 23 March 2010, cases C-236/08-238/08, Google France and Google/Louis Vuitton et al., para. 90.
[76] See CJEU, 25 March 2010, case C-278/08, BergSpechte/Trekking.at, para. 36 and 38-40.
[77] Cf. Ohly, supra note 53, 780; N. van de Laan, Die markenrechtliche Lage des Keyword Advertising, in: J. Taeger (ed.), Digitale Evolution – Herausforderungen für das Informations- und Medienrecht, Oldenburg: Oldenburger Verlag für Wirtschaft, Informatik und Recht 2010, 597 (605), who refer to active information obligations in unfair competition law. The practical consequences of this shift must be clarified in further case law. From the perspective of the trademark owner, the new formula may also be understood differently in the sense indicated in Max Planck Institute, supra note 53, para. 2.171, that "the origin function would be adversely affected (only) in the case where a third party's ad suggests that there is an economic link between that third party and the proprietor of the trade mark." For an overview of recent national case law, see N. van der Laan, The Use of Trade Marks in Keyword Advertising: If Not Confusing, Yet Unfair?, in: N. Lee/G. Westkamp/A. Kur/A. Ohly (eds.), Property and Conduct: Convergences and Developments in Intellectual Property, Unfair Competition and Publicity, Cheltenham: Edward Elgar, forthcoming, chapter 11, section 5.

Moreover, it must not be overlooked that there are strong structural incentives for the Court to apply at least eligibility criteria laxly. In Art. 5 TMD, for instance, a boundary line is drawn between use qualifying as trademark use in the sense of EU trademark law and falling under the harmonized rules set forth in Art. 5(1) to (4) TMD, and protection against use of a sign "other than for the purposes of distinguishing goods or services" that, in accordance with Art. 5(5) TMD, remains unaffected by the Directive. The regulation of "other use" of this latter nature, therefore, is left to the discretion of EU Member States. Apart from the Benelux countries that implemented Art. 5(5) TMD in regional trademark legislation,[78] this means that "other use" is governed by the various protection mechanisms against unfair competition in EU Member States.[79] Whenever the CJEU finds a particular form of trademark use not to constitute relevant trademark use, the Court, thus, foregoes the opportunity of bringing that form of use under the umbrella of harmonized EU trademark law.

The exclusion of referential use from the notion of trademark use would prevent the Court, for instance, from setting an EU-wide standard for the way in which the public may be informed about repair and maintenance services offered with regard to trademarked products.[80] A less flexible concept of trademark use, therefore, would reduce the level of harmonization which the Court can attain on the basis of the Trademark Directive.[81] Against this background, the Court is unlikely to abandon the elastic interpretation of the notion of trademark use developed in past cases.[82] In Google France, the Court may have felt that, nonetheless, it was unnecessary to qualify keyword advertising services offered by search engines as relevant trademark use. At least formally, the resulting harmonization vacuum could be filled by invoking the hosting rules laid down in the E-Commerce Directive instead.[83]

Similar incentive schemes for a generous approach to infringement criteria can be identified in the field of anti-dilution protection under Art. 5(2) TMD. The low threshold established by

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[78] See Art. 2.20(1)(d) of the Benelux Treaty Concerning Intellectual Property. Cf. Cohen Jehoram/van Nispen/Huydecoper, supra note 38, 366-367; Gielen, supra note 38, 256 and 286-287.

[79] With regard to the state of law against unfair competition in the EU and the interplay between harmonized EU law and national regimes, see F. Henning-Bodewig, Die Bekämpfung unlauteren Wettbewerbs in den EU-Mitgliedstaaten: eine Bestandsaufnahme, Gewerblicher Rechtsschutz und Urheberrecht International 2010, 273; F. Henning-Bodewig, Nationale Eigenständigkeit und europäische Vorgaben im Lauterkeitsrecht, Gewerblicher Rechtsschutz und Urheberrecht International 2010, 549; R.M. Hilty/F. Henning-Bodewig (eds.), Lauterkeitsrecht und Acquis Communautaire, Berlin/Heidelberg: Springer 2009; R.M. Hilty/F. Henning Bodewig (eds.), Law Against Unfair Competition – Towards a New Paradigm in Europe?, Berlin/Heidelberg/New York: Springer 2007.

[80] Cf. CJEU, 23 February 1999, case C-63/97, BMW/Deenik, para. 42, which concerned information on a car repair service specializing in BMW cars.

[81] Cf. Kur, supra note 30, 11; P. Dyrberg/M. Skylv, Does Trade Mark Infringement Require the Infringing Use be Trade Mark Use and if so, what is "Trade Mark Use"?, European Intellectual Property Review 2003, 229 (232).

[82] This may change with a change of the status of Art. 5(5) TMD in a mandatory provision of harmonized EU trademark law. In this way, forms of other use could be regulated by the CJEU without having to apply a broad notion of trademark use. See Max Planck Institute, supra note 53, para. 2.221-2.222 and 2.229, with regard to this solution. However, it seems that the adoption of Art. 5(5) TMD as a mandatory provision brings along the further expansion of trademark protection into fields that, so far, may largely remain unaffected, such as the educational, scientific and cultural use.

[83] These rules, however, are approached differently by the courts in EU Member States. As a guideline, the CJEU held that, in order to invoke the safe harbour for hosting, the service provider had to be "neutral, in the sense that its conduct is merely technical, automatic and passive, pointing to a lack of knowledge or control of the data which it stores." See CJEU, 23 March 2010, cases C-236/08-238/08, Google/Louis Vuitton et al., para. 114-119. This will hardly be sufficient to prevent different national standards. Cf. Ohly, supra note 53, 784, Van der Laan, supra note 77, 608-609.

the CJEU with regard to the central eligibility criterion of "having a reputation", for instance, has been criticized above as a missed opportunity to confine problematic protection against dilution to those trademarks that are likely to be blurred, tarnished or unfairly exploited. The low standard of niche reputation developed by the CJEU, however, may be deemed compatible with relevant international norms and soft law recommendations.[84] If Art. 16(3) TRIPS is read to formally recognize the trademark dilution doctrine, the indications given in Art. 16(2) TRIPS and Art. 2(2) of the WIPO Joint Recommendation Concerning Provisions on the Protection of Well-Known Marks suggest a rather low standard, according to which niche knowledge among only one specific target group of the products marketed under the trademark – consumers, distributors or other business circles – is sufficient.[85]

Further incentives for a niche reputation approach can be identified in the EU. In a regional common market with national sub-markets that differ considerably in size, a niche approach offers equal access to anti-dilution protection because it constitutes the smallest common denominator. A standard of nationwide reputation, arguably, would require less effort in small EU Member States. Community-wide reputation, by contrast, may be beyond reach for brands stemming from small countries.[86] Practical considerations of this nature may induce the CJEU to set a low threshold for the required territorial expansion of a mark's reputation even in the case of Community Trade Marks that enjoy protection across the entire EU territory. The Pago decision of the Court points in this direction.[87]

Considering these various incentives, it would be naive to assume that the Court is prepared to limit trademark rights to basic protection against confusion with minor extensions concerning dilution. By contrast, the Court is likely to stick to the expansion of trademark protection at least in respect of the flexible concept of trademark use and the low standard of "having a reputation". The doors to brand protection will thus remain wide open. In the field of infringement criteria, the Court might consider adopting a stricter approach to unfair advantage under Art. 5(2) TMD and continue to apply a cautious approach to the protection of communication, investment and advertising functions under Art. 5(1)(a) TMD. However, a fundamental departure from L'Oréal/Bellure, in the sense of a return to the high dilution threshold established in Intel/CPM and the abandoning of the newly created function theory, cannot necessarily be expected. Trademark rights in the EU, in other words, are not unlikely to remain relatively close to exploitation rights granted in other fields of intellectual property.

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[84] See Senftleben, supra note 4, 50-53.

[85] See WIPO Joint Recommendation Concerning Provisions on the Protection of Well-Known Marks, WIPO publication No. 833, Geneva 2000, online available at <http://www.wipo.int/about-ip/en/development_iplaw/>. Cf. A. Kur, Die WIPO-Vorschläge zum Schutz bekannter und berühmter Marken, Gewerblicher Rechtsschutz und Urheberrecht 1999, 866. For commentary on the TRIPS provisions, see N. Pires de Carvalho, The TRIPS Regime of Trademarks and Designs, Austin/Boston/Chicago/New York: Wolters Kluwer 2011, 343-382; D. Gervais, The TRIPS Agreement: Drafting History and Analysis, 3rd ed., London: Sweet & Maxwell 2008, 274-279; A. Kur, TRIPs and Trademark Law, in: Beier/Schricker (eds.), From GATT to TRIPs – The Agreement on Trade-Related Aspects of Intellectual Property Rights, Weinheim 1996, 93 (107-108).

[86] A requirement of Community-wide reputation could not be established under the Trademark Directive anyway. Art. 5(2) TMD refers to trademarks having "a reputation in the *Member State*" (emphasis added).

[87] See CJEU, 6 October 2009, case C-301/07, Pago/Tirolmilch, para. 29: "As the present case concerns a Community trade mark with a reputation throughout the territory of a Member State, namely Austria, the view may be taken, regard being had to the circumstances of the main proceedings, that the territorial requirement imposed by Article 9(1)(c) of the regulation is satisfied." As to the territorial scope of prohibitions against infringement, see CJEU, 12 April 2011, case C-235/09, DHL/Chronopost, para. 46-50.

6. Need for a New Limitation Infrastructure

Given this low probability for a fundamental departure from the problematic status quo, the time is ripe to devise appropriate limitations on trademark rights instead of waiting for the CJEU to change its expansionist course.[88] On the basis of the foregoing analysis, the need for a new limitation infrastructure in trademark law is evident for at least two reasons. Firstly, the architecture of the Trademark Directive was not designed to counterbalance the current scope of protection. As explained above, the Directive focuses on protection against confusion. Against this background, it is not surprising that the Directive specifically provides breathing space for the use of (trade) names and addresses, descriptive indications and indications of the purpose of products in Art. 6 TMD, whereas it remains silent on other fundamental concerns, such as safeguards for freedom of expression and information. As the extension of the notion of trademark use to referential and decorative use was not necessarily foreseeable, precautions in this regard seemed dispensable. Only the anti-dilution regime in Art. 5(2) TMD was equipped with the flexible defence of "due cause" that can be invoked to satisfy freedom of speech interests. This flexible defence, however, cannot generally be applied to all exclusive rights. It is confined to the regulation of brand protection in Art. 5(2) TMD. The moment the Court incorporates brand protection into other exclusive rights,[89] the system, therefore, inevitably becomes imbalanced. The newly introduced protection of typical brand functions under Art. 5(1)(a) TMD testifies to this weak point in the architecture of the Trademark Directive.

Secondly, it was not foreseeable that the Court would use the Trademark Directive to absorb more and more unfair competition law. With the extension of the notion of trademark use to referential and decorative use, the Court brought forms of use "other than for the purposes of distinguishing goods or services" under the umbrella of harmonized EU trademark protection standards. Considering Art. 5(5) TMD, it becomes clear that these forms of use were not intended to fall under the harmonized rights of trademark owners. By contrast, Art. 5(5) seeks to leave national provisions dealing with "other use" unaffected by the harmonized provisions in Art. 5(1) to (4) TMD.[90] If Member States decide to include forms of other use in their trademark statutes, Art. 5(5) TMD, moreover, ensures appropriate counterbalances by also providing for the flexible defence of "due cause". The CJEU, however, included referential and decorative use in the general notion of trademark use. In consequence, these forms of use become subject to the much less flexible Art. 5(1) TMD that grants exclusive rights without providing for an open defence that can be used to safeguard freedom of speech. As discussed above, particularly Art. 5(1)(a) TMD can easily become too heavy a burden for comparative advertising and parody. In the absence of a due cause defence, the breathing space for (commercial) freedom of expression is insufficient in this area of protection.

[88] For similar conclusions with regard to the situation in the US, see G.B. Dinwoodie, Lewis & Clark Law School Ninth Distinguished IP Lecture: Developing Defenses in Trademark Law, Lewis and Clark Law Review 13/1 (2009), 99 (152): "However, as the scope of trademark protection expands and the metes and bounds of protection become more uncertain, we cannot rely exclusively on creative interpretation of the prima facie cause of action to establish limits. Trademark law must more consciously develop defenses that reflect the competing values at stake in trademark disputes."

[89] For a description and assessment of this development, see Quaedvlieg, supra noot 11.

[90] However, see F. Henning-Bodewig, Nicht markenmäßiger Gebrauch und Art. 5 Abs. 5 Markenrichtlinie, Gewerblicher Rechtsschutz und Urheberrecht International 2008, 301, with regard to the influence of Art. 5(5) TMD itself on national unfair competition law in EU Member States.

In combination with the relaxation of infringement criteria in recent years, the corrosive effect of the outlined shortcomings in the architecture of the Trademark Directive must not be underestimated. Once the door to a scrutiny in the light of trademark rights is opened widely on the basis of a broad concept of trademark use, the continuous relaxation of infringement requirements enhances the risk of a rash finding of infringement. Without appropriate defences, the reaction of EU trademark law to forms of referential and decorative use, for instance for the purposes of comparative advertising and parody, will most probably be too harsh. Therefore, an enhanced limitation infrastructure is needed to re-establish a proper balance between rights and freedoms.

In fact, the process of devising new limitations has already started. In O2/Hutchison, the CJEU itself took first steps to create additional breathing space for comparative advertising:

> "Consequently, in order to reconcile the protection of registered marks and the use of comparative advertising, Article 5(1) and (2) of Directive 89/104 and Article 3a(1) of Directive 84/450 must be interpreted to the effect that the proprietor of a registered trade mark is not entitled to prevent the use, by a third party, of a sign identical with, or similar to, his mark, in a comparative advertisement which satisfies all the conditions, laid down in Article 3a(1) of Directive 84/450, under which comparative advertising is permitted."[91]

As pointed out above, the Court confirmed this new limitation in L'Oréal/Bellure.[92] In this context, the rules of the EC Comparative Advertisement Directive are openly applied as an external balancing tool that is not reflected in harmonized EU trademark law itself.[93] The explicit recognition of this new limitation in EU trademark law would give evidence of the particular importance attached to commercial freedom of speech in the context of trademark protection.[94]

With regard to parody, criticism and comment,[95] comparable external balancing tools are not readily available. The EC Copyright Directive[96] provides for limitations for the purposes of

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[91] See CJEU, 12 June 2008, case C-533/06, O2/Hutchison, para. 45.
[92] See CJEU, 18 June 2009, case C-487/07, L'Oréal/Bellure, para. 54.
[93] In O2/Hutchison, the CJEU could establish a link between the prohibition of confusion in Art. 3a(1)(d) of the Comparative Advertisement Directive and the likelihood of confusion test in Art. 5(1)(b) TMD. See CJEU, 12 June 2008, case C-533/06, O2/Hutchison, para. 69 and operative part. The balancing via external norms was less obvious under these circumstances.
[94] Cf. Max Planck Institute, supra note 53, para. 2.260-2.262, proposing the inclusion of an explicit limitation regarding honest referential use that, besides comparative advertising, would cover use for purposes of indicating replacement or service, use for purposes of commentary and criticism, and parody.
[95] For case law reflecting the need for appropriate balancing tools, see the aforementioned cases of the German Federal Court of Justice, 3 February 2005, case I ZR 159/02, "Lila Postkarte", Gewerblicher Rechtsschutz und Urheberrecht 2005, 583, and 11 March 2008, case VI ZR 7/07, "Gen-Milch", Neue Juristische Wochenschrift 2008, 2110, both online available at www.bundesgerichtshof.de. See also District Court of Amsterdam, 22 December 2006, case KG ZA 06-2120, "Denk vooruit", Intellectuele eigendom en reclamerecht 2007, 139; Paris Court of Appeals, 14th chamber, Sec. A, 26 February 2003, Greenpeace France/Esso and SPCEA/Greenpeace et al., International Review of Intellectual Property and Competition Law 35 (2004), 342; Constitutional Court of South Africa, 27 May 2005, Laugh it Off Promotions CC vs. South African Breweries Int. (Finance) B.V. t/a Sabmark Int., case CCT 42/04, International Review of Intellectual Property and Competition Law 36 (2005), 868. Cf. Z.M. Navsa, Trademark Dilution – No Luaghing Matter, European Intellectual Property Review 2009, 455; C. Geiger, "Constitutionalising" Intellectual Property Law? The Influence of Fundamental Rights on Intellectual Property in the European Union, International Review of Intellectual Property and Competition Law 37 (2006), 371 (395-397).

criticism and review, and caricature, parody and pastiche.[97] However, in spite of the growing overlap between the two fields of intellectual property,[98] copyright and trademark law are not intertwined to such an extent that copyright limitations could generally be applied analogously in trademark law.[99] Instead, the CJEU would have to directly invoke the fundamental guarantee of freedom of expression in Art. 11 of the EU Charter of Fundamental Rights and Art. 10 of the European Convention on Human Rights.[100] Therefore, the need to enshrine appropriate defences for parody, criticism and comment in EU trademark law can be deemed even more pressing than in the case of comparative advertising where the specific rules laid down in the Comparative Advertisement Directive are readily available.

Inspiration for this internalization of safeguards for freedom of expression can be found, for instance, in the US trademark system. After the US Supreme Court had required "a showing of actual dilution, rather than a likelihood of dilution" in Moseley vs. V Secret Catalogue,[101] the 2006 Trademark Dilution Revision Act amended the anti-dilution provisions in the US Lanham Act. The threshold for giving proof of dilution was lowered in this context.[102] Accordingly, the question of appropriate counterbalances arose and led to the introduction of a statutory, open-ended fair use provision that explicitly offers breathing space for parody,

[96] Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001, on the harmonisation of certain aspects of copyright and related rights in the information society (OJ 2001 L 167, 10).

[97] See Art. 5(3)(d) and (k) of the Copyright Directive.

[98] With regard to cumulative copyright and trademark protection, see S. Carre, Marques et droit d'auteur: Métaphore d'une belle rencontre, in: Geiger/Schmidt-Szalewski, supra note 17, 25; M.R.F. Senftleben, Der kulturelle Imperativ des Urheberrechts, in: M. Weller/N.B. Kemle/Th. Dreier (eds.), Kunst im Markt – Kunst im Recht, Baden-Baden: Nomos 2010; V. Vanovermeire, Inschrijving als merk van een in het openbaar domein gevallen werk, in: A. Cruquenaire/S. Dusollier (eds.), Le cumul des droits intellectuels, Brussels: Larcier 2009, 177; A. Ohly, Areas of Overlap Between Trade Mark Rights, Copyright and Design Rights in German Law, Gewerblicher Rechtsschutz und Urheberrecht International 2007, 704; D.W.F. Verkade, The Cumulative Effect of Copyright Law and Trademark Law: Which Takes Precedence?, in: J.J.C. Kabel/G.J.H.M. Mom (eds.), Intellectual Property and Information Law – Essays in Honour of Herman Cohen Jehoram, Den Haag/London/Boston: Kluwer 1998, 69; J.H. Spoor, De gestage groei van merk, werk en uitvinding, Zwolle: Tjeenk Willink 1990.

[99] This may be advisable, however, in cases where both rights apply cumulatively. Cf. M.R.F. Senftleben, De samenloop van auteurs- en merkenrecht – een internationaal perspectief, Tijdschrift voor auteurs-, media- en informatierecht 2007, 67; P.B. Hugenholtz, Over cumulatie gesproken, Bijblad bij de industriële eigendom 2000, 240.

[100] With regard to the impact of the fundamental guarantee of freedom of expression on trademark protection, see the in-depth analysis conducted by Sakulin, supra note 20, and C. Geiger, Marques et droits fondamentaux, in: Geiger/Schmidt-Szalewski, supra note 17, 163; L. Timbers/J. Huston, The "Artistic Relevance Test" Just Became Relevant: the Increasing Strength of the First Amendment as a Defense to Trademark Infringement and Dilution, Trade Mark Reporter 93 (2003), 1278; R. Cooper Dreyfuss, Reconciling Trademark Rights and Expressive Values: How to Stop Worrying and Learn to Love Ambiguity, in: G.B. Dinwoodie/M.D. Janis (eds.), Trademark Law and Theory: a Handbook of Contemporary Research, Cheltenham: Edward Elgar Publishing 2008, 261.

[101] See Supreme Court of the United States of America, March 4, 2003, Moseley vs. V Secret Catalogue, Inc., 537 U.S. 418 (2003). Cf. Moskin, Victoria's Big Secret: Wither Dilution Under the Federal Dilution Act, Trademark Reporter 93 (2004), 842-859.

[102] See Trademark Dilution Revision Act of 2006 (H.R. 683) amending the US Trademark Act of 1946 (15 U.S.C. 1125). With regard to the required proof of dilution, this new legislation clarifies that protection against dilution is to be granted "regardless of the presence or absence of actual or likely confusion, of competition, or of actual economic injury". Cf. Beebe, supra note 25, 1143; C. Chicoine/J. Visintine, The Role of State Trademark Dilution Statutes in Light of the Trademark Dilution Revision Act 2006, The Trademark Reporter 96 (2006), 1155.

criticism and comment. To safeguard the freedom of the press, the provision also limits trademark rights with regard to news reporting and news commentary.[103]

When comparable limitations are included in EU trademark law, these new limitations should be brought in line with existing limitations in the EC Copyright Directive that serve the same purposes.[104] In this way, a consistent system of corresponding limitations can be created that prevents the erosion of the freedom offered in copyright law in cases of overlap with trademark protection.[105]

Finally, it is remarkable that, besides the aforementioned specific limitations, the US provision generally exempts "[a]ny fair use, including nominative or descriptive fair use, or facilitation of such use".[106] This safety net of an open-ended limitation recalls the general defence of "due cause" in Art. 5(2) TMD. The US example shows that, irrespective of the introduction of several specific limitations, it is advisable to also provide for a general safeguard clause that can be invoked in the case of new, unforeseen developments that require additional balancing tools.[107] With a general limitation of this type, courts are rendered capable of reacting adequately to new technologies. The problems raised by keyword advertising can serve as an example in this regard. As trademark rights become broader, they also become more likely to absorb forms of use that serve important competing interests and should remain free for this reason. In this situation, the safety net of a flexible defence enables the courts to maintain a proper balance between rights and freedoms.[108]

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[103] Section 43(c)(3) of the US Lanham Act, as amended, reads as follows:
'(3) EXCLUSIONS – The following shall not be actionable as dilution by blurring or dilution by tarnishment under this subsection:

> (A) Any fair use, including a nominative or descriptive fair use, or facilitation of such fair use, of a famous mark by another person other than as a designation of source for the person's own goods or services, including use in connection with –
>
> > (i) advertising or promotion that permits consumers to compare goods or services; or
> >
> > (ii) identifying and parodying, criticizing, or commenting upon the famous mark owner or the goods or services of the famous mark owner.
>
> (B) All forms of news reporting and news commentary.
>
> (C) Any noncommercial use of a mark.'

For a description of the situation under the former US Federal Trademark Dilution Act, see M.K. Cantwell, Confusion, Dilution and Speech: First Amendment Limitations on the Trademark Estate: An Update, The Trademark Reporter 94 (2004), 549. With regard to common law fair use defences in the US, see J. Moskin, Frankenlaw: The Supreme Court's Fair and Balanced Look at Fair Use, Trademark Reporter 95 (2005), 848.

[104] See the aforementioned Art. 5(3)(d) and (k) of the Copyright Directive 2001/29/EC. With regard to use privileges for the press, see Art. 5(3)(c) of the Copyright Directive covering the reporting of current events.

[105] Cf. M.R.F. Senftleben, Overprotection and Protection Overlaps in Intellectual Property Law: The Need for Horizontal Fair Use Defences, in: A. Kur/V. Mizaras (eds.), The Structure of Intellectual Property Law: Can One Size Fit All?, Cheltenham: Edward Elgar Publishing 2011, available online at http://ssrn.com/abstract=1597123. With regard to proposals concerning the convergence of infringement criteria, see F.W. Grosheide, Zwakke werken – Een pleidooi voor een merkenrechtelijke benadering van de inbreukvraag in het auteursrecht, in: D.W.F. Verkade/D.J.G. Visser (eds.), Intellectuele eigenaardigheden: Opstellen aangeboden aan mr Theo R. Bremer, Deventer: Kluwer 1998, 121.

[106] For the text of the provision, see supra note 103.

[107] See Max Planck Institute, supra note 53, para. 2.266, also proposing a general fair use clause to allow for flexibility in situations not previously envisaged by the legislator, particularly with regard to new business models emerging in the digital environment.

[108] For a more detailed discussion of this point, see Senftleben, supra note 105, 170-179.

A need for additional flexibility may arise, for instance, with regard to research and teaching, and the use of trademarks for cultural purposes. Admittedly, activities in these fields do not necessarily occur "in the context of commercial activity with a view to economic advantage and not as a private matter."[109] Accordingly, they may be unlikely to constitute "use in the course of trade" in the sense of EU trademark law and would remain outside the reach of trademark rights from the outset.[110] With increasing partnerships between private companies and educational, scientific and cultural institutions, however, the absence of use in trade may become less evident, while the socially valuable objectives of sponsored activities still justify an exemption from the control exerted by trademark owners. In the case of cultural activities, it can be added that freedom of art may be understood to cover accompanying promotion and marketing activities.[111] From this perspective, it would also make sense not to rely exclusively on an exemption based on the condition of use in the course of trade.

A final lesson can be learned from the limited scope of the due cause defence in the current Trademark Directive. As indicated above, this open defence only applies to brand protection under Art. 5(2) TMD and the extension of trademark protection to use "other than for the purposes of distinguishing goods or services" under Art. 5(5) TMD. As the CJEU decided to offer brand protection and protection against other use also under Art. 5(1)(a) TMD, this limited scope of the defence led to imbalanced protection. Against this background, it is advisable to generalize this safety net and render the due cause defence applicable across all exclusive rights granted in EU trademark law. To avoid the creation of similar gaps in the future, the proposed specific limitations for the purposes of comparative advertising, criticism and review, caricature,[112] parody and pastiche, and the reporting of current events should also be implemented as defences that can be applied to all exclusive rights. In other words, these specific limitations and the open due cause defence should be added to the catalogue of limitations in Art. 6 TMD.

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[109] For this definition of "use in the course of trade", see CJEU, 23 March 2010, cases C-236/08-238/08, Google/Louis Vuitton et al., para. 50; CJEU, 12 November 2002, case C-206/01, Arsenal/Reed, para. 40.

[110] However, see the analysis conducted by the Max Planck Institute, supra note 53, para. 2.66, according to which "it appears that "in the course of trade" must be distinguished primarily from private use." Cf. also para. 2.160-2.162 of the analysis. Educational, scientific and cultural use does not constitute private use in a strict sense. Hence, it may qualify as use in the course of trade in certain cases and become subject to the exclusive rights of trademark owners.

[111] For an approach to the fundamental freedom of art covering both creation ("Werkbereich") and dissemination ("Wirkbereich"), see German Federal Constitutional Court, 3 November 1987, case 1 BvR 1257/84, "Herrnburger Bericht", published in the official collection BVerfGE 77 (1987), 240, where the Court held that the freedom of art covered advertising for a work of art. If the trademark of a third party is used for the purpose of advertising an art work, this freedom of art, necessarily, must be reconciled with the fundamental guarantee of property, including intellectual property. Cf. H.D. Jarass/B. Pieroth, Grundgesetz für die Bundesrepublik Deutschland – Kommentar, 11th ed., Munich: C.H. Beck 2010, 207-212. A new trademark limitation regulating this field could provide guidance for an appropriate balancing of interests in this context. As to the status of intellectual property within the EU system of human rights, see the critical comments by C. Geiger, Intellectual Property Shall be Protected!? – Article 17(2) of the Charter of Fundamental Rights of the European Union: A Mysterious Provision with an Unclear Scope, European Intellectual Property Review 2009, 113.

[112] The reference to caricature stems from Art. 5(3)(k) of the EC Copyright Directive and is proposed here, as pointed out above, also in the context of trademark law to harmonize the limitation infrastructure in the two – often overlapping – fields of intellectual property law. While the category of caricature may perhaps be deemed less relevant in a trademark context, it may still become important with regard to portrait trademarks. For a discussion of developments in this area, see C. Gielen, Portretmerk: een non-merk?, in: D.J.G. Visser (ed.), Commercieel portretrecht, 113.

7. Conclusion

In recent years, the CJEU has broadened the scope and reach of EU trademark protection constantly, in particular in the area of brand protection. Developing a flexible concept of trademark use that encompasses referential and decorative use, the Court opened the doors to trademark protection widely. With the adoption of a remarkably low threshold for a showing of reputation, these doors are kept wide open also with regard to enhanced protection against dilution. In addition, the Court found mere attempts to ride on the coat-tails of a mark with a reputation to amount to trademark infringement under Art. 5(2) TMD. Use having an adverse effect on typical functions of marks with a reputation – communication, investment and advertising functions – became actionable under Art. 5(1)(a) TMD.

This systematic relaxation of eligibility and infringement criteria can hardly be justified. The rationales underlying the protection of brand investment and brand communication are rather weak. In particular, the incentive and reward rationales that serve as a basis for exploitation rights in other fields of intellectual property are inapplicable in this context. Unlike inventors and authors, the brand owner cannot validly claim to have created intellectual property that furthers science or art. The trademark does not fall into the public domain after a limited period of time to enrich mankind's universal treasury of intellectual creations. Against this background, it remains unclear why the CJEU paved the way for more generous brand protection that becomes more readily available. With these steps, the Court approximated trademark rights to exploitation rights without a sound policy justification.

With the challenges arising in the digital environment, the imbalances caused by this jurisprudence clearly come to the fore. As the limitations recognized within the EU trademark system are incapable of coping with the excessive protection following from the extensions in recent years, the CJEU had to invoke the rules of the Comparative Advertisement Directive as an external balancing tool to create breathing space for comparative advertising. This external balancing mechanism is of crucial importance for competitors seeking to inform consumers about alternative offers via keyword advertising. It remains to be seen whether the Court will also find appropriate external balancing mechanisms with regard to parody, criticism and comment. Otherwise, an encroachment upon freedom of expression and information seems inevitable.

While the questions raised by keyword advertising may lead to the development of a more nuanced coat-tail formula in the context of Art. 5(2) TMD, and a cautious approach to the function theory governing Art. 5(1)(a) TMD, a fundamental departure from L'Oréal/Bellure, in the sense of a return to a high threshold for anti-dilution protection, cannot necessarily be expected. By contrast, trademark rights in the EU are not unlikely to remain relatively close to exploitation rights granted in other fields of intellectual property. Furthermore, the CJEU is unlikely to change its expansionist course in the area of eligibility criteria. A broad concept of trademark use allows the Court to bring more and more non-harmonized unfair competition law under the umbrella of harmonized EU trademark law. The lax reputation test in the field of anti-dilution protection may be deemed inevitable to offer equal access to anti-dilution protection in a regional common market with national sub-markets that differ considerably in size. The doors to generous brand protection will thus remain wide open.

For this reason, the time is ripe to devise an appropriate limitation infrastructure that is capable of counterbalancing the broad grant of protection. The limitation for comparative advertising that the Court deduced from the Comparative Advertisement Directive should be reflected in EU trademark law. Additional limitations are indispensable with regard to criticism and review, and caricature, parody and pastiche. To secure the freedom of the press, they should be accompanied by safeguards for the reporting of current events. Measures could also be taken with regard to the use of trademarks for research, teaching and cultural purposes. In any case, the updated limitation infrastructure should provide for a general due cause defence that can be used in unforeseen circumstances requiring the further limitation of trademark rights. As the CJEU tends to trespass the boundary lines between protection against confusion in Art. 5(1) TMD and protection against dilution in Art. 5(2) TMD, the new limitations and the general due cause defence should be applicable across all exclusive rights of trademark owners. They should be added to the list in Art. 6 TMD.

Patent Quality from a European Patent Office perspective: what is it? how do we recognize it? how do we control it?

keywords: patents, European Patent Office, EPO, quality, operational quality control, timeliness, legal certainty, patent value

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Abstract

The quality of intangible assets, in this case patents, is not a straightforward notion, unlike for tangible industrial products. Any attempt to define it by means of a more or less dogmatic definition will necessarily be difficult. However, you can recognize quality (or its absence) when you see it. So it is better to ask ourselves, either from the point of view of the EPO, or from the point of view of the users of the patent system: What are the elements of high quality? Which are those features that, when present, make somebody say "that is in fact a high quality patent!" or "the EPO should do better than that"? It appears better to resort to a so-called functional definition, and by doing so we hit two birds with one stone. On the one hand, we identify those features that impinge on quality and we realize how they relate to it. On the other hand, improving each of these features individually, we are certain to improve overall quality. Which feature to improve may be a question of policy and/or availability of resources. But it is nevertheless a great advantage to be able to adjust the various parameters that impinge on quality individually, and one at a time.

One tends to perceive quality as a factor which increases value for the stakeholders of the system. However, things get more complicated if one examines the different perceptions of patent value as seen by applicants, patent rights holders, opponents, and the public at large. Of course, these groups are not always different people. Rather, they are discrete roles taken by the same entities according to circumstances. For instance, it is normal that any company will appear before the EPO n any of these roles. The same company that will try to get the broadest possible claims granted (a patent of high value for them), will challenge the patent office for granting their competitors too broad claims (a bad quality patent!). The same holds for negative decisions, e.g. refusals. A company that files an

appeal against a refusal of their patent application, will probably say that the decision to refuse was unjustified, too strict or taken with hindsight, some or even all of these being, at least to the appellant's mind, indicators of low quality. However, the refusal will probably be of high value to the competitors. So patents are a case where what is "high value" for one entity can be "low quality" for another entity and vice versa. And, interestingly enough, what is "high value" for an entity under certain circumstances, can be "low quality" for the same entity under different circumstances. This dichotomy of value and quality gives an indication of the delicate task of the patent offices, and the careful balance they have to achieve when granting "high quality patents". The way an individual user understands value is, of course, important to the EPO. However, quality for the EPO has to be understood with regard to all users of the system and has to be somehow absolute. This gives to the EPO also the right to apply a notion of quality, in its everyday practice, that gives priority to the value created for the entirety of the users of the system, rather than to the value created for individual entities.

After exploring, to some extent beyond the obvious, the facets of quality touched on above, this paper presents a practical model of a quality system in the patent examining process, exemplified by the quality mechanism in the EPO.

1 Some fundamental terms and notions

This paper deals with patent quality, and what contributes to it, mainly in the perception of the EPO, but also taking into consideration the perception of the stakeholders of the patent system. Its purpose is dual: on the one hand, to identify and present those elements and factors that enable EPO to maintain and improve the quality of its products. On the other hand, to stir a discussion in interested circles as to how to improve whatever is eventually accepted to be understood under the term "quality".

The author draws inspiration not only from insights and experiences of day-to-day business within the EPO, but also from various publications that deal with patent quality[1]. References to various publications are made throughout the text, and the author is thankful to all those who invested time and effort in presenting their conclusions about quality, thus being a source of information and insight. The paper is not based on any survey or questionnaire of the stakeholders. Such work has been already done elsewhere and the results are quite revealing, and have been taken into consideration. Day-to-day involvement with the patenting business within the EPO, as well as insight and experience, have been the major sources of inspiration.

The paper doesn't deal with the drafting quality of patent applications, neither does it deal with quality metrics based on statistical data usually employed to judge patent quality, e.g. citations of the assessed patent in other patent documents, citations of other patents within

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[1] e.g. Bruno van Pottelsberghe de la Potteire, The quality factor in patent systems, http://www.epip.eu/conferences/epip05/papers/van%20Pottelsberghe.pdf, A Quality Index for Patent Systems, http://is.jrc.ec.europa.eu/pages/ISG/patents/documents/BrunovanPottelsbergheSevilla_ipts_Qualityindexforpatnsystems_June_2011.pdf

the assessed patent itself, number of claims etc[2]. Such metrics are relevant for assessing a patent from the viewpoint of its use, not the viewpoint of the granting authority.

Furthermore, for the authority granting the patent or refusing the patent application, a more global view is necessary. Even if the percentage of negative first instance decisions is low (e.g. refusals amount to only a small percentage of the patent examination outcomes, for instance 4.9% refusals according to EPO statistical data for 2010), it is helpful to understand patent quality as "the quality of granted patents, decisions to refuse patent applications, and decisions in the course of opposition proceedings". So "quality" in this paper encompasses all these aspects that relate to first instance proceedings. Furthermore, at this point it is helpful for the reader to rely just on his/her intuitive view of what is quality. Reading through this paper, the reader will eventually reach a more informed quality perception. The quality of other services offered by patent offices, which can also be a matter of discussion, is dealt with only to the extent it impinges directly on patent quality.

The term "stakeholders of the patent system" does not mean only the holders of the patent rights. It means all those (persons or entities) affected by the patent rights, as well as all those making use of patents rights for commercial purposes. This term encompasses more than one might initially think, because every granted patent means that the commercial exploitation of the patented matter becomes inaccessible to all but the holder of the rights.

For the purpose of this paper, it is not practical to try to define quality in terms of a rigid definition. One could possibly say that high quality is if the EPO simply complies with the legal standards and requirements of the European Patent Convention. However, it is exactly the nature of this essential task of the EPO that makes a rigid definition difficult, if not impossible. Instead, it is more useful to describe quality, in terms of its constituents (what constitutes high quality, what constitutes low quality). It is also useful to make a fundamental distinction between high patent quality (in terms of the service the EPO aspires to offer to the stakeholders of the patent system) on the one hand, and high patent value on the other. Patent value is the value a patent has for the holder of the rights, and such a value can be high or low, independent of the patent quality. Value can also vary with time and/or circumstances, whereas quality, in the sense the term is used here, is somehow invariant.

The notion of quality as advocated in this paper, and as also used within the EPO, is subject to two important requirements: it has to be controllable within the EPO, and it has to be "fit for purpose", i.e. whatever is meant under "quality", has to serve the overarching EPO task of supporting economic growth. This is also the final benchmark for whatever EPO understands under patent quality: it has to be workable, purposeful, functioning and useful for the economy.

2 The various aspects of patent quality found in literature or seen in day-to-day practice in the EPO

[2] see, for instance, http://www.vwl.uni-mannheim.de/stahl/!/van/ws05_06/Literature/restricted/LS_patqrp.pdf

Reading about patent quality in literature, but also dealing with the day-to-day EPO work, one can find various references to different kinds of quality, all using the same word. A careful reading will reveal the understanding of the term meant by the different authors. A brief listing of those perceptions follows, but is not meant to be exhaustive. What is important for any patent office, is whether the aspect is under control within the office, and whether it contributes to an understanding of quality which is fit for purpose.

2.1 Patent quality vs patent value

Instead of seeing applicants only as approaching the EPO and applying for a patent, one could (and in my view should) see the users of the patent system approaching the EPO in various roles: the same company will file an application for a patent (applicant), will oppose the patent granted to its competitor (opponent), will appeal a negative decision (an appellant, be it in examination or opposition), or will defend its patent against one or more opponents (rights holder as respondent). In exercising these roles, a company will defend its commercial interests by either trying to get their patent application through, by maintaining their patent, or by trying to destroy their competitors patent. The driving force is the commercial impact of patent rights, their own or those of their competitors. They will allege legal validity of their own patent and invalidity of their competitor's patent. A high quality patent (i.e. a patent able to survive legal challenge) can be either an advantage to them (if it is their own patent) or a detriment to them (if it belongs to their competitors). This exemplifies two aspects: an important criterion of quality (high legal validity), and the dichotomy between patent quality and the effect resulting from the patent rights, which is not always positive.

2.2 Patent quality and the "garbage in, garbage out" principle

Literature about patent quality, usually found in texts written by patent attorneys, stresses the importance of a professionally drafted patent application. Certain references in literature speak about a counterincentive, on the side of the applicants and their attorneys, to draft a high quality patent application, e.g. an absolutely clear, inclusive and enlightening description of the invention, and an even stronger counterincentive to draft absolutely clear claims[3]. However, the quality (in terms of clear and understandable definition of the invention) of the ensuing patent is definitely correlated to the quality of the overall patent application as filed. In other words, no patent examination process can transform a poorly drafted patent application into a patent of high quality. Experience from examining applications within EPO confirms that conclusion.

2.3 Patent quality and the amount of innovation

Publications about patents usually refer to the detrimental effect of trivial patents for the economy, and stress the importance of a proper threshold for innovative potential (inventive step) for patents to develop their positive effects. One might therefore understand that "patents of low quality" means, among others, "trivial patents". There is certainly some truth in that, and the issue whether trivial patents harm economy has been

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[3] see, for instance, http://www.ftc.gov/bc/workshops/ipmarketplace/apr17/docs/rwagner2.pdf

widely investigated[4]. Nevertheless, as innovation takes place before the drafting of the patent application, EPO has limited influence also on this aspect, although it is able to set the threshold for granting.

2.4 Patent quality and the legal standards of clarity, novelty and inventive step

Applying the legal standards of clarity, novelty and inventive step properly, and exercising the examiner discretion in the proper way, is absolutely under EPO control. Evidently, any issued patent with clarity defects and/or with insufficient inventive activity when compared with prior art, is perceived as a low quality patent, essentially a patent that should not have been granted.

2.5 Patent quality and the timeliness aspect

Various surveys show that applicants are very interested in a fast search report, in order to take commercial decisions, but are not always interested in a fast conclusion of the procedure, especially if the outcome threatens to be a refusal. But also in case of a grant, the financial burden of validation in the designated states (translations, fees etc) may be an incentive to prolong the proceedings. However, the EPO has to act in the interest of legal certainty, because not only the applicant, but the stakeholders as a whole (competitors, the public) have to know the outcome in time, in order to arrange their affairs. Unnecessary prolonging of the proceedings also prolongs the uncertainly as to he outcome. Timeliness is therefore a quality aspect that EPO can influence, and a basic constituent of patent quality.

2.6 Patent quality and the "legal validity vs cost" trade-off

A patent that collapses under legal challenge, for whatever reason, is perceived as a patent of low quality. Such legal challenge can take place within the EPO (opposition, appeal), or in national validity proceedings. Timely granting of legally valid patents is the essential task of EPO. It is under EPO control and a major EPO criterion of quality. It necessitates a complete and up-to-date documentation of the prior art, efficient search tools, skilful and competent examiners etc. However, pursuing legal validity cannot be unrelated to the cost. The EPO has to make a proper balance between those two factors. It is not the task of the EPO to allocate unrestricted resources to any single patent application, because the EPO has an obligation to apportion its resources to all applicants in an equitable way.

2.7 Patent quality and the legal aspect of "due process"

Due process means, broadly speaking, that when a person is faced with an adverse decision, e.g. deprivation of some right, this person is entitled to be notified in time, entitled to the right to be heard, and entitled to an impartial judge. Due process is a legal principle enshrined mainly in US law. However, the right to notice in due time, the right to

[4] for instance in the report by the Federal Trade Commission "To promote innovation: the proper balance of competition and patent Law and Policy", October 2003, http://www.ftc.gov/os/2003/10/innovationrpt.pdf

be heard, and the right to an impartial decision, are enshrined, explicitly or implicitly, in the European Patent Convention. Thus, in case a patent application is refused (after an interactive, sometimes lengthy examination procedure), meaning that the applicant is faced with an adverse decision, the refusal has to be substantiated to such a degree, that it enables a reasoned appeal to be filed. This is consistent with due process and definitely constitutes an element of quality in the patent system. All this of course under the condition of a well-defined and effective legal framework, put to practice with clear and consistent working instructions.

2.8 Patent quality and the openness and transparency aspects

Making all communications and information exchanged between the applicant (or the appellant or the opponent) and the patent office public, is also an element of quality. The public is informed about the state of affairs without delay, such that anyone can intervene, for instance by filing submissions during proceedings. Even if such submissions do not make the sender a party to the proceedings, they are being taken into consideration and may influence the proceedings, hence quality is improved.

2.9 Patent quality and "non-patentable subject-matter"

Should something be patented which, according to the legal provisions, is "non-patentable subject-matter", then this would certainly be an indication of low quality (although it might be of high value to the right holder, at least as long as it does not face validity litigation or it survives such challenge!). Especially in the European Patent Convention there are explicit provisions for subject-matter which is not being regarded as invention (Article 52 EPC).

2.10 Patent quality and the skills and competences of the workforce

If workforce means the engineers and scientists working on the matter to be applied for, then this kind of quality finds its way into the patent application. If workforce means the patent examiners, their search, examination and opposition work and the decisions they take, which are expected to be well founded, consistent and predictable, then their competences and skills contribute to the quality of the patent. Evidently, only the latter aspect of quality is in the hands of the EPO.

2.11 Patent quality and the user satisfaction surveys

EPO conducts systematically user satisfaction surveys[5], in order to assess whether EPO products are fit for purpose. However, it has to be stressed that the conventional wisdom "Quality is whatever the customer wants" does not apply for the EPO. On the one hand, EPO stakeholders have multiple roles, and looking at any individual user of the system as a customer would obscure the EPO's commitment to the entirety of users of the system. On the other hand, EPO's mission has to be seen under the aspect of implementing the European Patent Convention, and in this respect EPO will not necessarily do whatever the

[5] There have been 5 user satisfaction surveys conducted since 1997, the last one in 2010-2011

"customer" wants. This does not prevent EPO from having a service-oriented attitude. Having said that, the EPO pays extreme attention to user feedback, and certainly tries to accommodate the legitimate needs of the users of the system.

2.12 Patent quality and the use and valuation of patents as an asset

Valuation of patents has been a issue in itself and has been quite topical in the last years. Patents have to appear as assets with a defined value in the balance sheets of companies owning the rights, and this applies to all fields of technology that can be possibly patented. Furthermore, there have been companies dealing almost exclusively with patent rights, in which case the valuation of patents is an essential element of the very business of the company[6]. Methods to valuate patents range from straightforward calculation of the amount invested in reaching the granted patent, to complicated mathematical models involving predictions of future cash flow. At least in the latter case, one could refer to the quality of the patent in terms of potential to create income, for instance from royalties. It is easily seen that this kind of quality is irrelevant for the EPO's work.

2.13 Patent quality and the enforcement aspect

A question arises whether a patent possesses any kind of value in case it cannot be legally enforced. It can be perfectly valid from a legal point of view, it can be timely available to the patentee, but if there is either no competent court available to hear the case, or no effective enforcement mechanism to ensure that the court's decision is carried out, then it cannot develop its legal effect. In that (hypothetical) case the patent would be without a practical value for the holder of the rights, in fact an example of the dichotomy between patent quality and patent value. The issue is certainly outside the reach of the EPO.

2.14 Patent quality and making the court's life easy

Evidently, a patent with clear and unambiguous claims will make the court's work easier than a patent with clarity defects. The court will acknowledge the legal certainty and will recognize the patent in the first case as one of high quality.

2.15 Patent quality and the ISO9001 quality standards

ISO9001 certification purports to apply an eternal loop of the "plan - do - check - act" cycle on documented internal processes, such that by adhering to the processes and improving them, a certain level of quality is maintained. EPO is currently in the process of being certified.

2.16 Patent quality and the principle "you get what you pay for"

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[6] see, for instance, http://www.oceantomo.com/system/files/What_is_Patent_Quality_lesNouvelles_6.08.pdf

EPO operating principles and fee policy does not allow for applicants to buy better quality for one patent and lower quality for another. Even if one could think that hiring a better and more expensive patent attorney would eventually lead to a patent that could not be possible with less money, this aspect is neither corroborated by evidence nor supported by the day-to-day practice of EPO. Examiners in the EPO are helpful in finding patentable subject matter in applications, in cooperation with patent attorneys. But their commitment is to the entirety of the stakeholders, not to individual applicants.

3 The EPO perception of what is patent quality

Taking into consideration the different perceptions presented above, and the criteria mentioned, it is understood that EPO has control over the following elements, which at the same time are understood as meaning high quality: a well-defined and effective legal framework, clear and consistent working instructions, legal validity leading to legal certainty, timeliness also contributing to legal certainty, reasonable cost, predictable and stable working outcome, competent and skilful workforce, complete and up-to-date prior art documentation, efficient and effective working tools, and, last but not least, a mindset that avoids complacency, but establishes a working climate of continuous and systematic effort for improvement.

Therefore, one might describe a patent (or a decision to refuse a patent application) of high quality as one that

- within a well defined, predictable, stable and functioning legal environment, creates legal certainty for the users of the patent system that are directly or indirectly influenced by the rights conferred (and/or the rights taken away and/or denied), such that the users of the system can arrange their affairs with stability and predictability

- is decided in a reasonable time and with reasonable resources

- and offers a proper cost/benefit relationship to the holder of the rights.

4 The EPO patent quality system

There are numerous elements that, put together, form the EPO quality system. Synergy between them safeguards the high quality of EPO patents, which has been acknowledged in various studies and surveys[7]. Overall management and coordination is entrusted to a dedicated quality management department, staffed, among others, with examiners involved in the day-to-day examining business.

4.1 EPO examiners are recruited through a rigorous procedure. They are highly skilled professionals having acquired, as a rule, working experience in industry, who possess excellent knowledge of at least two of the three EPO official languages, and a working knowledge of the third. They are continuously trained in order to keep up with scientific

[7] Intellectual Asset management benchmarking survey (http://www.iam-magazine.com/issues/Article.ashx?g=018d033d-9ce9-4e00-8f40-df945e0b3d85), PATQUAL study on the quality of the patent system in Europe, http://ec.europa.eu/internal_market/indprop/docs/patent/patqual02032011_en.pdf

and technical developments. They operate in Examining Divisions consisting of three technically qualified persons, and if needed, extended by one legally qualified person. Their work is supervised by their superiors, who also exercise a quality assurance function.

4.2 EPO adverse decisions cannot be issued unless the right of the applicant (or patentee or opponent) to be heard has been respected. When issued, they are in fact substantiated to such an extent that they enable a reasoned appeal to be filed.

4.3 The opposition procedure, an *inter partes* mechanism for challenging grants, is also an element of the EPO quality system. The legal validity of EPO grants can therefore be challenged in first instance within the EPO. The appeal procedure, a mechanism for challenging adverse decisions of the first instance (either refusals or the results of the opposition procedure), can also be seen as a factor increasing the quality of the final EPO products. These two procedures exist in addition to any legal challenge in the national courts.

4.4 Approximately 8% of the work output (searches, grants) are subject to a peer quality check mechanism before being issued to the applicants, being essentially an operational quality control. The peers exercising this function are specially trained. They are rotated and the statistical results of their work are reported every 6 months. Harmonization and training measures for all examiners are based partly on these results.

4.5 A small scale quality audit mechanism checks patent grants after they have been issued to the applicant. The results are reported and fed back in a similar way like the operational quality control results.

4.6 A substantial part of working time is allocated to building and maintenance of the prior art documentation (European Classification System, ECLA) by the same examiners who use it for prior art searches. This assures the quality of the documentation as well as the efficient use of it. ECLA is subject to a permanent reorganization process, so that it is adapted to ongoing technical development. Recently EPO has concluded an agreement with Asian patent offices for acquiring access to Asian patent documentation in Chinese, Japanese and Korean languages, an agreement with Google on a project for machine translation in numerous languages including Chinese, Japanese, Korean and Russian, as well as an agreement with the USPTO for adopting ECLA as the common documentation system.

4.7 EPO is in the process of ISO9001 certification. Currently, the quality manuals for the various working processes within the EPO are written and scrutinized for correctness and completeness by the very persons involved in the processes.

4.8 To increase legal certainty created by the EPO patents, the project "Raising the Bar" has been initiated and is currently in its second phase. Part of the project concerns the facilitation of submissions of third parties, i.e. prior art or other submissions sent to the EPO by anyone, and relevant to the examination process for a specific patent application. These submissions, if found relevant, will be then taken into consideration by the Examining Division, thus increasing the quality of the final decision.

4.9 The EPO offers a lot of advice and support, within the framework of the European Patent Academy programme, regarding the proper drafting of patent applications. Furthermore, the EPO organizes the European Qualifying Examination (EQE), which assures that patent attorneys representing clients in front of the EPO are highly qualified. However, EPO has limited control on how applications are actually drafted, beyond the requirements of the European Patent Convention as to content, disclosure, clarity etc.

5 Possible future developments

To tackle the quality issue in an even more structured way, a project titled "Quality Roadmap" is currently running in the EPO, investigating all possible measures for maintaining and increasing quality. Numerous proposals are under legal and practical scrutiny. Just to mention one further possibility, it is conceivable that the reasons for granting a patent might be made public. It has been mentioned that any negative decision of the EPO contains the detailed reasons for the decision, such that it enables a reasoned appeal. EPO grants are reasoned (per se an element of quality), but the reasons are not disclosed to the public. However, a patent grant, although basically a positive decision, could be seen also as a decision that affects negatively everyone else but the patentee, because the patentee can prevent anyone from exploiting the patented matter. So, to be consistent with due process, grants should be *a fortiori* reasoned and the reasons disclosed to the public. It is expected that this would increase the quality of the EPO patent system in general.

6 Conclusion

A workable, "fit for purpose" perception of patent quality has been presented, which is implemented within the EPO. Based on this perception, the patent quality system within the EPO has been created and undergoes continuous development. Working with a view to preserve and improve the elements of this quality system in day-to-day business, will safeguard the leading position of the EPO as a reputable patent granting authority worldwide.

Author's professional profile

Yannis Skoulikaris is a Director with the European Patent Office. Since 2002, he has been heading one of the departments responsible for granting patents in computer technology, in particular system software and microprocessor architectures. His department is also dealing with oppositions to granted patents. He is also the liaison officer between the EPO and the Hellenic Industrial Property Organization (OBI), as well as between the EPO and the Cyprus Patent Office.

He holds a degree in Physics form the Aristoteles University in Thessaloniki (1977), a Certificate of Education as a programmer and systems analyst from Demokritos Research Centre in Athens (1978), a degree in Computer Science from the University of Hamburg (1988), and a Certificate of Education in European Patent Law from the Centre d' Études Internationales de la Propriété Intellectuelle, University of Strasbourg (1995). He has also followed two years of law studies at the University of London.

Prior to taking up his present management position with the EPO in 2002, he has worked as a programmer and systems analyst with the Hellenic Air Force Headquarters (Athens, 1977-1980), as a systems consultant with British Petroleum AG (Hamburg, 1984-1989), as a patent examiner with the EPO (Munich, 1989-1995) and as a patent examiners' tutor with the EPO (The Hague, 1995-2002).

His duties include, among others, defining and implementing EPO policy and practice in patenting computer-implemented inventions, as well as quality control in patent examination. He has been heavily involved in building up the EPO quality management system. He has also dealt with mediation in personnel matters. He has presented in academic and professional conferences, patent offices, chambers of commerce and various other fora, both in Europe and overseas, on the EPO legal framework and case law, and the EPO practice in examining computer-implemented inventions. Since 2009 he has also been a guest lecturer at the University of Maastricht, teaching at an Intellectual Property Masters course. He is a Senior Member of the IEEE.

Market size, education, trust, and the value of IPRs: Evidence from the validation of European Patents*

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Abstract

The value of a patent rights not only varies across inventions, but also across countries and sectors. This paper uses the validation behavior of holders of granted European Patents to estimate the value of patents and to identify its determinants. The potential market for the invention and the average education level in the sector of use are positively associated with the value of patent rights, whereas a high level of trust and weak enforcement of intellectual property rights reduce the value of these rights.

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We control for unobserved patent and country effects. We confirm that the distribution of the value of patent rights is highly skewed. We find that the aggregate value of European Patents granted in 2004 is EUR 2.9 billion. Introduction of the EU Patent would increase this value by 15 percent through a reduction in validation costs. A theoretical model of validation behavior provides the basis of the empirical analysis.

1 Introduction

The oldest and most widespread public policy that aims to encourage innovation is to reward inventors with a monopoly on the use of their inventions.[1] Although the value of patents has been studied extensively, few empirical researchers have focussed on the determinants of the value of patent rights. Knowing why a patent is worth what it is worth is of interest because it can guide policy makers in shaping incentives for innovation.

The impact of factors like market size on the value of patent rights is difficult to isolate because patents are heterogeneous in terms of the commercial potential of the underlying invention. We exploit a particular characteristic of European Patents to identify how the value of a single patent varies with country and industry characteristics. Once a European Patent has been granted, the holder of the patent has the choice to validate the patent in member states of the European Patent Convention (EPC). The patent-holder might choose not to validate his patent in a country if the cost of validation (validation fees, translation costs, and future renewal fees) are larger than the expected benefits of having a patent right in that country. We use these validation decisions to simultaneously infer the value of the patent right in particular countries and the factors that influence this value. We present a theoretical model of validation behavior that forms the basis of the empirical analysis.

We present evidence showing that potential demand influences the validation decision,

[1] The Statute of Monopolies passed by the English parliament in 1624 granted monopolies to skilled individuals for new techniques. The United States granted its first patent in 1790.

and by inference, the value of the patent. We find that the value of a patent is positively related to the potential demand for the underlying invention, i.e., the larger the market the more valuable the patent is. Potential demand is approximated by two variables. The first variable is market size measured in value added of the sectors in which the patent can be used. The second variable is the average education level in the sectors of use. Sectors that employ a higher educated workforce are more likely to demand advanced and recent technologies.

Besides potential demand, also the need for protection against infringement determines the value of patent rights. We use the level of general trust as an indicator of the inclination to imitate. For example, in high-trust sectors and countries (former) employees, suppliers or customers might be less inclined to steal business secrets. The (perceived) degree of protection in a country is positively related to the value of patent rights.

Validation costs for individual patents are approximated using the number of pages with claims for all European Patents granted in 2004. Validation costs are central to our analysis for two reasons. First, without validation costs, we would not be able to compute a monetary value for patent rights. We use validation costs in a similar way as Pakes and Schankerman (1984) and Schankerman (1998) use renewal fees to derive the value of patents. Second, validation costs of European Patents are very high compared to national patent systems Harhoff et al. (2009) and are the central in reforms of the European patent system, like the London Protocol van Pottelsberghe and Mejer (2008) and the EU Patent Danguy and Van Pottelsberghe de la Potterie (2009); Van Pottelsberghe de la Potterie and Mejer (2009); Van Pottelsberghe de la Potterie (2010).

We confirm earlier results that the distribution of patent rights is highly skewed. This property has been discussed by numerous authors, e.g. Pakes and Schankerman (1984), Pakes (1986), Griliches (1990), and Silverberg and Verspagen (2007). Finally, by adjusting validation costs and the costs associated with the numerous translation requirements, we can simulate the value added of introducting an EU Patent. Our simulations show an increase of 15 percent of the value of the European Patent stock granted in 2004.

A theoretical model of validation behavior provides the basis of the empirical analysis. We model the validation decision as the outcome of a three-stage game. In the first stage the incumbent firm decides on validation, in the second stage competing firms decide on entering the market, and in the third stage the incumbent decides whether to litigate or not if its patent is infringed by the entrant(s). The model is related to other models patent litigation by Bessen and Meurer (2006) and Galasso and Schankerman (2010).

There are two strands of literature closely related to our work. First there is the literature on patent value estimation using patent renewal data as initiated by Pakes and Schankerman (1984), who developed a model where the returns to protection evolve deterministically over time of a patent. Payment of renewal fees implies that the patentvalue is larger than the fee required to keep it in force, which in turn reveals the implicit value of the patent. Versions of this model have been applied by Schankerman and Pakes (1986), Sullivan (1994), and Schankerman (1998). A stochastic version of this model has been formulated by Pakes (1986) and has been applied by Lanjouw (1998), and Lanjouw et al. (1998). However, as remarked by Bessen (2008), many other factors influencing patent value are not explored in this context.

A second strand of literature related to our work uses proxy variables of patent value. These studies look, for example, at survey measures of subjective value of patents (Silverberg and Verspagen, 2007; Harhoff et al., 1999), the filing of opposition to and /or litigation of patents (Harhoff et al., 2003; Lanjouw and Schankerman, 2004), number of filed countries (Lanjouw and Schankerman, 2004), firm market value (Hall et al., 2005) and citations (Trajtenberg, 1990; Hall et al., 2005). Each of these indicators individually is not likely to lead to the best possible approximation of patent value. Studies combining various patent charactersitics and renewal data, such as Bessen (2008), claim that patent citations explain little variance in value suggesting a limited use as a measure of patent quality.

This paper contributes to both strands of literature by estimating the value of granted European Patents using the validation behavior of its owners. Once a European Patent has been granted, the owner has to decide in which Member States of the European Patent Convention[2] (EPC) she wants to validate the patent. Besides payment of validation and renewal fees for each of the selected countries, the owner also has to incur substantial costs for meeting translation requirements. These costs summed up are called validation costs and differ across countries and patents. The expected benefits of validation in a particular country also vary along countries and patents. By assuming that a patent owner will only validate a patent in countries for which the expected benefits outweigh the validation costs, we can identify the value of patent rights that are validated in some countries but not in others.

Our sample includes the validation decisions for all European Patents granted in 2004 and for 16 major EPC countries[3]. Validation decisions are modelled as a binary choice and are estimated by penalised partial likelihood McGilchrist and Aisbett (1991); Duchateau and Janssen (2008). We take the net present value of validation as a latent variable. If a patent is validated in a particular country, then we assume that the validation value for that particular patent-country combination is positive. The cost of validation are treated as given and the benefits of validation are estimating by including indicators for market size, education, trust, distance, common borders, shared language as regressors.

We can control for (unobserved) patent charactistics as we observe 16 validation decisions per patent, one for each country in our sample. We control for patent effects by conditioning on the number of countries a patent is validated in. This resembles the logit fixed effects estimator of Chamberlain (1980). Country characteristics are modelled as random effects, such

[2]See Appendix for the current members of the European Patent Convention

[3]Austria, Belgium, Denmark, Finland, France,Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Switserland, United Kingdom

that we can include regressors that only vary at the country level. Random effects are implemented by introducing a penalty function in the partial likelihood estimator McGilchrist and Aisbett (1991).

There are two reasons why we control for unobserved patent and country characteristics. First, this will avoid that residuals will be clustered by patent because of patent heterogeneity and this will avoid clustering by country caused by a.o. country-specific regressors. Avoiding clustering prevents that estimates of coefficients and standard errors are biased. Second, the patent effects can be used to infer the distribution of the value of patents. Similarly, the country effects can be used to compare a country's attractiveness for IPR conditional on market size, education, and trust.

Data on validation of European Patents are taken from the European Patent Office's (EPOs) INPADOC Legal Status database, other data on patents come from the EPOs PATSTAT data. A patent-country specific indicator of market size is constructed by using the OECD Technology Concordance (OTC) to link IPC codes with 4-digit industry data from OECDs STAN database. Education and trust data stem from the European Social Survey and are linked to patents using the OTC at the 2-digit industry level. Translation costs are approximated taking into account the number of pages with claims on each patent. Renewal and validation fees are extracted from the Official journal and the National Law relating to the EPC.

The second part of the results originate from simulations of the proposed introduction of an EU Patent, which would end the possibility of separate validation of European Patents for members of the European Union. In the simulations the adoption of a single EU Patent would imply no additional translation cost at the time of validation, a single validation fee, and single renewal fees within the EU. We infer that introduction of the EU Patent would raise the value of newly granted patents by at least 15 percent on average. These gains stem from two sources. First, the costs of validation decrease substantially, raising the net value of patent rights. Second, patents will be validated in more countries, such that benefits of patent rights come into existence that would have been forgone under the old validation regime.

This paper is organized as follows. The next section presents a model of the validation decision at the grant of an European Patent. Section 3 describes the accompanying empirical strategy. The data are described in Section 4. Section 5 presents the mixed effects logit estimates and a robutsness check. The distrubutions of the private value of patents are discussed in Section 6, followed by the simulations. Concluding remarks highlight the key findings and directions for future research.

2 A model of validation choice

A firm has invented a new product and has patented part of it, while keeping another part of the invention secret. After the patent has been granted, the firm has to decide in which countries it will validate the patent. A firm will validate in a particular country if the benefits of legal protection offered by validation in that country outweigh the validation fee and (additional) translation costs. The benefits of legal protection depend on the expected increase in operating profits if exclusivity is maintained and on the strength of legal protection if the patent is infringed.

We model the validation decision as the outcome of a three-stage game. In the first stage the incumbent firm decides on validation, in the second stage competing firms decide on entering the market, and in the third stage the incumbent decides whether to litigate or not if its patent is infringed by the entrant(s). The three stages are illustrated in Figure 1.

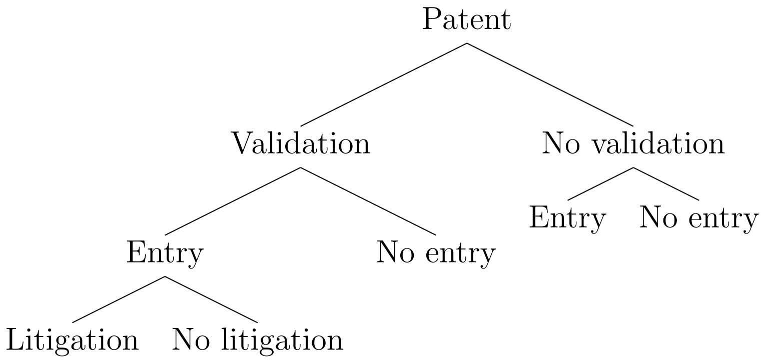


Figure 1: Validation game

2.1 Single entrant

Without entry by a competitor, the incumbent makes a monopoly operating profit π_m; with entry, the entrant and the incumbent form a (Cournot) duopoly in which both firms have the same operating profit π_d. Entry requires the entrant to invest e in imitating the incumbent's product. Let ϕ be the probability that litigation is succesful and the incumbent retains the exclusive right to sell its product and let the costs of litigation be l. The legal costs are bourne by the party that lost the case. We describe the decisions in each stage in reverse order:

Stage 3. The incumbent will respond to infringement by litigating if the expected value of litigation is positive, $\phi\pi_m + (1-\phi)(\pi_d - l) \geq \pi_d$.

Stage 2. The competitor enters the market if:

1. the incumbent refrained from validating the patent and the entrant's profits are at least as large as the costs of imitation $\pi_d \geq e$, or

2. the incumbent validates the patent and expected value of entry followed by litigation exceeds imitation costs, $(1-\phi)\pi_d - \phi l \geq e$.

Stage 1. The incumbent chooses validation if:

Table 1: Potential outcomes validation game

Case	Validation	Entry	Litigation	Litigation credible?
1. Entry is barred	no	no	no	irrelevant
2. Entry is deterred	yes	no	no	yes
3. Entry despite validation	yes	yes	yes	yes
4. Non-credible litigation	no	yes	no	no
5. High validation costs	no	yes	no	irrelevant

1. litigation is credible, validation deters entry, and monopoly profits minus validation costs exceeds duopoly profits, $\pi_m - f \geq \pi_d$, or

2. litigation is credible, validation does not deter entry, and the expected profits of litigation minus validation costs exceed duopoly profits, $\phi\pi_m - (1-\phi)(\pi_d - l) - f \geq \pi_d$

The three choices (validation, entry, litigation) imply five different outcomes that are consistent with profit-maximizing behavior. Table 1 lists the combination of decisions for each of the potential outcomes (Cases 1 to 5). The last column of the table shows whether litigation is credible

Validation will never be chosen if entry costs are prohibitive ($e > \pi_d$) or if validation costs are too high ($f > \pi_m - \pi_d$). When entry costs are high there is no threat of entry, such that the incumbent has no incentive to validate. This is Case 1. The incumbent will also choose not to validate if the maximum reduction in its profits due to entry is smaller than the costs of validation (Case 5). These cases are corner outcomes and do not involve strategic interaction. Combing both conditions, there will be an interior solution if $e \leq \pi_d \leq \pi_m - f$.

Validation will deter entry (Case 2) if an interior solution exists and two conditions hold:

1. Entry leads to losses if litigation is certain: $(1-\phi)\pi_d - \phi l < e$

2. Litigation must be credible: $\pi_d \leq \phi\pi_m + (1-\phi)(\pi_d - l)$

Validation will only deter entry if duopoly profits are small compared to litigation costs and compared to monopoly profits:

$$\pi_d < \min\left\{\frac{e+\phi l}{1-\phi},\ \pi_m - \left(\frac{1}{\phi}-1\right) l\right\} \tag{1}$$

When only the second condition holds, then entry will occur followed by litigation (Case 3). If the second condition does not hold (litigation is not credible), then validation is useless and we end up in Case 4.

Validation only has a positive value in Cases 2 and 3. In Case 2 the value of validation is $\pi_m - \pi_d - f$; in Case 3 the expected value of validation is $\phi\pi_m + (1-\phi)(\pi_d - l) - f - \pi_d$. Combining the conditions for Case 2 and Case 3, we know that a positive validation value will only occur if validation costs are not prohibitive and litigation is credible.

$$\pi_m - \pi_d > \max\left\{f,\ \left(\frac{1}{\phi}-1\right) l\right\} \tag{2}$$

In both Case 2 and 3, the value of validation hinges on the absolute difference between monopoly profits and duopoly profits.

2.2 Multiple entrants

We can generalize the game to allow for multiple entrants. Allowing for multiple entrants implies that a single patent needs to be defended more than once. This requires additional assumptions on how entry affects the probability of succesful litigation. We will discuss two extreme assumptions: 1) probability of success is independent of earlier trials and 2) trial outcomes are identical to the outcome of the first trial.

If the probability of success is independent of the outcomes of earlier trials, then the conditions under which litigation is credible become more strict. Suppose there are k potential entrants and entry is sequential. Let π_n be the operating profits when n firms are active in the market (such that $\pi_m = \pi_1$ and $\pi_d = \pi_2$). The conditions for Cases 1 and 2 remain essentially unaltered, while the condition for Case 5 changes into $f > \pi_m - \pi_n$. When entry costs permit the entry of just one firm, the incumbent has to win k cases in order to secure its monopoly. The expected value of litigation for the incumbent depends on the number of *potential* entrants:

$$\phi^k \pi_m + \left(1 - \phi^k\right)(\pi_d - l) \tag{3}$$

A larger number of potential entrants imposes stricter conditions on the credibility of litigation. This effect will be stronger if the market supports more than two firms.

Suppose now that trial outcomes are identical to the outcome of the first trial. If the incumbent wins, then no firm will enter the market, while if the incumbent loses then all firms enter the market provided that operating profits remain large enough to cover entry costs ($\pi_n \geq e$). The expected value of litigation depends on the number of *active* firms in the market:

$$\phi \pi_m + (1 - \phi)(\pi_n - l) \tag{4}$$

2.3 Empirical operationalization

Assuming that the first trial completely determines the outcomes of later trails and assuming $k \geq n$, the game gives us some simple solutions that can be operationalized empirically in a straightfoward manner. As $k \geq n$, entry costs will be binding and $\pi_n \approx e$. The expected value of validation now equals $\pi_m - e - f$ in Case 2 and $\phi\pi_m + (1 - \phi)(e - l) - f$ in Case 3. The incumbent's validation decision is positively related to monopoly profits and legal certainty, and is negatively related to validation and litigation costs and entry bariers:

$$\pi_m - e > \max\left\{f,\ \left(\frac{1}{\phi} - 1\right) l\right\} \tag{5}$$

As the majority of granted patents are never defended in court (Case 3 is rather rare), we can assume that $\pi_m - e > f$ for most patents. We will use this condition as the backbone of the empirical analysis.

3 Empirical strategy

Validation cost f can be approximated using data on the language of the patent and the number of pages with claims (see section 4), but we can not observe the expected benefits from validation $\pi_m - e$ directly. Instead, we treat $\frac{\pi_m - e}{f} \equiv v^*$ as a latent variable. If patent i is validated in country j, then we assume that the expected benefits from validation outweigh the validation costs:

$$\begin{aligned} v_{ij} &= 1 \quad \text{if} \quad v_{ij}^* > 1 \\ v_{ij} &= 0 \quad \text{if} \quad v_{ij}^* \leq 1 \end{aligned} \tag{6}$$

We let v_{ij}^* depend on validation costs, a set of variables related to profits and entry barriers, denoted by $\mathbf{x}$. We hypothesize that the expected benefits from validation are positively correlated with market size and education in the sector of use of the validated country. A larger market size in the sector of use implies greater potential demand for the products that make use of the patent. Education in the sector of use is a second indicator of the demand potential as a better educated workforce is likely to use more advanced and more recent technology.

We expect that the benefits of validation will be lower in countries and sectors with a high degree of trust. If people – notably former employees – are less tempted to steal business information, then there will be a smaller incentive for firms to seek formal protection of their intellectual property. Lastly, the incentive for validation is higher in countries and sectors where the (perceived) enforcement of intellectual property rights is stronger.

It is well-known that the value of patent rights varies wildly, but there is less agreement on the shape of the distribution of these values. As high-value patents are likely to be validated in more countries than low-value patents, we allow for patent fixed effects α_i. Unobserved differences across countries are captured by the country effects γ_j. As our indicators of IPR enforcement vary only at the country level, we treat the country effects as random effects in most regressions. Hence,

$$v_{ij}^{*} = \exp\left(\alpha_i + \mathbf{x}_{ij}\beta + \gamma_j\right)/f_{ij} \tag{7}$$

The vector of coeffients β and the patent and country effects are estimated with a binary choice model.

$$\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}\right) = F\left(\alpha_i + \mathbf{x}_{ij}\beta + \gamma_j - \ln f_{ij}\right) \tag{8}$$

Here, F is the cummulative distribution function of the residuals.

We treat the patent and country effects in different ways as the number of patents is very large and the number of countries is very small. The patent effects are taken into account by using a partial likelihood estimator. We assume that the residuals have a logistic distribution, such that integration of the partial likelihood function is straightforward. The advantage of this method is that no particular distribution is assumed for the patent effects: finding the distribution of the value of patent rights is interesting in its own right.

Patents with a large α_i are likely to be validated in more countries than patents with a small α_i. The fixed effects can be controlled for by conditioning the probability of validation of patent i in country j on the number of countries the patent is validated in $(\sum_j v_{ij})$.

$$\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}, \sum_h v_{ih}\right) = \prod_j \frac{\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}\right)}{\sum_h \Pr\left(\ln v_{ih}^{*} > 0|\mathbf{x}_{ih}\right)} \tag{9}$$

Using these conditional probabilities of validation, the partial likelihood function becomes:

$$\mathcal{L}(\beta,\, \alpha|\gamma,\, \mathbf{x}) = \prod_{ij} \frac{\Pr\left(\ln v^*_{ij} > 0|\mathbf{x}_{ij}\right)}{\sum_h \Pr\left(\ln v^*_{ih} > 0|\mathbf{x}_{ih}\right)} \tag{10}$$

The partial likelihood no longer depends on the α_i and can be written as:

$$\mathcal{L}(\beta,\, \alpha|\gamma,\, \mathbf{x}) = \mathcal{L}(\beta|\gamma,\, \mathbf{x}) = \prod_{ij} \frac{\exp\left(\mathbf{x}_{ij}\beta + \gamma_j - \ln f_{ij}\right)}{\sum_h \exp\left(\mathbf{x}_{ih}\beta + \gamma_h - \ln f_{ih}\right)} \tag{11}$$

Maximization of this likelihood function is straigthforward for given country effects.

The country effects are treated as random effects and are estimated by maximizing a penalised partial likelihood. Country effects are taken into account by conditioning on the number of patents that are validated in country j in similar way as the patent effects were controlled for by conditioning on the number of countries a patents is validated in. The main difference is that we impose that the country effects have a Gaussian distribution with mean zero and variance δ. This restriction takes the form of a penalty function.

The penalised partial loglikelihood function $l_{ppl} \equiv \ln \mathcal{L}_{ppl}$ consists of two parts: a partial loglikelihood l_{part} and a penalty function l_{pen}:

$$l_{ppl}(\beta,\, \gamma,\, \delta|\mathbf{x}) = l_{part}(\beta,\, \gamma|\mathbf{x}) - l_{pen}(\gamma,\, \delta) \tag{12}$$

The partial likelihood is the likelihood conditional on the patent *and* country effects.

$$l_{part}(\beta,\, \gamma|\mathbf{x}) = \sum_{ij} \left(\eta_{ij} - \ln\left(\sum_h \exp \eta_{ih}\right)\right) \tag{13}$$

$$\eta_{ij} \equiv \mathbf{x}_{ij}\beta + \gamma_j - \ln f_{ij} - \ln \sum_h \left(\mathbf{x}_{ih}\beta + \gamma_h - \ln f_{ih}\right)$$

The penalty function imposes a normal distribution on the country effects.

$$l_{pen}(\gamma,\, \delta) = \frac{1}{2} \sum_{j} \left(\frac{\gamma_j^2}{\delta} + \ln(2\pi\delta) \right) \tag{14}$$

Maximization of the penalised partial loglikelihood consists of an inner and an outer loop. In the inner loop, the β and γ are estimated for a given value of δ. In the outer loop, δ is estimated by restricted maximum likelihood given the estimates of γ. Details of the estimation procedures are described in Duchateau and Janssen (2008, Ch. 5).

4 Data

The empirical analysis relies on disaggregrated data on the legal status database and the PATSTAT produced by the EPO. From the EPO Legal Status database we extract patent lapses and the countries in which the owner wants its European Patent to be validated. The PATSTAT database provides information on grants, IPC classifications, etc. The sample contains 56,980 patents granted by the EPO in 2004 and validated in at least one of the sixteen major EPC Member States.[4] The independent variables are described hereafter.

Validation Validation is a binary variable which is one if a patent has been validated in a country. To construct this variable the following assumptions are made[5]: (i) when renewal fees have been paid for a particular patent or if it lapses, then it is assumed that this patent initially had been validated in that country; (ii) if a patent lapses in a particular country within 365 days after grant, then this patent is considered as lapsed ab initio in that country.

[4]The 16 countries of validation are Austria (AT), Belgium (BE), Switserland (CH), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Spain (ES) and Sweden (SE). Other EPC countries that have joined the EPC before 2004 are left out of the sample since they are still in the start-up phase.

[5]These assumptions are similar to those made in Harhoff et al. (2009) to analyse the patent validation flows between applicant and validation countries.

In other words, these patents are considered to have never been validated in that country.

Figure 2: Validation shares in EPC contracting states of European Patents granted in 2004

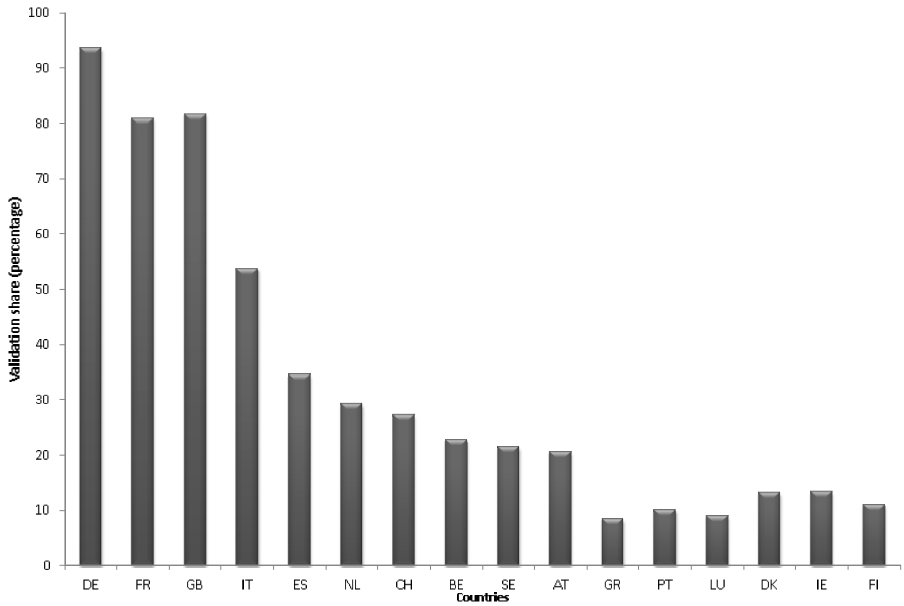
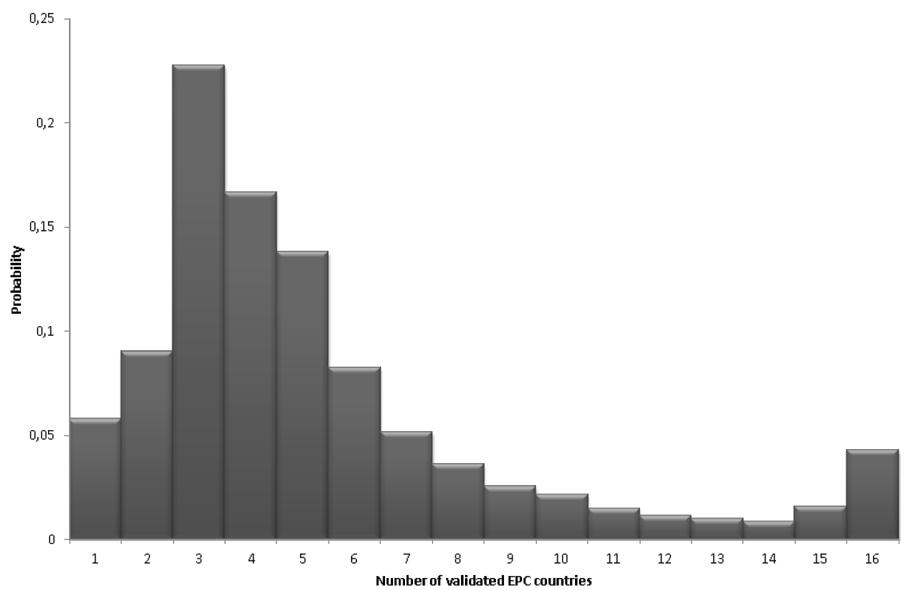


Figure 2 shows the validation shares of granted European Patents in 2004. In 2004, about 93 percent of all granted European Patents has been validated in Germany, 81 percent has been validated in France and 82 percent in the United Kingdom. Other contracting states of the EPC have lower validation shares. Different trends related to countrysize and EPC membership duration can be observed over time. At first, the larger countries Germany, France and United Kingdom have had high validation shares from the start of the EPC onwards. Other founding member states like the Netherlands, Belgium and Sweden show declining proportions of European Patents being validated at a steady pace. Late adopters of the EPC like Spain, Greece, Portugal and Denmark converge towards a more or less constant validation share. Straathof and Van Veldhuizen (2010) argue that low validation rates reduce technological competition within the EU and make individual countries less attractive for foreign innovators.[6]

[6]These arguments and the reduction of cost of patenting, are the most important reasons for implementing

The value of an European Patent and the number of member states in which it has been validated are highly correlated. Figure 3 depicts the distribution of the number of validated countries of European Patents validated in 2004. The distribution is skewed to the right and there is more probabilty mass at 15 and 16 validated countries. The patents characterised in this part of the distribution are patents of high value which would have been validated in more than 16 countries if possible. Due to the high correlation between the number of validated countries and patent value it is expected that the distribution of patent value follows approximately the same distribution. On average a patent has been validated in 5.3 countries.

Figure 3: Distribution of number of validated countries of European Patents granted in 2004



Market size Market size of a patent in country j is approximated by the weighted average of country specific production value of 4-digit industries that are associated with the IPC codes assigned to the patent. By denoting y_{ij} as the market size of patent i in country j, we

an EU Patent, see Danguy and van Pottelsberghe de la Potterie (2010) and Straathof and Van Veldhuizen (2010).

have

$$y_{ij} = \sum_{\substack{m \in \{IPC\}_i \\ n \in ISIC}} w_{im} \bar{w}_{mn} \bar{y}_{nj} \tag{15}$$

where w_{im} is the weight of IPC code m for patent i[7], $\bar{w}_{mn}$ is the relative frequency with which IPC code m is assigned to ISIC industry n according to the OECD Technology Concordance (Johnson, 2002) and $\bar{y}_{nj}$ is the market size of 4 digit ISIC industry n in country j .

Enforcement of intellectual property rights In the literature a few indicators are available that have gauged the overall strength of the patent system on the country level. Widely used is the Ginarte Park (GP) index (Ginarte and Park, 1997; Park, 2008), which is the unweighted sum of five seperate scores for coverage of inventions that are patentable, membership of international treaties, duration of protection, enforcement mechanisms and restrictions. Accordingly, the GP index measures IPR enforcement *de jure*, while we are interested in the *de facto* enforcement of such rights. The GP index shows almost no variation in our data sample and is therefore not very useful.

Another IPR enforcement indicator is available through the World Economic Forum's Executive Opinion Survey. This indicator resembles the protection of intellectual property including anti-counterfeiting measures per country over the period 2009-2010. It is important to note that this indicator has not been cleaned for generalized trust. The uncorrected indicator shows a reasonable amount of variation over the countries in our data sample. The third indicator we use is the IPR indicator constructed by the Property Rights Alliance (PRA). It is partially based on the GP index, as well as on the World Economic Forum's 2007-2008 Global Competitiveness Index and the US Trade Representative's 2008 Watch List Report.

[7] w_{im} equals one over the number of IPC codes assigned to patent i

Business climate indicators Focussing on IPR there are two relevant measures that shape the business climate on the country-industry level, namely trust and education. It is widely recognized in the social science literature that both measures are highly correlated. That is, general trust levels are higher among higher educated people. From the European Social Survey we have extracted the generalized trust in other citizens variable *ppltrst*[8] and the highest education level variable *edulvl*. The last variable has been transformed into years of education according to international standards. Both variables are measured per country at the two-digit industry level and are weighted in the same way as market size.

Validation fees The patentee has to pay a validation fee in a contracting state to validate a granted European Patent in that contracting state.[9] Validation fees differ considerably across EPC countries. For example, Belgium, Switserland, United Kingdom and Luxembourg do not charge validation fees at all, whilst the remaining countries in our sample do charge validation fees. Austria, Denmark, Finland, Spain and Sweden charge on top of a fixed fee also a page-based fee when a patent exceeds a certain number of pages.[10] The 2003 validation fees taken from EPO (2003) are illustrated in Figure 4.

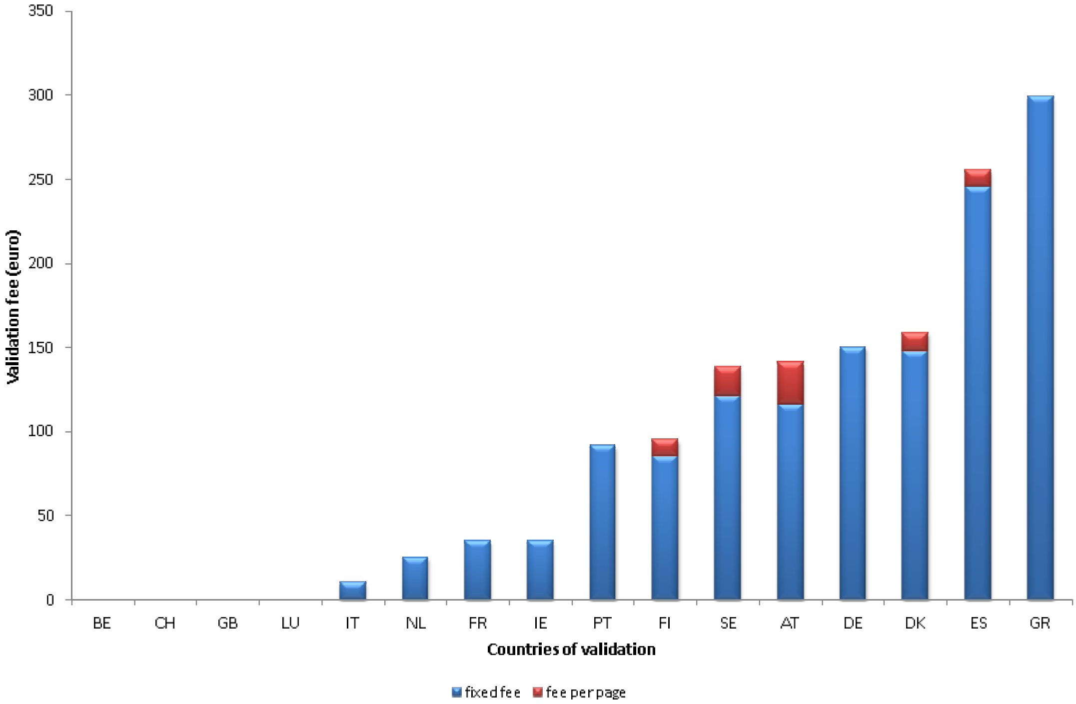
Renewal fees Figure 5 displays the renewal fees, grouped in subtotals over 5 years, for the EPC countries in the sample. The Netherlands, Austria and Germany overall charge the highest renewal fees, in particular in the last 5 years of the lifetime of a patent. Data on the renewals fees have been extracted from EPO (2003).

[8]The ESS question belonging to this variable: Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people? Please tell me on a score of 0 to 10, where 0 means you can't be too careful and 10 means that most people can be trusted.

[9]In case a European Patent is granted in one of the official languages of the country in which the patent should be validated (in other words the proceedings language is one of the offical languages of the country of validation), then no validation action is required and no validation fees have to be paid. Data on the proceedings language was used to correct validation fees for these cases.

[10]Page-based fee in Austria in excess of 5 pages, in Denmark in excess of 35 pages, in Finland in excess of 4 pages, in Spain in excess of 22 pages and in Sweden in excess of 8 pages.

Figure 4: Validation fee per country in 2003.



Translation costs Translation costs are primarily determined by the number of words that have to be translated and the number of languages in which they have to be translated. The best proxy available is the number of pages of descriptions and the number of pages of the claims, which have been taken from the Open Patent Services available from the EPO.[11]

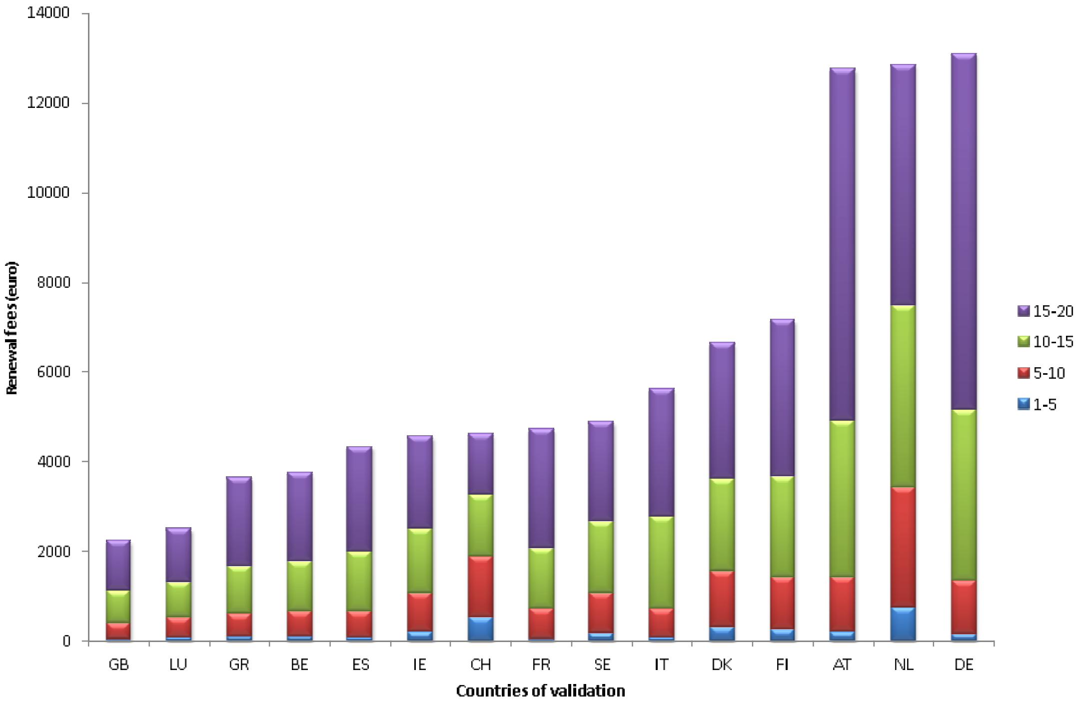
Translations of the patent are needed in two stages of the application proces, namely at the grant and validation procedures. In the application and granting stage, the patent descriptions are published in the proceedings language, whereas the claims have to be available in English, French and German.[12][13] In the second stage of validating the granted patent

[11]See `http://www.epo.org/patents/patent-information/free/open-patent-services.html`

[12]From May 2008 onwards the London Agreement has been entered into force aiming at reducing the translation costs of European Patents, see for example van Pottelsberghe and Mejer (2008). Our analysis is restricted to the period before May 2008, and henceforth, the translation requirements correspond to those before the London Agreement had set in.

[13]The official languages of the European Patent Office are English, French and German. A European Patent application should be filed in on of the official languages or, if filed in any other language, translated into one of the official languages. In general, the language in which the European Patent application has

Figure 5: Renewal fees by country in 2003.



in one or more contracting states, the descriptions and claims have to be translated in the official language of the particular contracting state. In case a contracting state has multiple official languages submitting a translation in one of these languages is sufficient. For our data sample the translation requirements are listed in Table 2.

Following the European Commission Communication (2007) we assume translation costs of 76 euro per page descriptions and 85 euro per page claims. Further it is also assumed that the translation costs for translations from any language A to any other language B is equal for all European languages A and B, with $A \neq B$. To give an impression of the translation costs we use an example taken from European Commission Communication (2007). Assume that a patent has 16 pages of descriptions, 4 pages of claims and is validated in 13 most frequently validated contracting states. [14] To meet the national translation requirements,

been filed will be used as the language of the proceedings.

[14]This patent is validated in Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy,

the descriptions and claims have to be translated into the remaining two of the three EPO languages and into Danish, Dutch, Finnish, Italian, Spanish and Swedish. Hence, the total translation costs are 12,448 euro.

Table 2: Translation requirements for the description and claims in the contracting states

Country	**Official language(s)**	**Country**	**Official language(s)**
Austria	German	Ireland	English
Belgium	Dutch, French, German	Italy	Italian
Denmark	Danish	Luxembourg	French, German
Finland	Finnish	Netherlands	Dutch
France	French	Portugal	Portuguese
Germany	German	Spain	Spanish
Great Britain	English	Sweden	Swedish
Greece	Greek	Switserland	German, French, Italian

5 Estimation results

Table 3 presents the empirical results for various versions of the baseline model. We first compare different specifications and then compare parameter the estimates in the preferred specification across countries of application and technology fields. The latter regressions are presented in table 4.

Regression (1) of table 3 is a standard logit model showing a positive parameter for market size. However, knowledge as captured by patents differ greatly in market potential, and the invention potential influences the validaton decision. Hence, there is a selection bias towards large countries, that have more low-valued patents. Regression (2) is a conditional logit model that filters out patent-applicant-specific effects. In addition, regressions (3)-(7) are mixed effect logit models which compute cluster-robust standard errors to correct for possible different error variances over countries. Note that the parameter values for

Netherlands, Spain, Sweden, Switserland and United Kingdom.

market size, education, trust and IPR protection are nearly constant when building up the specification. Market size, education and IPR protection postively influence the probability of validation, whilst general trust reduces the probability of validation. The bilateral distance indicators respond as expected, that is, distance infers a negative relationship whereas shared language and common border emlpoy a positive relationship.

As a measure of goodness-of-fit we use the hitrate of correctly predicted validations, wihch has been computed as follows. From the parameter estimations it is rather straightforward to recover α_i. In section 6 this has been explained in detail. Once the patent fixed effects are known the net present value of validating patent i in country j can be computed. We assume that actual validation happens when this value is nonnegative.

Table 3: Estimates of the patent validation model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(market size)	0.9679***	0.9257***	0.2817***	0.3217***	0.3023***	0.3101***	0.2995***
	(0.0025)	(0.0020)	(0.0191)	(0.0193)	(0.0194)	(0.0190)	(0.0191)
education				1.734***	2.287***	2.2927***	2.2328***
				(0.1584)	(0.1601)	(0.1599)	(0.1605)
trust					-4.003***	-4.0090***	-3.9356***
					(0.13)	(0.1297)	(0.1299)
IPR protection						5.4748***	5.3328***
						(1.3713)	(1.4584)
ln(distance)							-0.0149***
							(0.0044)
Shared language							0.1162***
							(0.0071)
Common border							0.0301***
							(0.0067)
econometric	standard	conditional	mixed effect	mixed effect	mixed effect	mixed effect	mixed effect
method	logit	logit	logit	logit	logit	logit	logit
hit rate	33.4%	33.4%	61.6 %	66.6%	70.1 %	74.8%	74.3%
No. observations	911,680						
No. patents	56,980						

Next we compare parameter estimates across the nationality of the applicant, where we distinct EU- and non-EU countries, tax havens, the United States of America and Japan. Large firms have their intellectual property registered at their headquarters address. Since a large amount of large firms have their headquarters located in taxhavens, this group has been seperated. For the EU countries the estimated coefficients are as expected. For non-EU countries the incentive captured by market size seems to be less important, whereas education and IPR protection show stronger positive effects and trust stronger negative effects compared to the EU sample. Moreover, the effect of distance cannot be distinguished from zero. For both market size as distance the effects can be explained by the following arguments. First, granted patents from applicants outside the EU are of relatively high value and quality since the costs for nonEU applicants are higher than for EU applicants. Hence, the marginal effect of market size is less important and the same argument holds for distance. Secondly, because physical distance between the patentee and the country in which her patent is validated is larger, she will be more demanding regarding the protection of the intellectual property.

When electrical engineering is included, market size is not significant for the USA and education is not significant for Japan. Estimations with all industries except electrical engineering yield coefficients that are to be expected. The estimations point out that characteristics of the electrical engineering industries of the USA and Japan are quite different. For US patentees education in the country of validation is far more important than marktsize. For Japanese patentees it is the other way around. This can be explained by the different natures of both electrical engineering industries. Japanese engineering is more focussed on development of products for large markets such as consumer electronics. Hence, this implies a relative large coefficient for market size in the estimations. Electrical engineering in the US is on the technology frontier, of which the most clear example is the research performed in Silicon Valley. For validation is in this case education more important than market size.

Table 4: Country estimates of the patent validation model

	All industries					All industries except electrical engineering	
	EU countries	non EU countries	Taxhavens	Japan	USA	Japan	USA
ln(market size)	0.4104***	0.08022***	0.3534***	0.6252***	-0.03126	0.8749***	0.2617***
	(0.0237)	(0.031)	(0.059)	(0.0632)	(0.0386)	(0.0556)	(0.0383)
education	1.683***	3.98***	3.497***	0.2909	3.769***	3.695***	4.791***
	(0.2072)	(0.2564)	(0.5868)	(0.5715)	(0.3189)	(0.711)	(0.3565)
trust	-2.356***	-7.41***	-3.428***	-5.565***	-6.845***	-4.341***	-5.794***
	(0.1678)	(0.2077)	(0.4928)	(0.4941)	(0.2563)	(0.5974)	(0.2886)
IPR protection	3.257***	7.851***	3.109*	8.164***	7.696***	4.394***	5.41***
	(1.2026)	(2.1766)	(1.5995)	(2.3526)	(2.5208)	(1.4582)	(1.4689)
ln(distance)	-0.163***	0.02114	-0.2643***	-1.873	0.9115	-1.677	0.5562
	(0.0048)	(0.0389)	(0.0281)	(2.0562)	(2.0984)	(1.2771)	(1.2108)
Shared language	-0.02089*	-0.1537***	0.1965***		0.1245		-0.1089
	(0.0109)	(0.0143)	(0.0531)		(0.5921)		(0.3414)
Common border	0.06732***	-0.1605**	-0.2769***				
	(0.0074)	(0.0816)	(0.0698)				
No. observations	486,544	425,136	40,944	164,720	219,360	101,104	154,288
No. patents	30,409	26,571	2,559	10,295	13,710	6,319	9,643

5.1 Robustness checks

Robustness of the estimation results is illustrated along four dimensions. We show that the main results hold under sample variation and under various ecocometric methods. Estimations with alternative regressors for education and IPR protection also confirm the main results, as does an industry decomposition.

5.1.1 Sample variation

Table 5 shiws estimation with variatons on the data sample. We see that for the sample of large firms the estimations are in line with the baseline estimations. Restricting the sample to patents that are not validated in neither Germany, France or the United Kingdom the estimations are still quite in line with the baseline results.

Table 5: Sample variation estimates of the patent validation model

	Large firms	Not validated in DE, FR or GB	Validated in more than 5 countries
ln(markt size)	0.3357***	0.2774***	0.284***
	(0.0357)	(0.0196)	(0.0235)
education	3.259***	2.129***	2.005***
	(0.2826)	(0.1629)	(0.1976)
trust	-6.419***	-3.893***	-2.094***
	(0.2238)	(0.1311)	(0.1547)
IPR protection	6.855***	5.246***	2.843**
	(1.6313)	(1.492)	(1.1781)
ln(distance)	0.09763***	-0.00985**	-0.05744***
	(0.0085)	(0.0044)	(0.0052)
Shared language	-0.001525	0.09536***	0.01382
	(0.0125)	(0.0072)	(0.0092)
Common border	0.07027***	0.04381***	0.07532***
	(0.0121)	(0.0069)	(0.0089)

5.2 Econometric methods

Table 6 show estimations using logit, conditional logit, mixed effect logit and conditional logit with country dummies. Using patent fixed effects and country dummies instead of mixed effects hardly changes the coefficients and the standard errors.From this we conclude that mixed effects logit employs reliable results. One could wonder whether using advanced econometrics as mixed logit pays off compared to conditional logit with country dummies. The use of mixed logit allows us to use indicators that vary on the country level, such as for example IPR indicators. Often, such indicators are only available on the country level.

Table 6: Various econometric methods applied to the patent validation model

	Logit	Logit patent fixed effects	Mixed effects logit	Patent and country fixed effects logit
ln(markt size)	0.9017***	0.8320***	0.2921***	0.2874***
	(0.0688)	(0.0026)	(0.0194)	(0.0196)
education	1.1185***	4.9587***	2.227***	2.2136***
	(0.0478)	(0.0742)	(0.1606)	(0.1607)
trust	-5.4142***	-1.3827***	-3.9300***	-3.9380***
	(0.0460)	(0.0419)	(0.1301)	(0.1302)
ln(distance)	-0.2980***	-0.1031***	-0.01500***	-0.0149***
	(0.0024)	(0.0040)	(0.0044)	(0.0044)
Shared language	0.6887***	-0.0690***	0.1165***	0.1166***
	(0.0088)	(0.0062)	(0.0071)	(0.0071)
Common border	-0.5269***	0.1711***	0.0299***	0.0298***
	(0.0095)	(0.0062)	(0.0067)	(0.0067)
No. observations	911,680			
No. patents	56,980			

5.3 Alternative regressors

Table 7 present estimations of the patent validation model with alternative regressors for education and IPR protection. From the ESS different measures for education are available. Next to our constructed education years variable, in Table 7 denoted as *education years* *(standardized)*, suitable alternative regressors are the original education years variable, denoted by *education years (ESS)*, education level denoted as *education level (ESS)* and R&D expenditures. Alternative regressors for IPR portection are the Ginarte-Park index (Ginarte and Park, 1997; Park, 2008) and the IPP index (Forum, 2008).

Comparison of the baseline estimations (regressions (1) and (5) in Table 7) with the estimations using alternative regressors for education and IP enforcement yields the following results. Substitution of alternative regressors for education does not influence the size and sign of the other regressors, see estimations (2) - (4) in Table 7. Inclusion of country level IP enforcement indicators does not influence the coefficients of the other regressors. The IPR indicator yields a positive significant effect on the probability of validation. Alternative regressors of IP enforcement yield a postive, but imprecisely estimated, coefficient on the probability of validation. We conclude that the baseline results keep one's feet under the robustness analysis of alternative regressors.

Table 7: Alternative regressors

	(1)	(2)	(3)	(4)	(5)	(6)
ln(market size)	0.2921***	0.3668***	0.2765 ***	0.2553***	0.2995***	0.2953***
	(0.0194)	(0.0197)	(0.01939)	(0.02153)	(0.0191)	(0.0194)
education years (standardized)	2.2271***			1.4440***	2.2328***	2.2295***
	(0.1606)			(0.1651)	(0.1605)	(0.1606)
education years (ESS)		2.3802***				
		(0.1092)				
education level (ESS)			0.9378***			
			(0.0853)			
ln(R&D expenditures)				0.0449***		
				(0.0200)		
trust	-3.9299***	-4.1161	-3.8634***	-4.6234***	-3.9356***	-3.9348***
	(0.1301)	(0.1305)	(0.1299)	(0.1356)	(0.1299)	(0.1300)
IPR protection					5.3328 ***	
					(1.4584)	
park index						6.6647
						(3.8597)
IPP						1.7585
						(1.1884)
ln(distance)	-0.0149***	-0.0140***	-0.0157***	-0.0168***	-0.0149***	-0.0149***
	(0.0044)	(0.0044)	(0.0044)	(0.0044)	(0.0044)	(0.0044)
Shared language	0.1165***	0.1208***	0.1168***	0.1238***	0.1162***	0.1164***
	(0.0071)	(0.0071)	(0.0071)	(0.0072)	(0.0071)	(0.0071)
Common border	0.0299***	0.0248***	0.0291***	0.03222***	0.0301***	0.0300***
	(0.0067)	(0.0067)	(0.0067)	(0.0068)	(0.0067)	(0.0067)
No. observations	911,680					
No. patents	56,980					

5.4 Industry decomposition

Patenting behavior varies across industries. For example, there are differences in traditions to patent, differences in proportions of low valued patens and lastly, per industry the channels through which the patent incentives run differ across industries. Table 8 contains the estimations on industry level. We follow the Fraunhofer industry classification, which distinguishes six industries on the highest level of aggregation.

The industry level estimates split the technology groups in three categories. The first category comprises chemistry and pharmaceuticals for which the estimations reveal that market value, education, generall trust and IPR protection are significant and have the signs corresponding with the baseline model. The second group consists of electrical engineering, mechanical engineering and other fields. This group can be identified by a positive coefficient for market size, but one or more other channels are not significant. Compared with the baseline is market size relatively more important in electrical engineering, general trust is relatively less important and IPR protection is relatively more important. The level of education is, however, not significant. In mechanical engineering only market size is important. The third category is instruments, for which trust and IPR protection are the only significant channels.

Table 8: Industry decomposition estimates of the patent validation model

	Chemistry	Electrical engineering	Instruments	Mechanical engineering	Other fields	Pharmaceuticals
ln(market size)	0.5547***	0.7451***	-0.1351	1.033***	0.4233***	0.3423***
	(0.0376)	(0.0696)	(0.111)	(0.0438)	(0.0559)	(0.043)
education	3.15***	0.1156	-0.6332	0.2989	2.221***	5.129***
	(0.361)	(0.6669)	(1.1114)	(0.4757)	(0.7951)	(0.6004)
trust	-2.628***	-2.474***	-4.771***	-0.2772	0.4278	-4.219***
	(0.2876)	(0.4955)	(0.7578)	(0.3986)	(0.634)	(0.3323)
IPR protection	3.131***	7.002***	10.19***	2.397	1.512	3.201***
	(1.0421)	(1.4195)	(3.8836)	(1.6887)	(1.4712)	(1.2102)
ln(distance)	-0.003532	0.07839***	0.07868***	-0.02817***	-0.1743***	-0.03107***
	(0.0084)	(0.0135)	(0.0194)	(0.0079)	(0.0134)	(0.0109)
Shared language	0.08377***	0.2392***	0.1992***	0.1487***	0.3058***	0.08284***
	(0.0136)	(0.0195)	(0.027)	(0.014)	(0.0257)	(0.0174)
Common border	0.02121	0.09745***	0.01053	0.02631**	0.09121***	-0.04089**
	(0.0133)	(0.0182)	(0.0271)	(0.012)	(0.0215)	(0.0196)
No. observations	208,768	175,600	75,520	281,456	67,808	102,528
No. patents	13,048	10,975	4,720	17,591	4,238	6,408

6 Implications

In this section the parameter estimates are used to simulate the ex post distribution of patent value. The analysis then focusses on te contributions of various technologies and nationalities of the patentee. Finally, the value added of introducing an EU Patent is derived.

6.1 Estimates of the private value of European Patent rights

In this section we derive the distribution of the private value of European patent rights of applications which have been validated in 2004 at the EPO. The private value of a single patent is given by

$$V_i = \sum_j (\Delta\pi_{ij} - f_{ij}) = \sum_j (y_{ij}\alpha_i f(L_j) g(O_j) - f_{ij}), \tag{16}$$

in which the patent-specific effects α_i are unknown. Below we discuss our strategy to recover the patent fixed effects α_i.

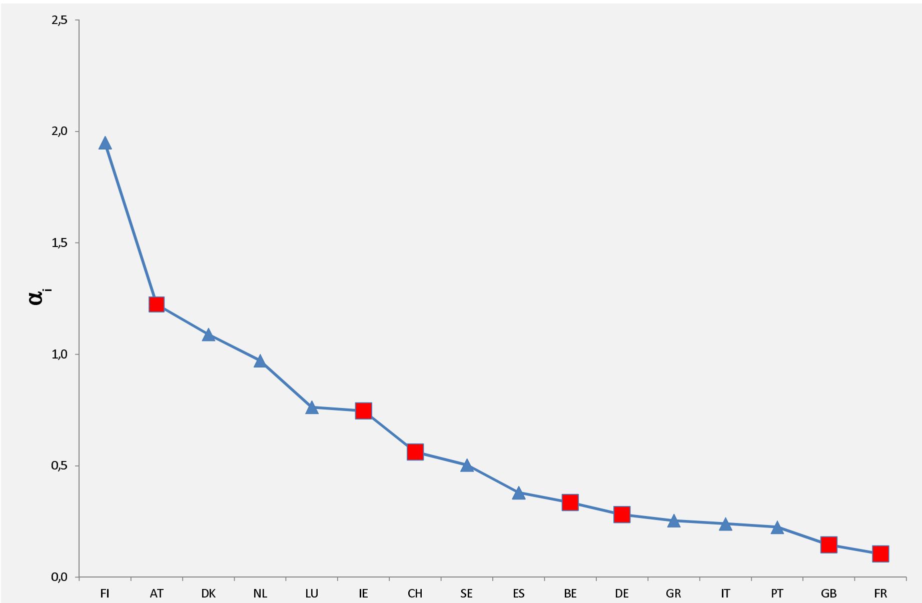
6.1.1 The proxy of patent fixed effects

Per patent we construct a series of φ's:

$$\alpha_i = \frac{C_{ij}}{y_{ij} f(L_j) g(O_j)}. \tag{17}$$

An illustration of such a series is given in figure 6. The patent fixed effect resulting from a country in the marge of validation is where we are interested in. Various approaches can be taken from here, since the marginal country generally does not exist. The preferred approach is to take $\max(\alpha_i)$ for every α for which holds that $v_{ij} = 1$. Likewise, an alternative approach would be to proxy the patent fixed effect by $\min(\alpha)$ for each α for which $v_{ij} = 0$. One could also take the average of both approaches, which in fact averages the upper- and lowerbound of the patent fixed effect. There are, however, reasons why the second approach is not preferred. Strategic behavior of firms avoiding competitors in countries in which they are not active is not captured by our empirical framework, whilst the beneifts of validating in these countries outweighs the costs. In the same line of reasoning, firms that are not active in particular countries might not consider to validate in these countries at all. Again, this is not captured by the current model specification. The computed series φ's belonging to validated countries are monotonically decreasing in value, whilst the computed series φ's belonging to nonvalidated countries do not. This confirms the strategic behavior described above. For this reason we use the first approach to compute the patent fixed effect.

Figure 6: Illustration of a series $\{\alpha_{ij}\}_j$ for a patent from the data sample. The patent has been validated in the countries marked by a red square.



6.1.2 Distribution of the value of European Patents

The distribution of the value of European Patent rights is presented in figure 7. Approximately 95% of the patents follow a power law, which has been plotted as well. The 5% of patents that are below the fitted power law represent patents that are validated in 15 and 16 countries. The current methodology underestimates their value, because these patents are not part of the estimation of the parameters. We assume that the estimated value of these patents should follow the same fitted power law.

Table 9 presents the value distribution by industry, where the top 5% has been fitted by a power law.[15] Most European Patents are of moderate value: the median value is 14k euro for the whole sample, only 6k euro in electrical engineering, 15k euro in instruments, 23k euro in chemistry, 11k euro in mechanical engineering and 116k euro in pharmaceuticals. The value rises sharply with the quantile, especially in pharmaceuticals. For all industries holds that there are some very valuable patents in the tail that represent a large fraction of the total value in each industry. For example, the 1 % most valuable patents in pharmaceuticals represent 11% of the total patent value in pharmaceuticals. For mechanical engineering this is 5%, while for the whole sample the top 1% patents represent about 9% of the total value.[16] Nonetheless, the means differ greatly along industries. Over all industries the mean patent value is about 51k euro. Electrical engineering, instruments and mechanical engineering have mean patent values of 18k, 27k and 15k euro, respectively. The mean patent value in chemistry is higher, namely 78k euro. Pharmaceuticals has, as to be expected, a much higher mean patent value: about 400k euro.

Table 9 confirms that patent value distributions are highly skewed, see for example Schankerman (1998). Our estimations of pharmaceutical patents differ largely from the ones by Schankerman (1998), whose value estimations of pharmaceutical patent are rather low. The estimations of Schankerman are largely influenced by regulation in the pharmaceutical sector in France in the 1980s, which leads to underestimations of the patent value. Our estimations, however, reveal that patents from the pharmaceutical industry are more valuable than patents in other industries. Given the substantial development and test phase costs,

[15] The value distributions by industry wihtout power law fits can be found in appendix B.

[16] The top 1% in electrical engineering represent about 7% of the total value; the top 1% of instruments about 8%; the top 1% in chemistry about 10%.

and the large markets for pharmaceutical products, it is more than likely that intellectual property in this industry is highly valuable.

Figure 7: Distribution of the value of European Patents granted in 2004 (blue dots). Power law fit (magenta solid line).

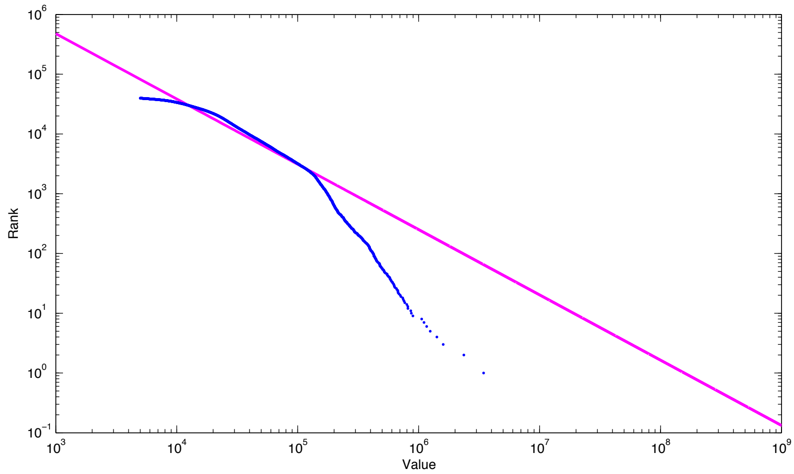


Table 9: Distribution of the value of European Patent rights after power law fit, by technology field.

Quantile	Whole sample	electrical engineering	instruments	chemistry	mechanical engineering	pharmaceu-ticals	other industries
.25	3,350	2,325	3,215	9,000	2,165	36,465	4,640
.50	13,750	5,825	15,100	22,735	10,500	115,730	11,700
.75	29,325	24,550	27,660	45,900	18,870	235,625	22,330
.90	62,500	38,950	59,125	92,400	35,000	544,625	38,850
.95	108,420	56,565	85,800	146,675	48,275	1,008,615	49,925
.99	472,730	129,975	202,975	794,925	73,620	4,382,340	66,860
mean	50,815	18,320	26,650	77,940	14,500	401,325	16,075

6.1.3 Relative contribution of determinants of patent value

The individual contribution of the determinants of the value of an European Patent are listed in table 10. The shares are scaled such that they add up to 100 percent. As it turns out, market size is the largest contributor to patent value: it accounts for about 67 percent of the value. The second major contributor is the enforcement of intellectual property rights with a share of 37%. Education accounts for 14 percent of the value, whilst generalized trust accounts for a reduction in value by 17 percent. The other determinants of patent value, namely distance, shared language and common border hardly contribute to the average value of European Patents.

Table 10: Contribution of explanatory variables towards the value of the patent stock

Explanatory variable	Share	Explanatory variable	Share
Market size	67%	Distance	-1.1%
IPR enforcement	37%	Shared language	0.1%
Education	14%	Common border	0.1%
General trust	-17%		

6.2 The value added of an EU Patent

European Patents are in reality nothing more than a bundle of national patents, with each country applying its own set of patent laws. Obtaining an European Patent in the current situation is very costly and there are possible legal difficulties for companies that want to protect their inventions across all European countries. Mainly for these two reasons the European Community has been working on a European Union Patent, or EU Patent[17], since the 1970s. The current status of this ongoing debate is a proposition by twelve member states to use the enhanced cooperation procedure to set up a unitary patent applicable in all participating European Union Member States. Twenty-five Member States have written

[17]The EU Patent is formerly known as the Community Patent, or European Community Patent, or EC Patent. Often, it is abbreviated as COMPAT.

to the European Commission requesting to participate. Spain and Italy remain outside the enhanced cooperation process of forming an enhanced coorperation EU Patent primarily on the basis of ongoing concerns over translation issues.[18]

Using the estimates of the private value of European Patent rights we find that the aggregate value of granted European Patents in 2004 is 2.9 billion euros. The average value of an European Patent granted in 2004 is approximately 51 thousand euros. Table 11 presents the aggregate value of gratned European Patents in 2004 under the reduction of validation and translation costs in the form of an EU Patent and an enhanced coorperation EU Patent. In these simulations it is assumed that the validation costs reduce to zero and the patent only has to be translated in the three official languages of the EPO, namely English, French and German. Since the renewal fees of the national patent offices are the major part of the revenues, we assume that the renewal fees for an EU Patent as a whole have to replace the renewal fees of the national patent offices. Under these assumptions we find that the introduction of an EU Patent would increase the aggregate value of European Patents granted in 2004 by 15%. The average value of an European Patent increases by 15% as well to 59 thousand euro. Excluding Italy and Spain from the EU Patent and maintaining the present situation for these countries would increase the aggregate value of European Patents granted in 2004 by 11% to 3.23 billion euros. The average patent value under enhanced coorperation increases by 11 % to 57 thousand euro.

For both the EU Patent as the enhanced cooperation EU Patent the gains in average

[18]On 15 February, the European Parliament gave its approval for member states to make use of the enhanced cooperation procedure for setting up a common patent system. The agreement among 25 member states concerns the creation of the European patent which in legal jargon is known as a "unitary patent title" as well as the use of English, French and German as the three main working languages. Before the agreement on enhanced co-operation had even been reached, on 8 March, the European Court of Justice ruled that the creation of a Community Patent Court would not be compatible with the provisions of EU law, thereby casting a shadow of doubt over plans to establish a Europe-wide patent system. On March 11 2011, ministers from 25 member states decided to go ahead with plans to introduce a common system for registering patents that would save European businesses millions of euros each year. Italy and Spain excluded themselves, because they refused to accept the proposed rules regarding the choice of official working languages.

and aggregate value stem from three sources. First, the cost associated with validation at the national level are cancelled. In 2004 the aggregate validation costs are over 90 million euro, leading to an average increase in patent value by 1,600 euro. The second source of value increase is cancellation of additional patent translations, except for the three offical EPO languages. On the aggregate level this leads a growth of aggregate patent value by 575 million euro. However, part of this aggregated patent value depreciates by 250 million euro due to patents that make a loss when validated in all EU-countries. This is the case for 16,620 European Patents granted in 2004. The remaining 40,360 European Patents generate additional benefits of patent rights when validated in all EU-countries. This third source generates an additional aggregate value of approximately 25 million euro. Summed up, The introduction of an EU Patent generates 575+90+25-250 = 440 million euro of additional benefits.

In the same way the introduction of an enhanced cooperation EU Patent lead to an increased aggregate value due to 70 million euro savings on validation costs, 470 million euro savings on patent translations, a 230 million euro depreciation due to patents making a loss when validated in the enhanced cooperation and an additional benefit of 20 million euro due to patent rights validated in the enhanced cooperation.

Table 11: Value estimates of European Patent, the EU Patent and the enhanced cooperation community patent.

European Patent	
Stock value (mln euro)	2,900
Mean patent value (euro)	50,895
EU Patent	
Stock value (mln euro)	3,340
Value increment	15%
Mean patent value (euro)	58,617
enhanced coorperation EU Patent	
Stock value (mln euro)	3,230
Value increment	+11%
Mean patent value (euro)	56,687

7 Conclusion

The value of patent rights varies across inventions, countries and industries, which makes it very difficult to study its determinants. Identifying the contribution of factors like market size and the level of enforcement of intellectual property rights can guide policymakers in shaping and enhancing incentives for innovation.

We exploit the validation behavior of European Patent owners to identify how the value of a single patent varies with country and industry characteristics.The patent-holder might choose not to validate his patent in a country if the cost of validation (validation fees, translation costs, and future renewal fees) are larger than the expected benefits of having a patent right in that country. These validation decisions are then used to simultaneously infer the value of the patent right in particular countries and the factors that influence this value.

The empirical evidence confirms earlier results that the value of patent rights is sharply skewed, with most of the value concentrated in the tail of the distribution. It also shows that there are differences between industries in terms of the characteristics of the distribution. Over all industries the mean patent value is about 51k euro. The mean patent values in electrical engineering, instruments and mechanical engineering are much lower, 18k, 27k and 15k respectively. Patent values in chemistry and pharamceuticals rise much sharper with the quantile than in other industries, resulting in higher mean values, 78k and 400k ,respectively.

We have presented evidence showing that potential demand for the underlying invention influences the validation decision, and by inference, the value of the patent. Potential demand has been approximated by market size measured in value added and the average education level in the sectors of use. The relative contribution of potential demand as measured by market size to the value of patent rights is 67%. For education this is 14%. Besides demand, also the need for protection against infringement is a determinant of the value of patent rights. We use the level of general trust as an indicator of the inclination to imitate. Our empirical results show that general trust accounts for a -17% contribution to the value of a patent right. Lastly, we have shown that the level of enforcement of IPR rights in a country positively affects the validation decision and the value of the patent as well. It accounts for 37% to the value of patent rights.

The aggregate value of European Patents granted in 2004 is about EUR 2.90 billion. By adjusting validation costs and the costs associated with the numerous translation requirements, we can simulate the value added of introducting an EU Patent. Our simulations show an increase of 15 percent of the value of the in 2004 granted European Patent stock to EUR 3.34 billion.

A EPC Member States

Table 12: EPC Member States as of June 2011

BE	Belgium	7 October 1977	TR	Turkey	1 November 2000
DE	Germany	7 October 1977	BG	Bulgaria	1 July 2002
FR	France	7 October 1977	CZ	Czech Republic	1 July 2002
LU	Luxembourg	7 October 1977	EE	Estonia	1 July 2002
NL	Netherlands	7 October 1977	SK	Slovakia	1 July 2002
CH	Switzerland	7 October 1977	SI	Slovenia	1 December 2002
GB	United Kingdom	7 October 1977	HU	Hungary	1 January 2003
SE	Sweden	1 May 1978	RO	Romania	1 March 2003
IT	Italy	1 December 1978	PL	Poland	1 March 2004
AT	Austria	1 May 1979	IS	Iceland	1 November 2004
LI	Liechtenstein	1 April 1980	LT	Lithuania	1 December 2004
GR	Greece	1 October 1986	LV	Latvia	1 July 2005
ES	Spain	1 October 1986	MT	Malta	1 March 2007
DK	Denmark	1 January 1990	HR	Croatia	1 January 2008
MC	Monaco	1 December 1991	NO	Norway	1 January 2008
PT	Portugal	1 January 1992	MK	Former Yugoslav Republic of Macedonia	1 January 2009
IE	Ireland	1 August 1992	SM	San Marino	1 July 2009
FI	Finland	1 March 1996	AL	Albania	1 May 2010
CY	Cyprus	1 April 1998	RS	Serbia	1 October 2010

B Value of European Patent rights

Table 13: Distribution of the value of European Patent rights, by technology field.

Quantile	Whole sample	electrical engineering	instruments	chemistry	mechanical engineering	pharmaceu-ticals	other industries
.25	3,350	2,325	3,215	9,000	2,165	36,465	4,640
.50	13,750	5,825	15,100	22,735	10,500	115,730	11,700
.75	29,325	24,550	27,660	45,900	18,870	164,660	22,330
.90	62,500	38,950	59,125	92,400	35,000	215,617	38,850
.95	109,325	56,565	85,800	135,980	48,275	288,940	49,925
.99	205,875	126,500	155,275	256,200	73,620	520,100	66,860
mean	27,240	16,940	23,395	38,975	14,490	120,380	16,075

References

Bessen, J., 2008, The value of US patents by owner and patent characteristics, *Research Policy*, vol. 37, pp. 932–945.

Bessen, J.E. and M.J. Meurer, 2006, Patent litigation with endogeneous disputes, *American Economic Review*, vol. 96, no. 2, pp. 77–81.

Chamberlain, G., 1980, Analysis of covariance with qualitative data, *Review of Economic Studies*, vol. 47, pp. 225–238.

Danguy, J. and B. van Pottelsberghe de la Potterie, 2010, On the consequences of an EU patent for inventors and patent offices, Tech. rep., VoxEU.org, http://www.voxeu.org/index.php?q=node/5294.

Danguy, J. and B. Van Pottelsberghe de la Potterie, 2009, Cost-benfit analysis of the community patent, Breugel Working Paper 2009/08.

Duchateau, L. and P. Janssen, 2008, *The Frailty Model*, Springer, New York.

EPO, 2003, National law relating to the EPC, Tech. rep., Munchen.

European Commission Communication, 2007, Enhancing the patent system in Europe, Com (2007) 165.

Forum, W.E., 2008, Global competitiveness index, Tech. rep.

Galasso, A. and M. Schankerman, 2010, Patent thickets, courts, and the market for innovation, *the RAND Journal of Economics*, vol. 41, no. 3, pp. 472–503.

Ginarte, J.C. and W.G. Park, 1997, Determinants of patent rights: a cross-national study, *Research Policy*, vol. 26, pp. 283–301.

Griliches, Z., 1990, Patent statistics as economic indicators: a survey, *Journal of Economic Literature*, vol. 28, pp. 1661–1707.

Hall, B.H., A. Jaffe and M. Trajtenberg, 2005, Market value and patent citations, *RAND Journal of Economics*, vol. 36, no. 1, pp. 16–38.

Harhoff, D., N. Francis, F.M. Scherer and K. Vopel, 1999, Citation frequency and the value of patented inventions, *Review of Economics and Statistics*, vol. 81, pp. 511–515.

Harhoff, D., K. Hoisl, B. Reichl and B. van Pottelsberghe de la Potterie, 2009, Patent validation at the country level - The role of fees and translation costs, *Research Policy*, vol. 38, pp. 1423–1437.

Harhoff, D., F.M. Scherer and K. Vopel, 2003, Citations, family size, opposition and the value of patent rights - Evidence from Germany, *Research Policy*, vol. 32, pp. 1343–1363.

Johnson, D.K., 2002, The OECD Technology Concordance (OTC): Patents by industry of manufactore and sectors of use, OECD Science, Technology and Industry Working Papers, 2002/5.

Lanjouw, J.O., 1998, Patent protection in the shadow of infringement: simulation estimations of patent value, *Review of Economic Studies*, vol. 65, pp. 671–710.

Lanjouw, J.O. and M. Schankerman, 2004, Patent quality and research productivity: Measuring innovation with multiple indicators, *Economic Journal*, vol. 114, no. 495, pp. 441–465.

Lanjouw, J., A. Pakes and J. Putnam, 1998, How to count patents and value intellectual property: The uses of patent renewal and application data, *Journal of Industrial Economics*, vol. 46, no. 4, pp. 405–32.

McGilchrist, C.A. and C.W. Aisbett, 1991, Regression with frailty in survival analysis, *Biometrics*, pp. 461–466.

Pakes, A., 1986, Patents as options: some estimates of the value of holding European Patent stocks, *Econometrica*, vol. 54, pp. 755–784.

Pakes, A. and M. Schankerman, 1984, The rate of obsolence of patents, research gestation lags, and the private rate of return to research resources, in Z. Griliches, ed., *R&D, Patents, and Productivity*, pp. 73–88, University of Chicago Press.

Park, W.G., 2008, International patent protection: 1960-2005, *Research Policy*, vol. 37, pp. 761–766.

Schankerman, M., 1998, How valuable is patent protection? Estimates by technology field, *RAND Journal of Economics*, vol. 29, no. 1, pp. 77–107.

Schankerman, M. and A. Pakes, 1986, Estimates of the value of patent rights in European countries during the post-1950 period, *The Economic Journal*, vol. 96, pp. 1052–1076.

Silverberg, G. and B. Verspagen, 2007, The size distribution of innovations revisited: an application of extreme value statistics to citation and value measures of patent significance, *Journal of Econometrics*, vol. 139, no. 2, pp. 318–339.

Straathof, B. and S. van Veldhuizen, 2010, Another reason for the eu patent: Declining validation rates, Tech. rep., VoxEU.org, http://www.voxeu.org/index.php?q=node/5909.

Sullivan, R., 1994, Estimates of the value of patent rights in Great Britain and Ireland, *Econommica*, vol. 61, pp. 37–58.

Trajtenberg, M., 1990, A penny for your quotes: Patent citations and the value of inventions, *RAND Journal of Economics*, vol. 21, pp. 172–187.

van Pottelsberghe, B. and M. Mejer, 2008, The London agreement and the cost of patenting in Europe, Discussion Paper 7033, CEPR.

Van Pottelsberghe de la Potterie, B., 2010, Europe should stop taxing innovation, Breugel Policy Brief 2010/02.

Van Pottelsberghe de la Potterie, B. and M. Mejer, 2009, Economic incongruities in the european patent system, Breugel Working Paper 2009/01.

International Patenting

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Abstract

Globalization, high growth rates in high-tech industries, growing emerging markets and harmonization of patent institutions across countries have stimulated patenting in foreign markets. We use a simple model of international patenting developed by Eaton and Kortum (1996), where the decision to patent in a foreign country depends on country characteristics and the quality of the patented invention. With access to a detailed database on individual patents owned by Swedish small firms and inventors, we are able to estimate some of these relationships and test their validity. Our results indicate that the propensity to apply for international patent protection increases with indicators of the quality of the invention and indicators of technological rivalry and market size in the host market.

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1. Introduction

A patent in a specific country protects the inventor from imitators producing in that country and from outside imitators selling there. To get a wider geographical protection, the inventor has to apply for patent equivalents, i.e. parallel patents for the invention in several countries. Accordingly, patent protection increases with the number of patent equivalents, i.e. with the size of the patent family. But to apply for patents in many countries is costly. Therefore, the decision to apply for patent protection in a given country reflects a tradeoff between gains and costs.

During the last decades, there has been a trend towards strengthening and harmonization of patent institutions across nations and regions. At the same time, international patenting has been increasing in importance. In 2010, more than 40 per cent of all patent applications in the world's patent offices were from non-residents. But still, most patents owned by small firms and inventors are patented in one or a few countries only.

The purpose of this study is to analyze the international patenting strategy of small firms and inventors. A theoretical model based on Eaton and Kortum (1996) is set up to analyze the patentees' choice to patent in foreign countries. The model predicts that the probability of patenting in another country is related to characteristics of the invention and indicators of the market where patent protection is applied for, like market size, growth rate and distance from the home country. In the empirical analysis, we use a detailed database on patents owned by Swedish small firms and inventors. It contains information on patent equivalents, a number of variables reflecting the economic value of the patents and characteristics of the firms and the inventors. This database is complemented with host country characteristics. We find that the results in the empirical estimations are in accordance with the model's predictions.

The paper is organized as follows. Some trends in international patenting are discussed in section 2. In section 3, the database and some statistical tests are presented. In section 4, we set up a theoretical model for international patenting. The parameters of the model are empirically estimated in section 5, and the final section concludes.

2. International patenting

In the early stages of the history of intellectual property rights (IPRs), discrimination between nationals and foreigners were frequent (see e.g. Scotchmer, 2004). Since the Paris convention was signed in 1883, foreign patent applicants were granted the same treatment as national applicants. But national patent regulations could still differ. In several agreements and especially with the establishment of the TRIPS (Trade Related Intellectual Property Rights) agreement in the WTO from 1995, dramatic steps towards harmonization and standardization of patent regulations have been made.[1] This agreement imposes minimum requirements for patent institutions and patent regulations on the member countries.[2] Patent institutions are still national (or regional, for instance in Europe), but their design is now regulated by the TRIPS agreement.

Japan, Europe and the U.S. have the largest patent institutions internationally in terms of number of patents. Traditionally, the three systems have differed according to national priorities. However, they have converged considerably in recent years.[3] But there are still some differences. In Europe and Japan, the "first to file" will be granted the patent right. In the U.S., the "first to invent" will get the patent. If a firm files a patent and is granted the patent right, another firm, which have invented first, can regain the right over the patent (Harison 2008). Thus, the validity and novelty of the patent can be challenged in

[1] Multilateral co-operation in the field of IPRs was extended after the Paris convention with an increasing number of member states and several new agreements. For example, the agreement on copyrights in the Bern-convention (1886), the Madrid conventions against false origin (1891), the universal copyright convention (1952), the Rome convention (1961) on protection of neighboring rights and the IPIC treaty (1989) to extend and harmonize IPRs internationally. Most of these multilateral treaties are administrated by the World Intellectual Property Rights Organization (WIPO) located in Geneva. The TRIPS agreement is administered by the World Trade Organization (WTO).

[2] Maskus (2000) provides an overview of IPRs in the world economy. OECD (2004) discusses trends and policy challenges in the world's patent system. In Hoekman and Kostecki (1995) the road from GATT to the WTO (and the TRIPS) is discussed and analyzed. For a critical discussion about reforms in the U.S. patent system, see Jaffe and Lerner (2004).

[3] For instance, before 1988 Japanese patents could only include one claim per patent in contrast to European and U.S. patents which could include multiple claims. Therefore, U.S. and European patents were more open for legal interpretation of their scope. However, in 1988 the scope of Japanese patents became broader and several claims could be included in a single patent. Moreover, before 2000, U.S. patents were not published until they were granted. Therefore, knowledge disclosure occurred later for U.S. patents than for patents from other countries. In 2000, this rule changed and publication now occurs 18 months after the patent is filed. As a result, knowledge diffusion now starts earlier for U.S. patents.

all regions, but the ownership right of the patent can only be challenged in the U.S.[4] Therefore, the risk of filing patents is higher in the U.S. than in Europe and Japan.[5]

Another difference is that the European patent system is much more fragmented than the U.S. and Japanese systems (van Pottelsberghe 2009 and 2010; van Pottelsberghe and Francois 2006). The costs for EPO-patents are considerably higher. After a patent is granted by EPO, the patentee can decide in which country to validate the patent.[6] The patent must be translated to the national language of the countries where the inventor wishes to get a patent right. These translation costs are significant. Renewal fees must be paid in every single country. Furthermore, there is no unitary European litigation court. Especially high-value patents are subject for litigation. If there are parallel litigations in different European countries, the outcome can diverge (upholding or invalidating a patent). At the moment, the EU commission has submitted a proposal of a single European patent which only needs to be translated to three languages (English, French and German) and where litigation would be decided at a unitary European court. However, several EU-authorities must approve this proposal.

During the 1970s, both resident and non-resident patenting relative to R&D decreased in several OECD-countries and in the U.S. in particular. For the U.S., also the absolute number of resident patent applications decreased. In Figure 1, these developments are illustrated for the U.S. Pessimism increased among many economists who feared that R&D had entered a phase of decreasing returns and productivity growth had slowed down. This pessimism was not well founded, since from the mid-1980s and onwards

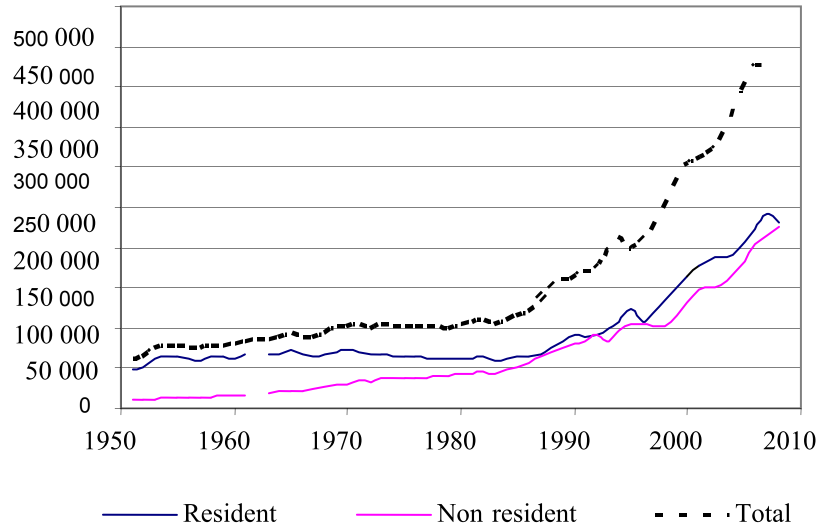
[4] An exception that the patent ownership can be challenged outside the U.S. is if an employee steals a non-patented invention (theft of firm secrecy) from his firm and then files a patent for the invention. The firm can then claim "better right" and can get the ownership of the patent.

[5] A consequence is that the social welfare might be lower in the U.S. as applications are delayed and know-how is not disclosed (Dasqupta 1988).

[6] If a patent is granted by EPO, the national patent offices always have to follow this decision. But if the EPO-patent is rejected or if no EPO-patent is filed, the inventor has always the possibility to get a patent in an individual EPO-member state if the patent is filed directly at the national patent office within the "priority year".

patenting surged.[7] Both national and non-resident patent applications increased. For the world economy, the number of patent families (i.e. the number of patented inventions, inclusive of their patent equivalents) has increased by around 80 % between 1990 and 2006 (WIPO).

Figure 1. Patent applications to USPTO 1952-2006



Source: WIPO

Figure 2 shows developments of the share of non-resident patent applications for all countries, for the U.S. and Japan as well as for U.S. and Japanese patents in EPO.[8] Figures 1 and 2 indicate that non-residents slowly have increased their share of patenting in the major economies.

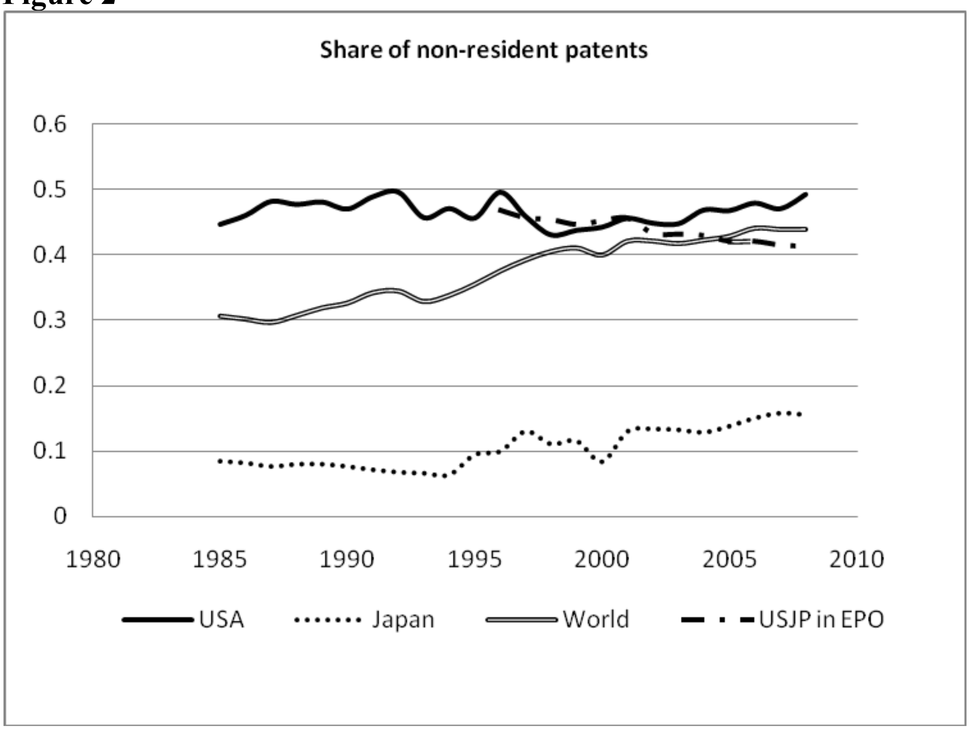
Our discussion above indicates that international patenting is of as great importance as national patenting. But international patenting – or patent families – has so far been the

[7] Griliches (1989) pointed at institutional weaknesses in the patent system to explain the falling trend. Subsequent institutional reforms (both in the U.S., in Europe, in other countries and multilaterally) may lend support to Griliches' view. Kortum (1993), on the other hand, has argued that developments in the number of patent applications (both from residents and non residents) can be explained by economic developments. He has argued that accelerated economic integration from the 1990s onwards has increased market sizes for new technologies and therefore profitability from innovation. The effects of patent institutional reform and the TRIPS agreement from 1995 onwards are still up for debate.

[8] Figures are different for the EPO since the member countries have changed over time. Therefore, internationalization is demonstrated most clearly with the use of large outside countries.

subject for relative few studies. An early contribution by Evenson (1984) discussed trends in international patenting. He showed that there are comparative advantage patterns in invention similar to patterns observed in countries' production. Thus, knowledge production is concentrated in economies with comparative advantages in high tech industries.[9] More recent contributions are Putnam (1996) and Lanjouw et al. (1996) (MORE HERE). Furthermore, several studies have found that the size of the patent family is positively related with patent or firm value (Schmoch *et al.* 1988; Lanjouw and Schankerman 2001; Harhoff *et al.* 2002). This is logical. Only those inventions with sufficiently high values will be patented abroad, given the high costs to file and renew the patents in many countries.

Figure 2



Source: WIPO

[9] Second, Evenson (1984) provides support for the pessimistic view that the number of inventions per scientists was on a declining trend in the early 1980s.

3. Database and descriptive statistics

We use a detailed data set on patents granted to small firms (less than 1000 employees) and individual inventors. The data set is based on a survey conducted in 2003-04 on Swedish patents granted in 1998. In that year, 1082 patents were granted to Swedish small firms and individuals.[10] Information about inventors, applying firms and their addresses as well as application dates for each patent, was received from the Swedish Patent and Registration Office (PRV). Thereafter, a questionnaire was sent out to the inventors of the patents.[11] 867 (out of 1082) inventors filled in and returned the questionnaire, i.e., the response rate was 80 percent. The falling off is not systematic with respect to IPC-classes or geographical regions.[12] The response rate is satisfactorily high, given that such a database has seldom been collected before and that inventors or applying firms normally consider information about inventions and patents confidential.

The questionnaire asked the inventors about the work place where the invention was created, if and when the invention had been commercialized, which kind of commercialization mode was chosen, the profitability of the commercialization, and some more information. The data set was later complemented with data on patent renewal, international patents and forward citations from the Espacenet (2010) website.

The 867 patents in the database have together 1 733 patent equivalents in other countries, i.e. almost exactly two equivalents per patent. The frequency distribution of patent equivalents is shown in Table 1. Only 334 (39%) out of the 867 patents have any patent

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[10] In 1998, 2760 patents were granted in Sweden. 776 of these were granted to foreign firms, 902 to large Swedish firms with more than 1000 employees, and 1082 to Swedish individuals or firms with less than 1000 employees. In a pilot survey carried out in 2002, it turned out that large Swedish firms refused to provide information on individual patents. Furthermore, it proved very difficult to persuade foreign firms to answer fill-in questionnaires about patents. These firms are almost always large multinationals firms. The sample selection in our data is not a problem however, as long as the conclusions are drawn for small firms and individuals located in Sweden.

[11] Each patent always has at least one inventor and often an applying firm as well. The inventors or the applying firm can be the owner of the patent, but the inventors can also own the patent indirectly, via the applying firm. Sometimes, the inventors are employed in the applying firm, which owns the patent. If the patent had more than one inventor, the questionnaire was sent to only one of the inventors.

[12] Of the 20% non-respondents, 10% of the inventors had outdated addresses, 5% had correct addresses but did not respond, and the remaining 5% refused to participate. The only information we have about the non-respondents is the IPC-class of the patent and the region of the inventors. For these variables, there was no systematic difference between respondents and non-respondents.

equivalents at all. This means that given that a Swedish patent has any equivalents, the average number of equivalents per patent is 5.2. The maximum number of equivalents for a given patent is 24.

Table 1. Distribution of the number of patent equivalents in the database.

	Number of patent equivalents														Total
	0	1	2	3	4	5	6	7	8	9	10	11-15	16-20	21-24	
Number of observations (patents)	533	80	43	36	27	27	23	20	14	13	8	31	10	2	867

In total there are patent equivalents in 35 different countries in the data set. The frequency for each country is shown in Appendix A, Table A1. The Swedish patents had 224 equivalents in the U.S. and 141 in Japan as well as 217 EPO-patents. The EPO-patent must then be validated in individual member-countries. The EPO-patents resulted in 1104 individual patents in the EPO-member countries, i.e. on average 5.1 individual patents per EPO-patent.[13] Only 30 equivalents were filed directly at the national patent offices in the EPO-area without filing an EPO-patent first. The EPO-patents in our database are filed most frequently in Germany, Great Britain and France – the large EPO-countries. In the third main area of interest, Japan, the Swedish patents had 141 equivalents. Thus, patent equivalents are not distributed randomly across the countries.[14] Van Pottelsberghe and van Zeebroeck (2010) have shown that there is a strong positive correlation between market size and the probability that an EPO-patent will be validated in that country.

Tables 2, 3, 4 and 5 show partial relationships between the number of patent equivalents and firm types, patent renewal, the number of patent citations and the commercialization decision, respectively.

[13] This average number of equivalents is the same as for EPO-patents in general (van Zeebroeck 2011).

[14] For example, the mean number of patent equivalents for an invention with a patent equivalent in the U.S. is 5.8. A patent with an equivalent in Estonia (or Romania) occurred only once. This had 24 equivalents (both for the Estonian and the Romanian cases). Those countries that are seldom chosen for patent applications occur mostly when also other countries are chosen.

Table 2. Patent equivalents across firm groups. No. of patents and percent.

Firm groups	Medium-sized firms (101-1000 employees)	Small firms (11-20 employees)	Micro companies (2-10 employees)	Individual inventors (no employees)	All firm groups	Chi-square test
No. of patents	116	201	142	408	867	------
Equivalents in 3 main areas	17 (15 %)	22 (11 %)	12 (8 %)	28 (7 %)	79 (9 %)	7.7 *
Equivalents in at least 2 main areas	30 (26 %)	45 (22 %)	41 (29 %)	76 (19 %)	192 (22 %)	9.7 **
Equivalents in at least 1 main area	63 (54 %)	76 (38 %)	62 (44 %)	110 (27 %)	311 (36 %)	35.3 ***
Any patent equivalent	66 (57 %)	87 (43 %)	66 (46 %)	116 (28 %)	335 (39 %)	39.7 ***
Average No. of equivalents	2.54	2.10	2.44	1.64	2.00	------

Note: The three main areas are EPO, USA and Japan. ***, ** and * indicate significance at the 1, 5 and 10 % level, respectively.

The international patenting strategy across firm sizes is shown in Table 2. In the sample, 116 patents are owned by medium-sized firms, 201 by small firms, 142 by micro companies and 408 by individual inventors. Firms have considerably more patent equivalents than individual inventors. This is expected, since international patenting is costly. For example, 54 % of the medium-sized firms in the sample had an equivalent in at least one of the three main areas (USA, EPO and Japan), whereas only 27 % of the individual inventors had chosen such a strategy. The differences in patent equivalents across firm groups are mostly significant using chi-square tests, but not in the case of patent equivalents in all three main areas.

In Table 3, patent equivalents are compared to the renewal of patents. Here, we expect a positive relationship, since both renewal and international patenting should be related to the private value of a patent. Renewal behavior has often been used to infer about the private value (distributions) of patents.[15] Patents which were still alive in 2004 had considerably more often equivalents than expired ones. For example 33 % of the patents still alive in 2004 had equivalents in at least two of the three main areas, but only 9 % of

[15] See e.g. Pakes and Schankerman (1984), Pakes (1986), Pakes and Simpson (1989), Schankerman (1998) and Schankerman and Pakes (1986). In Sweden and most other countries, patent owners must pay an annual renewal fee to the relevant patent office in order to keep their patents in force. The patent expires if the renewal fee is not paid in any single year. Thus, the patent owner has an option to renew the patent every year. The option for further renewal is acquired by renewing the patent at each mandatory date.

the expired patents. The chi-square tests of independence between groups are never lower than 28 which is very high, since the threshold value for 1 percent significance is 6.3.

Table 3. Patent equivalents and survival of patents. No. of patents and percent.

	Renewed in 2004		All patents	Chi-square test
	Yes	No		
No. of patents	482	385	867	------
Equivalents in 3 main areas	68 (14 %)	11 (3 %)	79 (9 %)	32.7 ***
Equivalents in at least 2 areas	159 (33 %)	33 (9 %)	192 (22 %)	74.0 ***
Equivalents in at least 1 area	232 (48 %)	79 (21 %)	311 (36 %)	70.9 ***
EPO-patent	185 (38 %)	32 (8 %)	217 (25 %)	103.1 ***
US-patent	167 (35 %)	57 (15 %)	224 (26 %)	44.0 ***
Japan-patent	107 (22 %)	34 (9 %)	141 (16 %)	28.1 ***
Average No. of equivalents	3.09	0.63	2.00	------

Note: The three main areas are EPO, USA and Japan. ***, ** and * indicate significance at the 1, 5 and 10 % level, respectively.

Table 4. Patent equivalents and forward citations. No. of patents and percent.

	Forward citations		All patents	Chi-square test
	Yes	No		
No. of patents	350	517	867	------
Equivalents in 3 main areas	73 (21 %)	6 (1 %)	79 (9 %)	97.8 ***
Equivalents in at least 2 areas	159 (45 %)	33 (6 %)	192 (22 %)	184.6 ***
Equivalents in at least 1 area	252 (72 %)	63 (12 %)	311 (36 %)	493.4 ***
Equivalents in none of the three main areas	98 (28 %)	454 (88 %)	556 (74 %)	
EPO-patent	181 (52 %)	36 (15 %)	217 (25 %)	222.7 ***
US-patent	185 (53 %)	39 (7 %)	224 (26 %)	223.6 ***
Japan-patent	114 (33 %)	27 (5 %)	141 (16 %)	114.6 ***
Average No. of equivalents	4.00	0.64	2.00	------

Note: The three main areas are EPO, USA and Japan. ***, ** and * indicate significance at the 1, 5 and 10 % level, respectively.

When relating international patenting to forward citations in Table 4, the positive relationship is even stronger. Patents with forward citations had 4.0 patent equivalents on average compared to 0.64 for patents without equivalents. 72 % of the cited patents had equivalents in at least 1 main area, but only 12 % of the non-cited ones, etc. Or from another point of view, 81 % (252 out of 311) of the patents with equivalents in at least 1 main area are cited, whereas only 18 % (98 out of 556) of the patents with no equivalents any main area are cited. Forward citations are considered as a measure on the social value of patents. One reason for this is that patents that are cited in subsequent patents' patent documents are considered as basic inventions which are useful for development of new knowledge. Many studies have also indicated higher private value of patents with many forward citations (see e.g. Jaffe and Trajtenberg, 2002). Thus, a positive correlation between the number of patent equivalents and the number of forward citations is as expected. In addition however, there may be other reasons why this correlation is so high: The citations are mostly added by independent patent examiners at the patent offices. The explanation for the high correlation between the number patent citations and the number of equivalents could be that when a Swedish patent has equivalents in EPO, Japan or the U.S., the patent is much more visible for patent examiners. This will increase the probability that the patent is cited even if the patent citations do not signal higher values of the cited patent.

In Table 5, international patenting is related to commercialization. Here, we also expect a positive relationship, since more valuable patents should both have more equivalents and be commercialized with a higher probability. The descriptive statistics give support to this view. The chi-square tests strongly rejects that there is independence between commercialization and equivalents. Commercialized patents have more frequently patent equivalents than non-commercialized ones. For example, 48 and 28 % of commercialized patents have equivalents in at least 1 or 2 main areas, whereas corresponding figures for non-commercialized patents are 23 and 13 %.

Table 5. Patent equivalents and commercialization. No. of patents and percent.

	Commercialization		All patents	Chi-square test
	Yes	No		
No. of patents	526	341	867	------
Equivalents in 3 main areas	60 (11 %)	19 (6 %)	79 (9 %)	8.5 ***
Equivalents in at least 2 areas	146 (28 %)	46 (13 %)	192 (22 %)	24.4 ***
Equivalents in at least 1 area	233 (48 %)	78 (23 %)	311 (36 %)	41.3 ***
EPO-patent	165 (44 %)	52 (15 %)	217 (25 %)	28.6 ***
US-patent	168 (32 %)	56 (16 %)	224 (26 %)	26.0 ***
Japan-patent	106 (20 %)	35 (10 %)	141 (16 %)	14.9 ***
Average No. of equivalents	2.62	1.04	2.00	------

Note: The three main areas are EPO, USA and Japan. ***, ** and * indicate significance at the 1, 5 and 10 % level, respectively.

4. A model set up for international patenting

The modeling set up presented below is the one developed by Eaton and Kortum (1996). Their model is a full fledged endogenous international growth model in which international patenting plays important roles. In Eaton and Kortum's model, R&D in different countries improves on the quality of input factors used in production processes domestically and in other countries. The degree to which an invention is used in other countries' production processes depends on the probabilistic size of each invention and a probabilistic applicable parameter. If the invention is used in a country's production process, the owner of the invention sells the technology monopolistically to the producer in that country. The owner of the invention faces a risk of imitation. This risk depends on whether or not the invention is patented. Eaton and Kortum (1996) develop the steady state growth paths in the model. This steady state is characterized by similar growth rates in all countries, but lower productivity in countries with low investments in R&D and little use of other countries' technologies. The incentives to do R&D and to patent internationally depend on market size, protection of IPRs and a set of other parameters.

Given the scope of this paper, our set up is less ambitious and meant to provide a rough theory basis for our empirical specification of international patenting. Our available data are micro data and this allows us to formulate patent owners' choice about where to patent.

The model is a quality ladder model of innovation á la Grossman and Helpman (1991). Output in each country is produced with the help of intermediates according to constant returns to scale Cobb-Douglas production function:

1) $$\ln \mathrm{Y} = \int_0^1 \ln\left(Z_v X_v\right) d_v \quad ,$$

where Y denotes production, X_v the quantity of intermediate v and Z_v its quality.

Improvements in the quality of intermediates are the result of R&D and inventions. Inventions improve the quality of an intermediate with a specific percentage amount, which is defined as the size of the invention. The size of an invention is a random variable Q drawn from an exponential distribution.[16] When an invention is adopted to one intermediate Z_v, the quality raises to Z'_v defined as:

$$Z'_{\mathrm{v}} = e^q Z_v \quad .$$

The randomness of invention size makes the patenting decision heterogonous. Inventions that are large may be patented widely; inventions that are small may only be patented in the home country of the owner.

Producers of a newly invented intermediate charge the highest possible price at which production without that invented intermediate is unprofitable (Bertrand competition). Intermediates are produced under a simple production technology where one hour work is needed to produce one unit. The final good is numeral, so given a wage level, w, the price charged by a firm producing the intermediate with the highest available quality, e^q, is given by equation 2. This equation implies *limit pricing* so that the leading firm in the market marginally undercuts the optimal price charged by the firm with next to highest quality. This firm's price optimal equals w after the leader has entered the market. The

[16] The average step of an invention can be parameterized as $1/\theta$.

produced quantity for a firm producing the intermediate v depends then on the demand function derived from equation 1. This demand function is given by equation 3.

2) $$p_v = e^{q_v} w$$

3) $$X_v = \frac{Y}{p_v} = \frac{Y}{e^{q_v} w}$$

Profits from an invention of size q are therefore equal to:

4) $$\pi_v = p_v X_v - wX_v = \frac{e^{q_v} wY}{e^{q_v} w} - w\frac{Y}{e^{q_v} w} = \left(1 - e^{-q_v}\right)Y$$

Equation 4 relates profitability of patenting to market size. This proves to be an important empirical regularity.[17]

A patent reduces the probability that the invention will be imitated in any period during the patents lifetime from k to zero. For simplicity we assume that patents last forever.[18] The discounted values of an unpatented and patented invention of quality q in country j originating in country i at time t are therefore:

5) $$V(q)_{ijt}^{nopatent} = \int_t^{\infty} \left(1 - e^{-q}\right) Y_{jt} e^{g_j s} e^{-(r+k)s} ds$$

6) $$V(q)_{ijt}^{patent} = \int_t^{\infty} \left(1 - e^{-q}\right) Y_{jt} e^{g_j s} e^{-rs} ds$$

Above, r denotes the discount rate and g the growth rate in the economy. The value of patenting is the difference $V(q)_{ijt}^{patent}$-$V(q)_{ijt}^{nopatent}$. The inventor will seek patent protection if this difference exceeds the cost of patenting in country j at time t, C_{jt}. Therefore the equality:

7) $$V(q)_{ijt}^{patent} - V(q)_{ijt}^{nopatent} = C_{jt}$$

[17] For similar formulations of the above relationships, see Eaton and Kortum (1996) or Grossman and Helpman (1991a or 1991b, chapter 4).

[18] It is easy to generalize to a reduction in imitation rates from any $k^{nopatent}$ to any k^{patent}. Also, it is a simple task to introduce a statutory maximum lifetime for patents. This complicates the derived empirical specifications without adding clarity.

determines the threshold quality level $q*$ such that innovations of higher quality are patented while those with lower qualities are not.[19] The threshold $q*$ is given in equation 8. The derivation of it is presented in Appendix B.

8) $$q_{jt}* = -\ln\left(1 - \frac{C_{jt}\left(r-g_j\right)\left(r+k-g_j\right)}{Y_{jt}k}\right)$$

It is seen from equation 8 that the threshold value for q depends on patent costs, market size, interest rate, the growth rate and the risk of being imitated without patenting. The higher the threshold value the lower is the probability that an invention is patented in the particular market. The following results are easily derived:

Lemma 1.

$$\frac{dq_{jt}*}{dC_{jt}} > 0$$

$$\frac{dq_{jt}*}{dY_{jt}} < 0$$

$$\frac{dq_{jt}*}{dg_{jt}} < 0$$

These three results have the following characteristics: The first simply means that the higher the patenting costs, the higher is the threshold value for the quality of an invention to be patented. Therefore, the higher the patenting costs in a country, the lower the probability that an invention will be patented in that country. The second result means that the larger is the GDP in a country the lower is the threshold value for the quality of an invention to be patented. Therefore, the probability that an invention will be patented will be increasing in the market size of a given country. The third result is similar for growth in total GDP.

[19] Note that the cost function, C, has subscripts jt. This indicates the country in which patent protection is applied for and the time when patent protection is applied for. It does not indicate in which country the patent originate however. This reflects the requirement in most international patent treatments of *national treatment*, i.e. that foreign applicants shall treated similar to national applications.

Generally, the quality of patented inventions has unknown distributions. If it is, for instance log normal, the log of returns will be normal. Many other distributions will be possible to analyze. A rough approximation will be to analyze the binary choice (to patent or not) as:

$$9) \qquad PQ_{jt} = \begin{cases} 1 \ \text{ if } \ q_{jt} \geq q_{jt}^{*} \\ 0 \ \text{otherwise} \end{cases}$$

Above, PQ_{jt} denotes whether a patent of quality q is patented in country j or not. Note that the threshold value of the quality of an invention to be patentable is country specific. It depends on characteristics in the country where patent protection is sought. If we assume that a patent's quality can be written as observable patent specific characteristics multiplied with a basic random variable so that for a patent k, $q_k = qh(x_k)$, the probability that the owner of an invention k seeks protection in a country j can be written as:

$$10) \qquad P(PQ_{jk} = 1) = f(\alpha_k \mathbf{Q} + \beta_j \mathbf{T})$$

In equation 10, ***T*** denotes a vector of characteristics of the country in which patent protection is applied for, while ***Q*** denotes a vector of characteristics of the patented invention.

5. Econometric analysis

Our empirical strategy is to run probit regressions on variants of the above model. In our dataset, we have information on whether a patent has been granted in any of the 34 countries (see Appendix A, Table A1).[20] On the basis of this, we create an expanded dataset consisting of 867*34 = 29 478 observations. The dependent binary variable is the choice to apply for patent protection for patent k in country j. Accordingly, we will use a standard probit model to estimate how various explanatory variables are related to the dependent variable.

[20] We lack data for Taiwan (for which there is only one patent equivalent).

5.1 Explanatory variables

All explanatory variables, basic statistics and their expected impact on patent equivalents are described in Appendix A, Table A2. We have collected country specific data from the World Development Indicators (World Bank 2011). The vector of country specific variables includes:

- Total GDP reflects market size in the host country. We use GDP in 2000.
- Growth in GDP in the host country in the period from 1990 to 2000.
- Total patent costs in the host country.

The expected influence of these variables on the probability to be granted a patent equivalent follows directly from our theoretical model above.

The patent cost variable is not available for all countries. One reason for this is that costs of patenting depend on several components. One is the filing costs. Very often (official) translation of the patent documents is required. If so, this adds a new cost component. Often, patentees use patent agencies for handling national patent offices which adds costs that may be diverse. Then renewal costs are added if the patent is granted. In most countries such renewal costs are low but increasing with the age of the patent. In Europe, patent protection can be applied in many countries via EPO. If so, the patent needs to be validated and subsequently renewed in each of member countries individually. But patents in Europe can also be obtained through patent applications to each of the individual countries. There is no patent cost index for all countries. We have therefore chosen to use the patent costs from the survey by Helfgott (1993).[21] A problem with Helfgott's cost data is that they do not overlap the countries in the Swedish patent database. Hefgott's cost data cover 20 of the 34 countries for which we have Swedish patent equivalents data (see Appendix A, Table A1). We report separately estimation results when cost data are included and when they were not included.

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[21] One problem is that the survey is old. The patents covered by our database were granted in 1998, but applied for in the mid-1990s. The costs reported in Helfgott (1993) are therefore too low as compared to the costs faced by the applicants in our dataset. Furthermore, we do not know whether they changed proportionally to each other or not. A second problem is how patent costs via EPO are reported. These should be added validation costs in individual countries to reflect the costs faced by the Swedish firms when applying for patent equivalents in other EPO member countries. We do not have access to these validation costs. We choose to include EPO as a single observation in versions of our regressions and leave EPO out in others.

In addition, we include several host country characteristics:

- R&D intensity (as percent of GDP) in the host country reflects increased probability of being imitated.
- Distance between Sweden and the country in which patent protection is applied for in kilometers. This variable should be included for two reasons. First, trade is known to depend negatively with distance. Therefore the value of patenting will be lower in distant countries (less goods are exported there). But it may also be that distance indicates higher (non-formal) costs of patenting in the country in question. The inventor may have to travel there. Languages and cultures may be more different.
- (GDP per capita. A country's GDP per capita may reflect the technological level of this country and therefore a higher probability of being imitated. The a priori assumption would be a positive effect.)

The patent specific variable vector includes variables from the database. These are:

- Firm size. Due to credit constraints, larger firms should have a higher propensity to apply for patent equivalents (see Table 2). The firm types are included in the regressions as dummy variables.
- Patent survival is a clear and direct indicator of the quality of a patented invention. We include a dummy variable for whether the patent was still alive in 2004 and also the year for which it was first applied for (see Table 3).
- Commercialization. The database contains a dummy variable whether the invention was commercialized. Commercialized patents should have a higher value so that they will be patented in more countries (see Table 4).
- Forward citations. As mentioned above, forward citations should reflect the social value of the patent. Higher private value would imply lower q and higher probability of patenting the invention in any market. Higher social value could imply stronger technological rivalry and higher risk of imitation against the patented invention and therefore higher values of patenting. In this connection, the relationship between forward patent citations and international patenting should a priori be expected to be positive.

In line with the previous literature (Schmoch *et al.* 1988; Lanjouw and Schankerman 2001; Harhoff *et al.* 2002), one of our main hypotheses is that valuable inventions will be more frequently patented abroad than less valuable ones. The last three variables listed above indicate valuable inventions. However, we have reasons to believe that our data is characterized by endogeneity problems. If a patent proves valuable, it will probably both have higher probability of commercialization, it will be renewed for longer periods, receive more forward citations *and* have a higher probability of being granted patent equivalents. It is not clear at the outset that causality runs from any of our right-hand value indicators to patent equivalents. In principle it might be that causation runs in both directions or from our dependent variable towards the independent variables. Therefore, we include the variables indicating invention value with caution.

Since patenting is known to vary much between industries and technology classes (Levin et *al*, 1987), we expect this to be important. Therefore, we use 30 different industry classes – based on the IPC technology class system – according to Breschi *et al* (2004). We define 30 additive dummy variables for these 30 industry classes. However, a patent may belong to several different technology classes. In Espacenet (2010), the technology classes are listed in alphabetic order for each patent. Thus, it is not possible to evaluate which technology class is the main one. Therefore, a patent in our database may belong to as many as four different industry classes. This means that the 30 industry dummies are not mutually exclusive and their estimated parameters should not be interpreted in the normal way.

5.2. Empirical estimations

Since the cost variable is missing for many of our host countries, the results of the estimations are presented without (Table 6) and with the cost variable (Table 7)

In columns A and B of Table 6, only the main country specific variables and the firm size dummies are included. The regressions lend support to our main hypotheses from the modeling exercise above. Market size (log of total GDP) and growth rates in total GDP both correlate positively with the probability of triggering a patent equivalent. Firm size influences positively and significantly on the probability of equivalent patents. Firms without employment constitute the reference group, so other types of firms have higher probability of international patenting than these. The result is as expected and it is highly significant. When including technology class dummies (column B), the results for the other variables are not altered. The probability to apply for a patent equivalent varies significantly across technology classes (not shown in Table 6).

Table 6. Basic estimations without the cost variable.

Dependent variable: the existence of a patent equivalent of patent *k* in country *j* — Statistical model: Probit model

Explanatory variables	A	B	C	D	E	F	G	H
GDP	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***
Growth	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***
Distance			- ***	- ***	- ***	- ***	- ***	- ***
R&D/GDP			-	-	-	-	-	-
Medium	+ ***	+ ***	+ ***	+ ***	+ ***	+	+ ***	+
Small	+ ***	+ ***	+ ***	+ ***	+ **	+	+ **	-
Micro	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ *
Commerce					+ ***			+ ***
Renewal						+ ***		+ ***
Citations							+ ***	+ ***
Technology class dummies	No	Yes	No	Yes	Yes	Yes	Yes	Yes

Note: + or – indicates the sign of the estimated parameters. ***, ** and ** indicate significance at the 1, 5 and 10 percent-level, respectively. Number of observations equals 29 478, of which 1 732 takes on the value of 1 for the dependent variable.

In columns C and D we also include *Distance* and *R&D/GDP* without and with technology dummies. Geographical distance seems to retard patent equivalents as expected. R&D intensity in the country has no significant impact.

Columns E, F, G and H, alternatively and successively, introduce patent specific variables measuring patent value. Commercialization, renewal and forward citations are all strongly positively correlated with the probability of equivalents. The endogeneity issue might be present however. But when including all three patent value variables in column H, the results of the estimated parameters are not strongly affected. It seems like only the firm size variables are affected when the renewal variable is included.

Table 7. Estimations with the cost variable.

Dependent variable: the existence of a patent equivalent of patent *k* in country *j* — Statistical model: Probit model

Explanatory variables	A	B	E	F	G	H	I	J
GDP	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***
Growth	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***
Costs	+ ***	+ ***	-	- *	-	-	-	-
Distance			- ***	- ***	- ***	- ***	- ***	- ***
R&D/GDP			+	+	+	+	-	-
Medium	+ ***	+ ***	+ ***	+ ***	+ ***	+ **	+ ***	+
Small	+ ***	+ ***	+ **	+	+ ***	+	+ **	-
Micro	+ ***	+ ***	+ ***	+ ***	+ ***	+ *	+ ***	+ *
Commerce			+ ***			+ ***		+ ***
Renewal				+ ***		+ ***		+ ***
Citations					+ ***	+ ***		
Citations Intra							+ ***	+ ***
Citations Inter							+ ***	+ ***
Technology class dummies	No	Yes	No	Yes	Yes	Yes	Yes	Yes

Note: + or – indicate the sign of the estimated parameters. ***, ** and ** indicate significance at the 1, 5 and 10 percent-level, respectively. Number of observations equals 17 340, of which 1 536 takes on the value of 1 for the dependent variable.

In Table 7, we report similar regressions where patent costs are included. But here we jump models C and D. Instead we split the forward citation variable in intra and inter-industry citations according to Maurseth (2005). We focus on the patent cost variable. The results for the other explanatory variables are as same as in Table 6, although the inclusion of the cost variable and .the fact that the number of observations is heavily reduced.

Surprisingly the cost variable has a positive and significant impact on patent equivalents in columns A and B. The explanation for this is the high costs of patents in the EPO area, which is located close to Sweden. When including the distance variable in Column E and onwards, the parameter of the cost variable gets the expected negative sign. However, the significance is fragile.

Note that our results are in line with those of Harhoff *et al.* (2009). They estimate a gravity relationship for patenting among European countries (and for other non-European patent applications in Europe) and find similar results for the aggregate number of patent equivalents between these countries. Equivalents depend positively on market size, negatively on distance and negatively on costs.

Both forward citations within and between technology classes matter (Columns I and J in Table 7). These technology classes are defined according to whether the cited and the citing patent belong to the same narrowly defined technology class (four-digit IPC level). In Maurseth (2005), it was found that patents that were cited by patents within the same technology class lapsed earlier. Such citations were therefore interpreted as rival patents that potentially may make the patent obsolete. In our context such rivalry should increase the profitability of patenting. The positive and significant coefficient is in line with this interpretation. Inter technology class citations may indicate high economic values of a patent. Such a patent may mark a scientific breakthrough and open up opportunities for further research. The positive and significant coefficient is in line with this interpretation. For our interpretations of the effect of citations one should note the above warning that there may also be spurious correlations and possibly endogeneity problems. In future research we intend to go deeper into this issue.

The dataset consists of the patent dimension and the country dimension. Therefore the more than 30 000 observations are not independent. In principle the structure of the data is a panel. The cross section dimension is for the patents. The other dimension is for countries. In Table 8 (not yet finished), we reproduce the results from Table 7 from a panel data regression. The results are fairly similar to those reported above. *We need to rerun these regressions.*

Quantitative interpretations of estimated parameters have to be undertaken.

6. Summary and concluding remarks

We have presented trends in international patenting based on a database on Swedish patents and their international equivalents. We also modeled international patenting as the result of a strategy where gains and costs were traded off against each other. The model predicts that equivalents depend on market size, growth, patent costs and patent specific variables.

Our empirical results support the predictions from the theoretical model. First, more valuable patents – either measured as patent renewal, commercialization or forward citations (both within and between technologies) – have more patent equivalents. Second, also the country specific variables have estimates in line with expectations. Market size, economic growth and distance have coefficients with expected signs which also are significant. Also R&D intensity has the expected impact (when costs are included), but is not significant. Patenting costs influence equivalents negatively as expected, but probably due to low data quality, the significance of the estimated coefficient is fragile. The choice to apply for patents abroad also varied across technology classes.

In future work we intend to extend the study. First, we will include overlap in R&D and in industrial specialization between Sweden and the country in question in order to better reflect the probability that an invention will be marketed and that it will imitated. Second, we need to improve the patenting costs data.

Appendix A

Table A1. Basic information about patent equivalents and costs.

Country	No. of patent equivalents	of which via EPO	EPO member in 1998	Costs available (Helfgott 1993)
United States	224		0	Yes
Canada	41		0	Yes
Brazil	5		0	Yes
EPO	217	217	---	Yes
Germany	210	195	1	Yes
Great Britain	177	174	1	Yes
France	150	148	1	Yes
Netherlands	80	79	1	Yes
Belgium	45	45	1	No
Ireland	34	34	1	No
Switzerland	57	56	1	Yes
Austria	42	41	1	Yes
Italy	87	87	1	Yes
Spain	82	82	1	Yes
Portugal	21	21	1	No
Greece	17	17	1	Yes
Denmark	65	62	1	Yes
Finland	62	58	1	Yes
Luxembourg	3	3	1	Yes
Cyprus	2	2	1	No
Norway	38		0	Yes
Monaco	4		0	No
Russia	16		0	No
Estonia	1		0	No
Poland	21		0	No
Czech Republic	5		0	No
Hungary	2		0	No
Romania	1		0	No
Bulgaria	3		0	No
Japan	141		0	Yes
China	37		0	No
Hong Kong	4		0	No
Taiwan	1		0	Yes
Korea, Rep.	1		0	Yes
Australia	53		0	Yes
New Zealand	1		0	Yes

Table A2. Explanatory variables and hypotheses.

Denotation	Description	Mean	Std. dev.	Expected impact
GDP	Log of GDP in the host country in 2000 (USD)	26.0	1.83	+
Growth	Annual growth rate in GDP in the host country between 1990-2000 (USD)	-1.48	0.17	+
Costs	Log of total costs of patenting in the host country (USD) (Helfgott 1993)	-1.68	0.75	-
Distance	Log of distance in kilometers between Sweden and the host country	7.72	1.01	-
R&D/GDP	R&D expenditures per GDP in the host country in 2000 (percent)	1.44	0.84	+
Medium	Dummy which equals one if patent is owned by a medium-sized firm (101-1000 employees)	0.13	0.34	+
Small	Dummy which equals one if patent is owned by a small firm (101-1000 employees)	0.23	0.42	+
Micro	Dummy which equals one if patent is owned by a micro company (101-1000 employees)	0.16	0.37	+
Commerce	Dummy which equals 1 if the patent was commercialized, and 0 otherwise	0.61	0.49	+
Renewal	Dummy which equals 1 if the main patent was still alive in 2004 and 0 otherwise	0.56	0.50	+
Citations	Number of forward citations per five years period between application date and 2007	0.50	1.00	+
Citations Intra	Number of intra-technology forward citations per five years period between application date and 2007	0.45	0.92	+
Citations Inter	Number of inter-technology forward citations per five years period between application date and 2007	0.05	0.20	+
Technology class dummies	30 different technology class dummies, which are not mutually exclusive	----	----	Various

Appendix B

Derivation of equation 8

$$V(q)_{ijt}^{patent} - V(q)_{ijt}^{nopatent} = \int_0^\infty (1-e^{-q}) Y_{jt} e^{g_j s} e^{-rs} ds - \int_0^\infty (1-e^{-q}) Y_{jt} e^{g_j s} e^{-(r+k)s} ds$$

$$= (1-e^{-q}) Y_{jt} \int_0^\infty \left(e^{(g_j - r)s} - e^{(g_j - r - k)s} \right) ds$$

$$= (1-e^{-q}) Y_{jt} \left(\frac{1}{r-g_j} - \frac{1}{r+k-g_j} \right) = (1-e^{-q}) Y_{jt} \left(\frac{k}{(r-g_j)(r+k-g_j)} \right) = C_{jt}$$

$$\rightarrow (1-e^{-q}) = \frac{C_{jt}(r-g\ \ )(r+k-g_j)}{Y_{jt}k}$$

8) $$q_{jt}* = -\ln\left(1 - \frac{C_{jt}(r-g_j)(r+k-g_j)}{Y_{jt}k} \right)$$

References

Breschi, S., F. Lissoni and F. Malerba, 2004, 'The empirical assessment of firms' technological coherence: data and methodology', in: Cantwell, J., Gambardella, A., Granstrand, O. (eds.), *The Economics and Management of Technological Diversification*, Routledge, London, 68-96.

Dasqupta, P., 1988, 'Patents, Priority and Imitation or, the Economics of Races and Waiting Games', *The Economic Journal*, 98(389), 66-80.

Eaton, J. and S. Kortum, 1996, 'Trade in Ideas. Patenting and Productivity in the OECD', *Journal of International Economics,* 40, 251-278.

Eaton, J. and S. Kortum, 1999, 'International Technology Diffusion: Theory and Measurement', *International Economic Review*, 40(3), 537-570.

Eaton, J. and S. Kortum, 2001, 'Trade in Capital Goods', *European Economic Review,* 45, 1195-1235.

Eaton, J. and S. Kortum, 2002, 'Technology, Geography and Trade', Econometrica, 70(5), 1741-1779.

Espacent, 2010, Espacenet database, http://www.epo.org/searching/free/espacenet.html

Evenson, R.E., 1984, 'International Invention: Implications for Technology Market Analysis', in Griliches, Z. (ed.) *R&D, Patents and Productivity*, NBER University of Chicago Press, Chicago,

Fagerberg, J., 1994, 'Technology and International Differences in Growth Rates', *Journal of Economic Literature,* 42, 1147-75.

Fagerberg, J., 1987, 'A technology gap approach to why growth rates differ', *Research Policy*, 16, 87-99.

Griliches, Z., 1990, 'Patent statistics as economic indicators: A survey', *Journal of Economic Literature,* 28, 1661-1707.

Griliches, Z., 1989, 'Patents: Recent Trends and Puzzles', *Brookings Papers on Economic Activity*, Microeconomics, 291-319.

Grossman, G.M. and E. Helpman, 1991a, 'Quality Ladders in the Theory of Growth', *Review of Economic Studies,* 58(1), 43-61.

Grossman, G.M. and E. Helpman, 1991b, *Innovation and Growth in Global Economy*, MIT Press, Cambridge, Ma.

Kortum, S., 1993, 'Equilibrium R&D and the Patent-R&D Ratio: U.S. Evidence', *American Economic Review,* Papers and Preceedings, 83(2), 450-457.

Harhoff, D., K. Hoisl, B. Reichl and B van Pottelsberghe, 2009, 'Patent Validation at the Country Level – The Role of Fees and Translation Costs', *Research Policy*, 38, 1423-1437.

Harhoff, D., M. Scherer and K. Vopel, 2002, 'Citations, Family Size, Opposition and Value of Patent Rights', *Research Policy*, 32(8), 1343-63.

Harison, E., 2008, *Intellectual Property Rights, Innovation and Software Technologies. The Economics of Monopoly Rights and Knowledge Disclosure*, Edward Elgar, Cheltenham, U.K., and Northampton, Ma.

Helpman, E., 1993, 'Innovation, Imitation and Intellectual Property Rights', *Econometrica*, 61, 1247-80.

Hoekman, B. and M. Kostecki, 1995, *The Political Economy of the World Trading System. From GATT to WTO*, Oxford University Press, Oxford.

Jaffe, A.B., 2000, 'The U.S. Patent System in Transition: Policy Innovation and the Innovation Process', *Research Policy*, 29, 531-57.

Jaffe, A.B. and J. Lerner, 2004, *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It*, Princeton University Press.

Jaffe, A.B. and M. Trajtenberg, 2002, *Patents, Citations & Innovations. A Window on the Knowledge Economy*, MIT Press, Cambridge Ma.

Krugman, P., 1979, 'A Model of Innovation, Technology Transfer and the World Distribution of Income', *Journal of Political Economy*, 87, 253-66.

Lanjouw, J., A. Pakes and J.D. Putnam, 1996, *How to Count Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data*, NBER Working Paper 5741.

Lanjouw, J. and M. Schankerman, 2001, 'Characteristics of Patent Litigation: A Window on Competition', *RAND Journal of Economics*, 32(1), 129-51.

Lévêque, F. and Ménière, Y., 2004, *The Economics of Patents and Copyright*, The Berkeley Electronic Press, http://www.bepress.com/leveque/

Levin, R. C., A.K. Klevorick, R.R. Nelson and S.G. Winter, 1987, 'Appropriating the Returns from Industrial Research and Development', *Brookings Papers on Economic Activity,* 783-831.

Maskus, K.E., 2000, *Intellectual Property Rights in the World Economy* Institute for International Economics, Washington D.C.

Maurseth, P. B., 2005, 'Lovely but dangerous: The Impact of Patent Citations on Patent Renewal', *Economics of Innovation and New* Technology, 14(5), 351-374.

Pakes, A., 1986, 'Patents as Options: Some Estimates of the Value of Holding European Patent Stocks', *Econometrica*, 54, 755-84.

Pakes. A. and M. Schankerman, 1984, 'The Rate of Obsolescence of Patents, Research Gestation Lags and the Private Return to Research Resources', in Griliches Z. (ed.) *R&D, Patents and Productivity,* NBER, University of Chicago Press, Chicago, 73-88.

Pakes, A. and M. Simpson, 1989, 'Patent Renewal Data', *Brookings Papers of Economic Activity,* Microeconomics, 331-410.

Putnam, J.D., 1996, *The Value of International Patent Rights*, Ph.D. thesis, Yale University.

Schankerman, M., 1998, 'How Valuable Is Patent Protection? Estimates by Technology Field', *RAND Journal of Economics*, 29, 77-107.

Schankerman, M. and A. Pakes, 1986, 'Estimates of the Value of Patent Rights in the European Countries during the Post-1950 Period', *Economic Journal*, 96, 1052-76.

Scotchmer, S., 2004, *Innovation and Incentives*, MIT Press, Cambridge, Ma.

Schmoch, U., H. Grupp, W. Mannsbart and B. Schwitalla, 1988, *Technikprognosen mit Patentindikatoren*, Verlag TÜV Rheinland, Köln.

Van Pottelsberghe, B., 2009, *Lost Property: the European Patent System and Why It Doesn't Work*, Bruegel Blueprint, Brussels.

Van Pottelsberghe, B., 2010, 'Europe Should Stop Taxing Innovation', *Bruegel Policy Brief* 2010/02.

Van Pottelsberghe, B. and D. Francois, 2006, 'The Cost Factor in Patent Systems', CEPR Discussion paper No. 5944, CEPR, London.

Van Pottelsberghe, B. and N. Van Zeebroeck, 2008, 'A Brief History of Space and Time: The Scope-Year Index as a Patent Value Indicator Based on Families and Renewals', *Scientometrics*, 75(2), 319-38.

Van Zeebroeck, N., 2011, 'The Puzzle of Patent Value Indicators', *Economics of Innovation and New Technology*, 20(1), 33-62.

World Bank, 2011, available at http://databank.worldbank.org/ddp/home.do

Do university patents have an impact on the local innovative activities? Evidence from a large panel of regions from United States and Europe

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Keywords

University patents, localization, inventive entrepreneurship

Abstract

This paper investigates the connection between inventions from public research organisations and those from business at local level in US and EU15 countries using patents as indicators of innovative activities. It is based on an extensive use of an exhaustive EPO database. First, it addresses the co-location of public research (not business) inventions and business inventions in the same region. Then, the relationship between public research inventions and inventive entrepreneurship at the regional level is analyzed with an econometric model.

There are several findings of this study. First, patenting activity by business and non business organisations tend to take place in the same regions, once controlled for other factors like size of the region. Second, co-location is stronger within individual technological fields, suggesting that the local connection between NBO and business inventions is mainly technology specific rather than generic and coincidental. Third, co-location of NBO and business inventions has been increasing over time, between the early 1990s and the mid-2000s, possibly reflecting the impact of changes in the policy and economic environment of innovation (E.g. closer links between university and business). Lastly, NBO patenting is closely associated to inventive entrepreneurship at the local level, identified with new patenting businesses: regions where NBOs are more inventive are also those where more newly inventive enterprises are established and the two display a similar pattern by technical fields.

Introduction

Over the past decade or so, the regional dimension has taken an increasing place in innovation policies. "*Clusters*" (Richard Porter [42]), "*poles de compétitivité*" (France), "*industrial districts*" (Italy), "*learning regions*" (Richard Florida, [14]) are now central notions in innovation policy in most OECD countries [37]. There is a dominant view in economic and policy circles that the location of innovation activities matters and that the geographical concentration of innovative activities is favourable to their efficiency. Already one century ago Alfred Marshall [31] pointed to the notion of *"external economies"* which encapsulate the idea that some activities are more efficiently conducted when they are performed in a same location: this notion is now applied to innovation and it is being implemented by policy makers.

At the same time, the notion of technology transfer from the non business organizations (hereafter also NBOs) to industry has become a central theme of innovation policy [34, 35]. Governments want more of the research conducted in the public sector (mainly universities but also other public research centres) to be used in the economy and for that matter they have set up various types of instruments which should give incentives to universities to do more transfer and to industry to be more receptive to such transfers. This is exemplified by the Bayh-Dole act in the US (1980) – followed by similar legislation in many European countries and more in general in OECD level – which allowed public research organisation to file patents for their inventions. According to its advocates this act would have facilitated the implementation of the corresponding inventions by businesses, reassured by the legal exclusivity provided by patents. Most university systems in the world are now encouraging the development of Technology Transfer Offices (hereafter aslo TTOs), whose mission is to enhance the commercialisation of inventions made in universities [37].[1]

[1] One recent example of a national innovation policy having a strong emphasis on local clusters and on university-industry linkages is the "Pôles de Compétitivité" set up in France since 2005. These poles gather, on a local basis, businesses (established or new), research labs, public or private, and education institutions. The aim is to foster the innovation at the national level by relying on synergies and co-operations at the local level. The underlying idea is that such interactions are more easily handled, and more fruitful, when developed between neighbouring partners.

The research questions addressed by this paper is at the cross road of these two policy themes. It deals both with the local dimension and with technology transfers. Investment in university research can be one of the tools used by government (national or local) in view of boosting local innovation. The underlying vision is that innovation is favoured by proximity of innovators and that universities can enhance this proximity-based positive effects. It is therefore of high interest to know to what extent university research affects local industrial innovation.

More in particular - using novel and extensive quantitative evidences – the goal of this paper is the investigation of the connection between inventions from public research organisations and those from business at local level in the US and EU15 countries using patents as indicators of innovative activities. On the one hand, the paper answers to the question to what extent public research inventions and business inventions are co-located in the same region. On the other hand, the relationship between public research inventions and new inventive entrepreneurship at the regional level is analyzed.

When examining university-industry linkages, previous studies have accounted the diversity of channels and of effects of university research on industry inventions, which can all have variegated size and variegated geographical scope. Certain effects, involving training and the labour market [36, 4], or any direct, face to face, repeated interaction [45], will be rather localised [6], whereas effects involving the transfer of codified and abstract knowledge (embodied in publications or patents) could well be immediately national or global [18]. However, often the knowledge produced in universities with direct interest for industry can be non-directly operational and require further adaptations [35]: in this case the effects of universities research is mediated by several local factors such as local skills, research infrastructure, venture capitalists, efficiency of the TTOs, etc.

The effects can also be variegated in terms of the actors involved: innovation can be developed by established and large firms, or it can be conveyed by new firms, start-ups. Both types of firms can be affected by university research, but probably in different ways. Clusters characterised by the presence of a large and dominant firm benefit more from academic research conducted in the same region and same technological field [3]. In clusters with no such large firm the transmission mechanism of knowledge from universities is mediated by the presence of the so called *"star scientists",* individuals with an outstanding scientific carrier and strongly legitimized to act also in the industrial context [52, 55], or by pre-existent knowledge, managerial and venture capitalists networks [44,10,47]. Again these studies points to the localized nature of knowledge produced in universities.

Our study builds over this stream of literature and reports several new findings and research advancements. First, this paper is among the first attempts to bring extensive quantitative evidences of the impact of university inventions across a US and European regions. Second, we document that patenting activity by business and non business organisations tend to take place in the same regional context across all the countries considered. Third, co-location is stronger within individual technological fields, suggesting that the local connection between NBO and business inventions is mainly technology specific. Fourth, co-location of NBO and business inventions has been increasing over time, between the early 1990s and the mid-2000s, possibly reflecting the impact of changes in the policy and economic environment of innovation (E.g. government policies promoting closer links between university and business). Lastly, NBO patenting is closely associated to inventive entrepreneurship at the local level, identified with new patenting businesses: regions where NBOs are more inventive are also those where more newly inventive enterprises are established.

The paper proceeds as follows. Section 1 reviews the literature on clustering of innovation activities and discusses some testable hypothesis. Section 2 reports the statistical sources, that is the patent database used, and how university patents were identified among all patents. Section 3 shows the co-location of industry and university inventive activities – they tend to occur in the same regions. Section 4 analyses the relation between university inventive performance on entrepreneurship with an econometric model, showing that they have a significant linkage.

1. Literature review and hypothesis

In this section we review the innovation studies literature that has addressed the regional dimension of the impact of university research on industry and we advance some research hypothesis to be tested in the latter part of this paper. Firstly, we briefly synthetize how the previous contributions have broadly analyzed the channels of interactions of university and business innovative acticities (section 1.1). Secondly, we review the studies on the effects of geographical distance on the innovative activities and how it interplays with knowledge transfer from universities (section 1.2). Lastly, we focus on role of the universities in fuelling entrepreneurship at the local level (section 1.3).

1.1 Why university research is important for industry

Previous studies on university-industry linkages addresses the impact of university research on industry, distinguishing three types of interactions: knowledge spillovers, human capital and knowledge transfers.

Firstly, universities conduct basic research that when it is published can be accessed by all society, including business. The "public good" aspect of knowledge allows its use at zero or very low direct cost across society. The lack of appropriability of this knowledge justifies the fact that it is funded by government, as market forces result in a private rate of return which is lower than the social rate of return, hence reducing the incentive to conduct R&D in a market context [5,11].

Secondly, universities train people at all levels, notably researchers, as part of doctorate or post-doctorate programs, contributing to the growth of human capital in the regional and national context [36, 35]. Researchers in the business sector are trained in universities, they often start their research career in universities, where they learn basic research techniques, scientific standards, they integrate professional networks etc. When moving to a job in a business, a former student or university researcher will bring this human capital with him/her.

Thirdly, university research can generate knowledge that could be of direct interest for industry [35]. However, the knowledge transfers from universities might require particular efforts and involve commercial transactions. One underlying reason is that all knowledge is not codified; much of it is tacit, embodied in individuals and groups of researchers. This know-how requires dedicated efforts to be transferred: researchers have to spend time etc. In addition, the knowledge coming out of university research is often not directly operational; it requires further development before being put at industrial use. As a result, there is a variety of channels for technology transfer beyond the mere publication of results, and a variety of contractual forms corresponding to these channels. Universities can encourage the creation of spin-offs, generally involving the researchers who have made the initial discovery; they can grant licenses to businesses which will implement the discovery, which often involves dedicated effort to transfer know-how; university professors can do consulting for businesses in their area of expertise, etc. [53, 54]. Active, self-interested participation of discovering scientists is an essential condition for successful commercial licensing of most university inventions. When the knowledge is both scarce and tacit, as it is often the case in breakthrough discoveries, it constitutes intellectual human capital retained by the discovering scientists and is embodied in them. In such circumstances, labour mobility is required to transfer the knowledge successfully (as found empirically by Jensen and Thursby [24]).

1.2 The impact of distance on innovative activities

The major reason why knowledge transfers are sensitive to distance is that they often require personal contact, either of an informal, random nature, or of repeated nature [45]. Personal contacts are necessary in order to pass on knowledge that cannot be articulated or expressed in formal language. Typically, personal contacts are favoured by the mobility of workers across employers, which is largely local as the labour market itself is mainly. Moreover frequent interpersonal contacts, which in turn facilitate information exchange, lower uncertainty, facilitate trust and control, diffusion of common values and beliefs, and promote learning.

Previous econometric studies have shown that knowledge transfers are geographically bounded. For example, Jaffe, Trajtenberg and Henderson [20], using US patent citations within more than 400 technological fields as an indicator of knowledge spillovers, finds evidence that knowledge spillovers are quite localised: citing patents are 1.2 times more likely than the control group to come from the same country as the cited patent, two times more likely to come from the same US state and six times more likely to come from the same country. For Europe, Maurseth and Verspagen [32] shows a negative influence of distance, positive influence of “being in the same country” and “having the same language”, positive influence of “technological compatibility” (having patents in sectors which cite a lot each other). Bottazzi and Peri [9] analyse 86 European regions in the 1977–1995 period and test if expenses on R&D exert an impact on patenting activities in neighbouring regions. They find a small but statistically significant influence over a distance of 300 km from the source region. Outside of the 300 km range no effect is identifiable, which confirms the hypothesis that knowledge flows decay with distance.

Agglomeration, clustering of innovative activities occurs as a consequence of the negative impact of distance on knowledge transfers: if closer interactions are favoured by small distance, and if closer interactions increase efficiency, then innovative activities will tend to cluster and agglomerate. More in general, the tendency of economic activities to agglomerate has been shown in various studies: as Paul Krugman [23] observes, “production is remarkably concentrated in space”. That applies also to innovative activities, as it was shown by Acs, Audretsch and Feldman [2], and even more in industries where the fast generation of new knowledge plays an important role – such as computers and semiconductors, pharmaceuticals and biotechnology, etc. (See also [6]).

Distance also affects several factors that impact on innovative activities beyond knowledge transfers. Typically, the labour market is localised - pools of specialised skills, engineers, experts etc. – as people travel and move with a cost [4]. In addition, physical access to specific infrastructure is needed for certain innovative activities: research equipment, research centres, training centres etc [26]. Finally, distance impact also the financing of R&D projects: it has been shown that the probability that a firm obtains funding from a venture capitalist (VC) decreases with the distance between the firm and the VC [46].

While all these studies point to clear empirical evidences on business R&D activities benefit from agglomeration, few studies have addressed specifically the geographical dimension of university-industry linkages. Jaffe [19] shows that knowledge spills over for business use from university as well as industrial labs, within US states. Feldman and Audretsch [13] found that the knowledge created in university laboratories spills over to contribute to the generation of commercial innovations by private enterprises. The location of “*star-scientists*” has been found by Zucker, Darby and Brewer [55] to determine the location of start-up firms in biotechnology, which are heavily based on their scientific activities.

The channels of knowledge transfer and the types of entities involved matter in the ability of clusters to generate an efficiency premium to their members. For instance, Agrawal and Cockburn [3] show that clusters characterised by the presence of a large and dominant firm benefit more from academic research (conducted in the same region and same technological field) than clusters with no such large firm. They call this effect the “anchor-tenant hypothesis”.

Thus, co-location could be considered a first hint of some interaction at the local level between universities and businesses. If such interactions are important, one would expect the two types of activities to be located close to each other. Co-location analysis does not say anything about causality; it does not say what the channels of interaction are (communication, infrastructure, formal/informal, etc): that is its limit, but also its merit as it can reflect the joint outcome of all these aspects, which is useful as a first step investigation. Hence, we advance the following hypothesis:

> *Hypothesis 1: Ceteris paribus, university and business inventive activities are spatially collocated.*

1.3 Universities and regional entrepreneurship

The tendency of entrepreneurship to be locally embedded has attracted the attention of scholars and policy analysts and has fuelled a new wave of studies in the last decade. According to a survey conducted by Sorenson and Stuart [47] using ISI Web of Science repository there were 350 entrepreneurship studies in year 2006 and this number is three times larger than in year 2000, which in turn was also three times larger than the number of articles published in year 1990. While these studies are quite diverse in terms of approach and conclusions, there is general consensus on the fact that entrepreneurship activity has effects on the regional economy and is strongly influenced by regional factors.

On the one hand, the effects of entrepreneurship on economic growth (value added or employment) at the regional level have been identified in various studies on the US, Germany, Spain, Sweden etc (see the survey [6]): regions with stronger entrepreneurship activity are also the ones with higher economic growth and job creation. The advent of the knowledge economy and the parallel development of science-based industries (e.g. biotechnology, software) have been accompanied by the emergence and success of start-ups, which in many instances have out-performed incumbent firms. Examples include Microsoft in operating systems, Google and Yahoo in web applications, Amgen and Genentech in biotechnology, Echelon in automation and many others.

One the other hand, the determinants of entrepreneurship are partly localised. First, many entrepreneurs are initially employees of large firms or university researchers operating in the region where the new firm is started: industry case studies have focused on biotechnology [33, 39, 52, 25], chemical and electrical engineering [21, 35], semiconductor and laser [22], and medical instruments [50]. Hence an innovation cluster, which gathers already a large number of individuals with technical and entrepreneurial knowledge, is a favourable milieu for entrepreneurship to flourish. In particular, Zucker and Darby [54] show that in a given region of one of the 26 largest scientific countries the number of "star scientists" (taken from the 5,401 most cited scientists identified by the ISI over 1981-2004) significantly increases the probability of firm entry in similar technological.

A second explanatory factor for the localised nature of entrepreneurship activity is related to the fact that creating a new firm requires much "social capital" which gives access to knowledge networks, to financial networks, and managerial networks, all networks with a local dimension (not exclusive also of a broader, national or global, dimension as well) [44, 41]. The biotechnology industry in the San Francisco Bay Area is a quintessential example. First, when knowledge networks are characterised by their independent and self-sustaining dynamics, often they are also lead by principles of openness to all the members of a local community and diversity of the focal partners (business and public research organizations) [44]. Second, the venture capital community which was born in the so called Silicon Valley in the 1970s has been a decisive factor in the emergence of a biotechnology industry in the same place in the 1980s [46, 43]. Finally, the managerial networks have arisen and incubated in some few early companies located in San Diego area propelled their beneficial effect along the whole development of the industry and region [10].

A third explanation for the localised nature of entrepreneurship is given by geographical proximity that can facilitate technological transfer and licensing from universities. Previous research has shown that inventions covered by university patents are characterised by a high technological generality, which point to large spillovers vis-à-vis business inventions [18].[2] Licenses from universities are not necessarily local, but in many cases their implementation

[2] We validated this finding by several interviews with TTO managers in US and EU countries. Even, for the most experienced universities in the technological transfer process, their patent are far more distant from the commercialization and exploitation than business patents on average. For example, one TTO manager from MIT claimed that the time to market of a MIT chemical patent is on average almost double than for patents invented by industry. Interview with JF, MIT Technology Licensing Office, November 4, 2010.

requires complementary knowledge transfer that will be eased by proximity [12]. In this direction universities can fuel the generation of knowledge and complementary infrastructure facilities that can be particularly beneficial for the economic activities of new high-tech start-ups during an early stage of their life. For example, Benneworth and Charles [8] – analyzing two cases studies based on the historical development of the high-tech clusters of Twente and Newcastle – argue that university and their spin-off programs not only have created a regional knowledge pool that is actively used and relevant to other firms but also in turn they have incepted a positive loop process that could propel further firms' agglomeration dynamics based on knowledge externalities even in "peripherical" type regions.

According to the study of Audretsch, Lehmann, and Warning [7] new high-tech firms strategically locate in cities with large and active universities. However, the mechanism how firms benefit from the knowledge pool created by universities is not simple and straightforward. In particular, they show that it depends both on type of spill-over mechanism – research vis-à-vis human capital – and knowledge context – natural science vis-à-vis social sciences. In the same vein, using a large sample of high-tech start-ups from East German Landers, Lejpras and Stephan [27] find that the proximity to university is the main determinant of the firm's innovativeness in the start of their activity. However, they show that this effect tend to be mitigated by age and in a latter stage non-local collaboration links are more conducive to innovativeness than the local ones.

Hence, our second research hypothesis claims:

> *Hypothesis 2: University inventive activities have a positive impact on the local level of entrepreneurship.*

2. Data and descriptive evidences

2.1 Use of patent data

In this study we make use of patent data for addressing the regional dimension of inventive activities. Patents are a means of protecting legally inventions developed by firms, non for profit institutions or individuals, and as such they may be interpreted as indicators of invention (see

OECD Patent Statistics Manual, [38], for a detailed account of the statistical properties of patents, the way to use patent indicators and their limits). Before an invention can become an innovation, further entrepreneurial efforts are required to develop, manufacture and market it. Patents are legal instruments aimed at ensuring market exclusivity to their holder on the protected invention: no third party is allowed to make any use of the invention without the consent of the patent holder. The patent is applied to a national patent office, for the corresponding national market. If a patent is granted (it can be also rejected), it is valid for a maximum of 20 years, after which the invention falls in the public domain.

Patent indicators convey information on the *output* and *processes* of inventive activities. Patents protect inventions and, although the relationship is not simple, many studies have shown that after applying the proper controls there is a positive relationship between patent counts and other indicators related to inventive performance (productivity, market share, etc.). The relationship is not perfect: not all inventions are patented (although most of the significant ones are); certain patent applications correspond to strategic purposes rather than covering actual inventions. The relationship between patents and inventions can vary across countries, industries and over time, but it can definitely be identified as many studies have shown [38].

Due to the richness of information reported in patent documents, statistical exploitation of the data can provide a unique insight into invention processes. Published patent documents reveal information on the technological content of the invention (notably its particular technological fields) and on the geographical location of the inventive process (via the addresses of the inventors and of the owners). By identifying the inventors and owners of inventions, patent data, when matched with complementary data, can provide insights into the organisation of the underlying research process (for example, alliances between firms, co-operation between firms and public research organisations, the respective role of multinationals and small firms, size and composition of research teams, etc.). Patents give unique information on the technological fields of inventions (biotechnology, wind energy, etc.). Patents can also reflect the type of output of inventors or their mobility and networks; and patents allow tracking the diffusion of knowledge (the influence of particular inventions on other, subsequent inventions).

This study makes an extensive use of the OECD REGPAT database, that is a comprehensive source of EPO patent applications filed over the period 1978-2008 that have been linked to regions according to the addresses of the inventors and of the applicants (REGPAT is presented in detail in [30]). We think that having limited our analysis only to the EPO system is not serious drawback. Indeed, due to higher cost of filings the EPO takes into account only the most relevant patent inventions which are more suitable for international comparisons.

We have consider in this study solely the addresses of inventors (which are either the address of their working place, most often, or, more rarely, their personal address), as reflecting the place where the research leading to the patent application was done. Regionalisation has been done over the period 1991-2005 at two levels: territory level #2 (hereafter also TL2) corresponds to about 51 US states and 208 regions in EU15 countries (e.g. German Landers, French and Italian Administrative Regions) and territory level #3 (hereafter also TL3) is about 2,621 US counties and 1,069 unit in EU15 (such as French departments and Italian Provinces). Most of the analysis is done at TL3 level but sometimes we conducted robusteness checks also at TL2. The TL3 allows to isolate better more homogenous and closely tied territorial units, corresponding to the notion of "clusters" (see [56] and [62] for a discussion on US and EU respectively). Table 2.1. depicts the distribution of patenting regions by country in our dataset.

Table 2.3. Distribution of patenting regions by country during 1991-2005

[about here]

2.2 Identifying university patents

Patenting by NBOs has increased rapidly and substantially after the introduction in US Bayh-Dole Act in 1981 – followed then by similar legislations in other countries – that allowed the retain of ownership rights over patentable inventions generating from publicly funded research projects. The increase has been more substantial in US with respect to Europe, although some studied have shown that the there are some systematic institutional differences in patenting of inventions spin-out from public laboratories that favour the assignment to a public organization in USA and to a business partner in collaboration with academic inventors in Europe [28]. Even in the case US the assignment of patents to the public organizations is not total with at least one quarter of them assigned to private firms, although the phenomenon seems to be more severe in the European case [49]. This suggests a careful interpretation of the results in comparing different geographical contexts, and it invokes for more precise definitions to identify NBOs patenting than just by focusing on the institutional sector of the patent holder.

Since the goal of this paper is the analysis of patents invented by the NBOs – not only those directly owned by them – we followed a combination three definition to identify a patent by a Non Business Organisation. First we classified the applicant names by institutional sector using the approach suggested by [29], which methodology adopts the Frascati Manual taxonomy given by the following entities: Individuals (1), Business Sector (2) Government (3), Universities (4), Hospitals (5), Private & Non Profit (6), and a residual category called Unknown (7). Within this taxonomy we considered a NBO patent whose at least one applicant is classified to the category (3), (4) and (5). This means for instance that in the case of France, NBOs include universities, hospitals, the CNRS, INRIA, CEA, etc.

Second, to define a NBO patent we searched in the inventor name for the suffix "Prof.". Indeed the title "Professor" is attributed only to an employee in universities, hospitals, and other non-profit research centres. In some countries – in particular from central Europe – the tradition of including the suffix "Prof." as a permanent part of an individual name is wide spread. So doing, we aim to identify those patents that are not assigned directly to an NBO but that have been invented by an NBO employee and taken by a business partner.

Third, we analyzed the inventor's address information trying to identify his institutional affiliation. We found several patents where there is clear evidence from the address information that the inventor is affiliated to a NBO, independently who the patent has assigned to.

The results of this complex search methodology are reported in Table 2.1. There is a clear and significant gain of using the three definitions with respect to the situation of considering just the first definition relying on the classification of applicant names. In particular we have an additional amount of patent documents of about 10.6% by relying on the suffix "Prof." and an additional quantity of about 8.7% by analyzing the inventor's address information. Thus, the overall gain by using the three definitions jointly is about of 16.1%. The intersection set of the three search methodologies is only 90 patent documents, suggesting that the three methodologies capture clearly different patterns in the patenting activity by Non Business Organisations.

Table 2.1. NBOs patents by different definitions and their combinations

[about here]

The validity of our search methodology can be assessed through the applicant's country distribution by different definitions of a NBO patent: Table 2.2 depicts the distribution of NBO patenting for US regions and the largest six EU countries. As a comparison we rely on the PATVAL survey presented in Crespi et al. [59], who have reported a complete institutional categorization for a representative sample of EPO patents in these six EU countries. Moreover, Crespi et al. [59] provide an accurate estimate of patenting by NBOs in the US context.

Overall our definition of NBO patenting shows a high level of approximation to PATVAL survey for Germany, Spain, France and slightly more distantly also for UK. Indeed, for these countries adopting complementary definitions of NBO patenting reveals significant benefits. On the one hand the definition based on SET B can identify a large part of patenting by NBOs in the central European countries such as Germany - but also Austria and Switzerland - that are countries which used to be characterised traditionally by the so-called "*Professor's Privilege*" that consists the right of professors to patent their own inventions. On the other hand, the definition relying on SET C can capture many patent applications in countries such as United Kingdom and Spain that have an intensity of patenting by NBOs similar to the US context.[3] For other the countries our definition shows a lower percentage of NBO patenting compared to PATVAL survey. For USA this lower estimated could be related to the fact that we are considering EPO and not US patents. In fact, the NBO sector in US could have a smaller international filling propensity as compared with the business sector (e.g. due to cost or to market perspectives). For Italy, previous studies [28] reported that the assignment of patents spurred of research collaborations across industry and NBO sector are typically owned by the industrial partner: in this case our complementary definitions can compensate of this trend only partially. It must also be taken into account the fact that the reference population of PATVAL (EPO patents granted in years 1996-1998) differs deeply from ours, which includes all applications filed in the EPO history: in view of the changing

[3] Other countries for which the definition based on SET C can capture significant share of NBO patenting is Sweden and Norway.

behaviour of universities since the early 1980s that might affect significantly the relative structure of the two datasets. In conclusion, we think that with few some caveats our definitions show a satisfactory accuracy for the goals of this study.

Table 2.2 NBO patents by different definitions and country of the applicant

[about here]

2.3. Time and technological trends

The patenting by NBOs has steadily increased in the last two decades with an acceleration in the mid 1990s (see Figure 2.1). This can be directly linked to the adoption of legislation by European countries similar to the Bayh-Dole Act in US since that period such as for example: the UK National Health Service Circular of 1998; Germany in 1998; France in 1999 with the Innovation Law; and Belgium in 1999 with the Degree on Education. Moreover, there has been a trend towards the repeal with specific legislative laws of the "Professor's Privilege" in Germany (2001), Austria (2002), Denmark (2000), Italy (2001), etc.[4] Beside the regulatory changes many universities – with the financial support from local and national governmental authorities – have launched and further developed the Technology Transfer Offices [15].

The growth of NBOs patents can be further appreciated if we take into account the fact that its proportion with respect to the total patents has been stable in a period when the overall patenting activity experienced a burst both in the EPO and USPTO (see respectively [15] and [16]). Large part of the patenting explosion has been lead by the growth new emerging technologies such as biotechnology, nanotechnology, and ICTs including software.

Figure 2.1 Annual growth rates of patent applications over time

[about here]

[4] See Geuna and Rossi [60] for an historical analysis of legislative changes regarding "Professor's Privilege" in EU15 countries.

Indeed, in absolute terms a large share of the NBOs patenting is the field of pharmaceuticals and biotechnology.[5] Figure 2.2 shows that patents held by NBOs constitute about 20% in pharmaceuticals and biotechnology (class 4) followed then by instruments (class 2) and chemicals (class 3).

Figure 2.2 NBOs patenting as share of total patenting by OST7 technological fields

[about here]

Figure 2.3 depicts the time dynamics of the relative importance of university patents for emerging fields such as biotechnology, nanotechnology and ICTs including software. We can notice that biotech stands very high compared to the others. Nanotech patents by NBOs have accelerated significantly in year 2001 shifting from 6% to about 10%. The other technological fields do not show any particular trend, all converging in the last years to about 5%.

Figure 2.3. Share of NBOs patenting by new technological areas and priority year

[about here]

3. Analysis of the co-location of university and business inventive activities

In this section we analyse to what extent business patents originate from the same regions as NBO patents, by countries, by time periods and by technological fields. This empirical evidence is corresponded by the discussion of Hypothesis 1, when we argued on the benefits of geographical proximity in the knowledge transfer process and the factors sustaining spatial agglomeration of the innovative activity. The evidences documented in this section fully confirm this prediction. In particular the empirical analysis is threefold.

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[5] In terms of technical differences across inventions we define technological fields the one digit aggregation of the International Patent Classification suggested by Observatoire des Sciences et de Techniques (OST [40], pag 513-514). In particular, it is made up of seven macro areas: 1- electrical-electronics, 2- instruments, 3- chemicals, 4- pharmaceuticals, 5-industrial materials, 6-mechanical technologies, and 7-consumption materials.

A first level of analysis can be conducted graphically by comparing the maps reporting the distribution of NBO and business patenting by region over the three periods, 1991-1995, 1996-2000, and 2001-2005.[6] This exercise can establish whether the most productive regions in terms of business patents are also those in terms of patenting by NBO. In the US context we can notice that a few regions are at the top of the distribution of the two types of patenting: California on the East Coast, the area across the Massachussets, New York and New Jersey, Illinois and Texas. In Europe, two regions are characterised by a very high level of patents by business patenters and NBOs: Rhône-Alpes in France and Bayern in Germany.

Secondly, in order to assess more systematically co-location we conducted both a correlation analysis and a controlled regression analysis. The correlation analysis is reported in Table 4.1 and it was conducted across all the regions according to various dimensions: overall dataset; three time periods, 1991-1995, 1996-2000 and 2001-2005; different industries; different countries and group of countries. We considered Spearman rank correlation, instead of the Pearson correlation index because the former test should be robust to the overall amount of patenting in a region.[7]

We can notice a high and statistically significant correlation between business and NBOs patenting activity across regions. The co-location is much higher at the TL2 level of aggregation than at the TL3, which could indicate that the level at which more interaction between NBOs and businesses take place is not the most detailed one. Moreover, we can notice that the correlation has tended to increase over time, as it is much higher (especially for TL3 regions) after year 2000 than it was in period 1991-1995. That could reflect a strengthening of the interactions between NBOs and businesses over time, in relation to changes in the legal and economic frameworks. We find consistent results also in individual countries for which the correlations are significant (most countries don't have enough regions for the coefficients to be statistically significant: their results are not reported in the table).

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[6] For brevity we have omitted these maps, which are available under request.

[7] Indeed patents counts are downward truncated (they cannot be negative), and hence, if in a region there is a low number of business patents and absent patenting activity by NBOs – that occurs in about 18,3% of the TL3 regions in the sample - we would observe a spurious linear correlation of the collocation measure across the business and NBO patents.

Table 3.1: Co-location of patenting by business organizations and NBOs

[about here]

Correlations by technological fields are substantially higher than all-fields correlations. This indicates that relations between NBOs and businesses are quite technology specific, they occur within more than across technological fields. The correlations are higher in technological fields usually seen as closer to science: pharmaceuticals, chemicals and instruments. These are also the fields where there is more NBO patenting. It is noticeable also that the correlation has been increasing over time, from 1991-1995 to 1996-2000 and 2001-2005, in all industries.

The third and last empirical analysis on the spatial collocation of university and business inventive activities has relied on an econometric model. We estimated different regression models trying to relate the variability of the business patenting by region with that of NBO patents with various control variables. This analysis complements the correlation analysis, as it allows to control for a richer set of factors. The estimated relationships cannot be interpreted still as reflecting causality. The explained variable is the number of business patents by region, year and technological field. Explanatory variables are the number of patents taken by NBOs, by the same region, year and technological field, plus population and dummies for years, technological fields and countries. The regressions shows a very strict proportionality between business and NBOs patents, with one NBO patent for 24.0 business patents on average. The same regression was conducted separately on US and EU15 regions, giving highly significant coefficients. We can notice higher coefficients for US than for European regions.

Table 3.2. Co-location of patenting by business organizations and NBOs: conditional correlation of NBO patenting on business patents

[about here]

4. Evidence of the impact of university inventions on entrepreneurship

This section includes the empirical findings supportive of Hypothesis 2 which claims on positive impact of university inventive activities on the local level of entrepreneurship. As discussed this

Hypothesis is based on the assumption that determinant factors of entrepreneurship are partly localised and secondly that university patents are characterised by high level of generality, generating broader innovational spillovers compared to the invention triggered by the business sector. We demonstrate Hypothesis 2 with the mean of an econometric model which is discussed in details in the next section.

4.1. Empirical model

Our empirical model is similar to Crescenzi et al. [58] and Rodriguez-Posse & Crescenzi [57] who develop an approach based on the Knowledge Production Function (Griliches, 1979). The unit of analysis is given by a TL3 region - 2,621 US counties and 1,069 NUTS3 units in EU15 observed over annual periods during 1991-2005; since we aim to condition for technology trends we introduce another dimension given by the seven technological classes discussed in section 2.3 (see also Figure 2.2 and footnote 5). Moreover, we account for the knowledge spillovers from the neighbouring regions defined as those regions that belong in the same TL2 region.

The modified production function reads as in the following:

$$F_{ic} = A \ KB_{ic}{}^{\alpha} KU_{ic}{}^{\beta} KSpill_{ic}{}^{\gamma} C_{ic} e^{u} \tag{1}$$

Where F is the innovative output by the business sector in region i and technological class c, A is constant, KB is the stock of knowledge by the business sector, KU is stock of knowledge by the non business sector, $KSpill$ captures knowledge spillovers from the neighbouring regions, C is a set of controls at the regional and technological level, and u is a disturbance.

One first approach to estimate equation (1) is the regression of an empirical model in terms of the growth rate of dependent variable, that can at least partially mitigate autocorrelation over time in the error term (Crescenzi et al. [58] and Rodriguez-Posse & Crescenzi [57]). However, since our innovative output is given by the birth rate of new patenters firms in a region and technology field, relative growth rates measures will be affected by small numbers bias, and hence absolute growth variables are preferred. In particular, we have that (1) becomes:

$$Ln(F_{ict+1} - F_{ict}) = a \ + \alpha * \ln(KB_{ict}) + \beta * \ln(KU_{ict}) \ + \gamma * \ln(KSpill_{ict}) + C_{ic} + u \tag{2}$$

Typically we can estimate (2) with panel data estimators such as fixed effects at regional and technology level, which allows to control for time invariant unobserved heterogeneity at the regional level.

However, if the impact on the regional innovation outcome adjusts with a lag panel, then data are obsolete and in the productivity literature has suggested the alternative estimations with the means of the generalized method of moments (GMM) (Hall and Mairesse, [67]). GMM is particularly suitable in the production function estimations case because it is robust to heteroskedasticity across units of analysis and correlation of the disturbances within units over time. Moreover, the efficiency can be achieved under fewer assumptions on the disturbances assuming that the cross-section dimension is sufficiently large (For further discussion on the rationales of GMM estimation for production functions see Hall and Mairesse, [67]). A possible specification could be that of estimating (1) in log levels accounting also for the autoregressive structure of exogenous and endogenous variables [63]. In this case we have that:

$$Ln(F_{ict}) = a + Ln(F_{ict-1}) + \sum_{k=o}^{n} \alpha_{t-k} \ln(KB_{ic(t-k)}) + \beta_{t-k} \ln(KU_{ic(t-k)}) + \gamma_{t-k} \ln(KSpill_{ic(t-k)}) + C_{ic} + u \quad (3)$$

The approaches of GMM estimations are twofolds. Firstly, the DPD-DIF estimator adopts first-differenced panel data approach and exploits all possible lags of the regressors as instruments (Arellano and Bond [65]). This transformation allows to eliminate any time-invariant unobserved regional specific effect. On the other hand DPD-SYS estimator uses lagged differences as instruments for a system of equation in differences and levels (Arellano and Bond [66]). This system approach is more efficient than the DPD-DIF in case of highly persistent time series, which are characterised by a weak correlation between the variable in first differences and its past levels. While the size of the coefficients of the DPD-SYS estimator are comparable to the standard panel data context, the DPD-DIF offers different insights on the regressors' elasticities.

Finally, it is noteworthy that the implementation of equation (3) by a VAR methodology allows to test Granger causality in a panel data context [63].

4.2. Measurement issues

Our dependent variable is represented by inventive entrepreneurship, which has been measured by "first time patenters": these are firms whose name appears for the first time as owner of a patent application. It indicates that the firm changes from the status of non patenter (it is absent from the database) to the status of patent application holder. We interpret this event as reflecting the first significant technical achievement of the firm, either because the firm itself is new (an inventive start-up) or because it was less inventive before. It may happen that a firm applies for its first patent long after it was created, hence being not really a new firm at that point: however this change means that the firm is taking a new inventive stance.

We compile the number of "first time patenters" at the level of regions as an indicator of regional inventive entrepreneurial performance using the EPIP database of patent applications and applicants linked to business registry information (The dataset is presented in details in Thoma et al. [48]). Using this dataset we could obtain unique and harmonized identifiers for the applicants in the EPO dataset and generate a complete history of their patenting activity since the inception of the EPO. Moreover, patent owner have linked with the founding year of the related legal entity. The overall linking rate have resulted in more than 90% of EPO patent application by business applicants from US and EU15, which accounted more than 80% of patenters. When we could not retrieve a founding year of the legal entity we imputed the earliest priority years in the patent portfolio.

Our explanatory variables include the stock of patents by NBOs at the regional level, which is the main variable of interest. The other explanatory variables are the stock of patents by business organisations and the spillover variable, whereas the controls consists in log population and dummies for region, technological field, country and year. Stocks of business patents account for the general fertility of the business environment in the region, its absorptive capacity etc. But it can also be seen as a variable of interest, as one source of new entrepreneurs is existing firms, whose staff can establish their own venture. The stocks are in logs and cumulated numbers of patent applications filed over the previous five years, with no depreciation rate: we want to reflect the involvement of the regional NBOs in the technological field, not to assess their patent portfolio (which would require to take into account the legal status of the patent applications etc).

In addition to simple patents counts we measured also citation weighted patents. The purpose is to take into account the value of the patents, which is known to be highly diverse [50] and for which citation counts are a usual indicator. Citations are counted within a three years window from the priority date. Lastly, the spillover variable is measured at TL2 in line with previous studies such as [61, 57, 58]. The overall innovative activity at level TL2 is normalized by an accessibility index that proxy for the easiness or cost that knowledge can be "reached" with the territorial unit. In our case we considered citation weighted patents and the accessibility index is given by the physical area of the territorial unit measured in squared kilometres. The variable is than disaggregated at TL3 level by detrending for the its patent counts at TL3 level.

Table 4.1 reports some descriptive statistics of business and NBO patenting and inventive entrepreneurship at the regional level. Over the whole period 1991-2005 an average region in one technological area of our sample is characterised by more than 7.825 (s.d.=37.393) business patents and 0.630 (s.d. 3.540) NBO patents. The stock variables are larger for EU regions than US counties, but when we count citation weighted patents, differences in means are relatively smaller. The entry of new business patenters by priority year is about 0.336 (s.d. 1.288) and it is halved if we consider the incorporation year, confirming the small bias effects of this variable.

Table 4.1. Descriptive statistics

[about here]

4.3. Results

Table 4.2 reports the regression results, with explanatory variables in logs. The sub part (a) depicts the regressions with a reference year of entry given by the priority year of earliest patent in the company patent portfolio, whereas in part (b) we have that incorporation year of the company is considered as entry year.

Table 4.2 (a) reveals that the yearly number of new patenting firms per region is influenced positively and significantly by NBO patenting. In terms of marginal effects elasticities measured at the mean-value, the stock of NBO patents of the region has an impact of 1.0%. This implies that, for an "average region" (with a stock of more than 30 patent business patent applications),

the filing of one further standard deviation in NBO patenting will be associated, on average, with the annual creation of 0.030 new firm, meaning about 3 new firms over a decade.
This might not seem a lot, but it has to be kept in mind that it is mainly radical inventions which are patented, and both the NBO patents and the new inventive firms are associated with significant inventions, the ones which according to Zucker and Darby [54] generate the more growth and jobs. In addition, another factor on the right hand side of the equation is sensitive to NBO patenting: the stock of business patents (as new business patents join the stock after a few years). Its effect would partly cumulate with the direct effect of NBOs and reinforce it over time.
When the incorporation year of the company is considered as entry year - Table 4.2 (b) - similar findings are confirmed in terms of positive sign and statistical significance of the coefficients. The size of the coefficients is smaller, but we have to take into account that entry by incorporation of new patenters is also lower.
In model 3, we executed the regression based on citation weighted patents. The results are substantially similar to those of the model 1, in terms of signs and significance of the coefficients. This means that an additional citation received by a NBO patent has at least the same impact than the filing of new patent by a NBO. More generally, the finding seems to be line with previous studies such as Jaffe, Henderson, and Jaffe [20] and Maurseth and Verspagen [32] who claimed the role of patents citations as paper trail to track the existence of knowledge spillovers from patents.

The estimations at the level of finer disaggregation of regions unpack some interesting differences across US and EU. In particular, we have that the relative size of the elesticities of NBO patents are slightly higher for US counties than EU regions. The difference is more evident for citation weighted patents pointing to a stronger signalling role that citations have for US patenters (Hall, et al, [64]). This finding can be also interpreted as reflecting the early adoption the Bayh-Dole Act in USA (1981) compared to the reforms in EU countries.

In Model 2 and 4 we advanced additional robustness checks. We included only NBO patents directly owned by NBOs, excluding those invented by university researchers but owned by other entities ("Set A"). The elasticities are very comparable to those in Model 1 and 3, but since the patents of SET A are fewer in number this means that the marginal effects of these patents is higher than those of SET B or SET C. Hence, one standard deviation increase of the NBO inventions owned by the NBOs themselves seems to have a wider change in the entry of new patenters in the region than for NBO inventions not owned by NBOs themselves. That could come from the fact that most of such inventions are actually owned by established businesses and have therefore little impact on entrepreneurship.

At the level of the control variables we find large and positive impact of spillovers effects at TL2 regions both in US and EU countries. This confirms the important role of proximity in fostering knowledge complementarities and inventive entrepreneurship [20, 32, 9]. The size of the coefficients of spillovers effects shows a high stability and robustness across all the specifications. The coefficients are higher for EU regions of about 4 times and it can explained by the fact that EU TL2 regions are smaller in size than US the states. Put differently, the spillover effects is stronger in Europe because the distance to the regional unit border is also smaller.

In conclusion, we conducted further robustness checks using VAR analysis and GMM estimations.[8] First, the VAR analysis – executed for computation reasons at the country level – demonstrates that it is the NBO patenting that Granger causes entry and not viceversa (See Table 4.3). The Chi-Squared test of NBO patenting on the entry of business patenters is statistical significant at 1% level, but the reverse effect is not significant even at 10% level of confidence. The VAR analysis has been performed having as endogenous variable also the stock of business patents and ad exogenous variables the constant, spillovers at TL2, time, technology, and locational dummies.

Second, the PDP-SYS GMM estimator in level reports very comparable results in terms of sign, statistical significance and impact of the coefficients with those discussed previously (Remember that the dependent variable of Table 4.2 is the absolute growth in logs). In particular, we have the stock of NBO patents of the region has an annual impact of 1.5% on the entry of new patenters. Similarly, the PDP-DIF estimator in first differences confirms the sign and statistical significance of the coefficients: it also reveals that the elasticity of NBO patenting on entry of new patenters has higher magnitude than business patenting. The finding could be reconducted by larger innovation spillovers from NBO patenting vis-à-vis business patenting, and it confirms the claim

[8] This has been implemented in the STATA 11.0 toolbox.

that university inventions are featured by a higher level of technological generality compared to other patents [18].

Table 4.3 and Table 4.4

[about here]

Conclusions

In this paper we explored the relation across inventions originating from public research (non business) organisations and inventions from business at a regional level in the US and EU15 countries using patents as indicators of innovative activities. Firstly, we analyzed the co-location of public research inventions and business inventions within the regional boundaries. We found strong evidence that NBOs and business inventions tend to co-locate and this effect is stronger within technological fields. Moreover, the increasing co-location of NBO and business patenting over time could be potentially related to the impact of changes in the policy and economic environment of innovation.

Secondly, we analyzed the relationship between public research inventions and inventive entrepreneurship at the regional level with an econometric model. We found that NBO patents are significantly correlated to the size of inventive entrepreneurship at the regional level. In particular we this effect is especially strong for US regions. The results are robust also when estimate the model with citation weighted patents and with GMM estimation. The estimator in first differences demonstrates that the elasticity of NBO patenting on the inventive entrepreneurship has higher magnitude than business patenting. The finding could be reconducted by larger innovation spillovers from NBO patenting vis-à-vis business patenting [18].

These evidences are consistent with economic analysis which underlines causality relationships from NBO inventive activities to business inventive activities. In such a framework, they could be interpreted as confirming the *impact* of NBO inventions on entrepreneurship at a local level. Accordingly, these findings have certain implications for policies. On the one hand, policies engaged in the 1980s and 1990s in US and EU and more in general OECD countries with the view to strengthen the links between universities and business seems to have met with significant results, with a visible impact at the regional level.

On the other hand, policies aiming at encouraging the creation of new, inventive firms, or of turning the inventivity of existing and non inventive firms into inventive, can use local, public research facilities as leverage. Measures which improve the density of institutional and informal linkages between NBOs and businesses at a local level can be effective in encouraging the creation of new ventures and the development of inventive activities by established firms. The connection between NBO's research and inventive entrepreneurship being mainly local, such policies have to take into account the spatial dimension and to involve local authorities and resources.

REFERENCES

[1] Acs, Z. J., D. B. Audretsch, and M. P. Feldman, R&D Spillovers and Innovative Activity, Manag. Decis. Econ., 15 (1994) 131-138.

[2] Agrawal, A., and I. Cockburn, The Anchor Tenant Hypothesis: Exploring the Role of Large, Local, R&D-Intensive Firms in Regional Innovation Systems, Int. J. Ind. Organ., 21(9) (2003) 1217-1433.

[3] Almeida, P. and B. Kogut. Localization of Knowledge and the Mobility of Engineers in Regional Networks, Manag Sci., 45 (1999) 905-917.

[4] Arrow, K. J., Economic welfare and the allocation of resources for innovation, in R. Nelson (ed.), The Rate and Direction of Inventive Activity. Princeton University Press: Princeton, NJ, 1962 pp. 609–626.

[5] Audretsch, D.B., and M.P. Feldman, Knowledge spillovers and the geography of innovation and production, Am. Econ. Rev. 86(3) (1996) 630–640.

[6] Audretsch, D. and M.P. Feldman, Knowledge Spillovers and the Geography of Innovation, in J. V. Henderson and J. Thisse, ed. Handbook of Urban and Regional Economics, Volume 4. North Holland Publishing, Amsterdam, The Netherlands.

[7] Audretsch D. A., E. E. Lehmannb, and S. Warning, University spillovers and new firm location, Res. Pol., 34 (2005) 1113–1122

[8] Benneworth P. and D. Charles, University spin-off policies and economic development in less successful regions: learning from two decades of policy practice, Eur. Plan. Stu., 13(4) (2005) 537 – 557.

[9] Bottazzi L. and G. Perri, Innovation and Spillovers: Evidence from European Regions, Eur. Econ. Rev., 47(4) (2003) 687-710.

[10] Casper, S., How do technology clusters emerge and become sustainable? Social network formation within the San Diego biotechnology cluster, Res. Pol., 36(4) (2007) 438-455.

[11] Dasgupta, P., P.A. David, Toward a new economics of science. Res. Pol., 23 (1994) 487–521.

[12] Di Gregorio, D. and S. A. Shane, (2003), Why do some universities generate more start-ups than others?, Res. Pol., 2 (2003) 209-227.

[13] Feldman, M. P. and D. B. Audretsch, Innovation in Cities: Science-based Diversity, Specialization, and Localized Competition, Eur. Econ. Rev., 43 (1999) 409-429.

[14] Florida R., The Rise of the Creative Class, Harper Collins Publishers, New York, 2001.

[15] Guellec, D., and B. van Pottelsberghe de la Potterie, The Economics of the European Patent System: IP Policy for Innovation and Competition New York: Oxford University Press, 2007.

[16] Hall, B.H., Exploring the Patent Explosion, J Tech. Transf. 30 (2005) 35-48.

[17] Hausman, J., B. H. Hall, and Z. Griliches, Econometric Models for Count Data with an Application to the Patents-R & D Relationship, Econometrica 52 (1984) 909-938.

[18] Henderson R., A. Jaffe, and M. Trajtenberg, Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting 1965-1988, Rev Econ Stat, Vol LXXX (1) (1998) 119-127.

[19] Jaffe, A. B, Real Effects of Academic Research, Am. Econ. Rev., 79(5) (1989) 957-970.

[20] Jaffe, A., Trajtenberg, M., Henderson, R., Geographic localization of knowledge spillovers as evidenced by patent citations, Q. J. Econ. 63(3) (1993) 577–598.

[21] Kenney, M., and R.W. Goe, The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford, Res. Pol., 33 (2004) 691-707.

[22] Klepper, S., Employee Startups in High-Tech Industries, Ind. Corp. Change, 10(3) (2001) 639-674.

[23] Krugman, P., Geography and Trade. MIT Press, Cambridge, 1991.

[24] Jensen A. & M. C. Thursby, Patent Licensing and the Research University, NBER Working Papers 10758, National Bureau of Economic Research, Inc. Cambridge (MA), 2004.

[25] Jong S., Academic organizations and new industrial fields; Berkeley and Stanford after the rise of biotechnology., Res. Pol., 37(8) (2008) 1267-1282.

[26] Justman M and M. Teubal, Technological infrastructure policy: Creating capabilities and building markets, Res. Pol., 24(2) (1995) 259-281.

[27] Lejpras A. and A. Stephan, Locational Conditions, Cooperation, and Innovativeness: Evidence from Research and Company Spin-Offs, German Institute for Economic Research, DIW Berlin, http://ssrn.com/abstract=1424891, Berlin, July 2008

[28] Lissoni, F. P. Llerena, M. McKelvey, B. Sanditov, Academic Patenting in Europe: New Evidence from the KEINS Database, CESPRI Working Paper, Milano, 2007.

[29] Magerman T., B. Van Loy. M. Song, Search Methodology for Identifying Applicant Institutional Classification, Eurostat Working Paper, Luxembourg, 2008.

[30] Maraud S., H. Dernis, C. Webb, V. Spiezia, D. Guellec, The OECD Regpat Database: A Presentation, STI Working Paper 2008/2. OECD, Paris, 2008.

[31] Marshall, A., 1920. Principles of Economics, 8th ed. MacMillan, London.

[32] Maurseth, P. B. and B. Verspagen, Knowledge Spillovers in Europe. A Patent Citations Analysis, Scand. J. Econ., 104 (2002) 531-545.

[33] McKelvey, M. Evolutionary Innovations. The business of Biotechnology. Oxford: Oxford University Press, 1996.

[34] Mowery D., R. R. Nelson, B. N. Sampat, and A. A. Ziedonis, Ivory Tower and Industrial Innovation: University-Industry Technology Transfer before and after the Bayh-Dole Act. Stanford University Press, Stanford, CA, 2004.

[35] Mowery, D., and Rosenberg, N. Paths of Innovation: Technological Change in 20th-Century America. New York: Cambridge University Press, 1998.

[36] Nelson, R.R., Institutions supporting technical advance in industry, Am. Econ. Rev., 76 (1986) 186–189.

[37] OECD, Turning Science into Business OECD, Paris, 2003.

[38] OECD. Patent Statistics Manual, OECD, Paris, 2009.

[39] Orsenigo, L., The emergence of biotechnology. Cambridge University Press, Cambridge and New York, 1990.

[40] OST, Science and technology indicators 2004, Observatoire des Sciences et des Techniques, Paris, 2004.

[41] Owen-Smith, J. and W. W. Powell, Knowledge Networks as Channels and Conduits: The Effect of Spillovers in the Boston Biotechnology Community, Organ. Sci., 15(1) (2004) 5-21.

[42] Porter, M.E., Clusters and the New Economics of Competition, Harv. Bus. Rev., November-December 1998, pp. 77–90.

[43] Powell, W. W., K.W. Koput, J.I. Bowie, and L. Smith-Doerr, The Spatial Clustering of Science and Capital: Accounting for Biotech Firm-Venture Capital Relationships, Reg. Stud. 36(3) (2002) 291-306.

[44] Powell, W. W., D. R. White, et al., Network Dynamics and Field Evolution: The Growth of Interorganizational Collaboration in the Life Sciences, Am. J. of Sociol 110(4) (2005) 1132-1205.

[45] Saxenian, A., Regional Advantage: Culture and Competition in Silicon Valley and Route 128, Harvard University Press, Boston, MA, 1994.

[46] Sorenson, O. and T.E. Stuart, The geography of opportunity: Spatial heterogeneity in founding rates and the performance of biotechnology firms, Res. Pol., 32 (2003) 229-253.

[47] Sorenson, O., and T. E. Stuart, Entrepreneurship: A field of dreams?, Acad. Manag. Ann., 2 (2008) 517-543.

[48] Thoma G., S. Torrisi, A. Gambardella, D. Guellec, B. H. Hall, and D. Harhoff, Methods and software for the harmonization and integration of datasets: A test based on IP-related data and accounting databases with a large panel of companies at the worldwide level, paper prepared for presentation at the PatStat Conference - Conference on Patent Statistics for Decision Makers, Vienna, September 3-4, 2008.

[49] Thursby J., A. Fuller, M. Thursby, US Faculty Patenting: Inside and Outside the University, Res. Pol., 38 (2009) 14-25.

[50] Trajtenberg, M. A Penny for Your Quotes: Patent Citations and the Value of Innovations, Rand J. Econ., 21 (1990) 172-187.

[51] Usai S., The geography of innovation activity in OECD regions, STI Working Paper, OECD, Paris, 2008.

[52] Zucker L. G. and M. R. Darby, Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry, Proceedings of the National Academy of Sciences, November 12, 1996, 93(23) (1996) 12709-12716.

[53] Zucker L. G. M. R. Darby, and Jeff Armstrong, Geographically Localized Knowledge: Spillovers or Markets? Econ. Inq., January, 36(1) (1998) 65-86.

[54] Zucker L. G. and M. R. Darby, Innovation and Regional and National Immigration, NBER Working Paper N. 13457, National Bureau of Economic Research, Inc. Cambridge (MA), 2008.

[55] Zucker L., M.R. Darby and M. Brewer, Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises, Am. Econ. Rev., 88(1) (1998) 290-306.

[56] Hausman N., Effects of University Innovation on Local Economic Growth and Entrepreneurship, Harvard University Working Paper, (2010).

[57] Rodriguez-Posse A. and R. Crescenzi, Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe, Regional Studies 42(1) (2008) 51-67.

[58] Crescenzi, R., A. Rodriguez-Posse and M. Storper, The territorial dynamics of innovation: a Europe-United States comparative analysis, Journal of Economic Geography 7 (2007) 673-709.

[59] Crespi G., A. Geuna, O. Nomaler and B. Verspagen, University IPRs and knowledge transfer: is university ownership more efficient?, Economics of Innovation and New Technology, Taylor and Francis Journals, vol. 19(7) (2010) 627-648.

[60] Geuna, A. and F. Rossi, Changes to university IPR regulations in Europe and the impact on academic patenting, Research Policy 40 (2011) 1068– 1076.

[61] Belenzon S. and M. Schankerman, Spreading the word: geography, policy and university knowledge diffusion, Review of Economics and Statistics, forthcoming, (2010).

[62] Mariani M., What determines technological hits?: Geography versus firm competencies, Research Policy, 33(10) (2004) 1565-1582.

[63] Rouvinen, P. Issues in R&D-productivity dynamics: causality, lags, and 'dry holes', ETLA Working Paper, 1999

[64] Hall, B. H., Thoma, G., Torrisi, S., The Market Value of Patents and R&D: Evidence from European firms, NBER Working paper N. 13426, National Bureau of Economic Research, Inc. Cambridge (MA), 2007.

[65] Arellano, M., and S Bond, Some tests of specification for panel data: monte carlo evidence and an application to employment equations. Review of Economic Studies, 58(2) (1991) 277-297.

[66] Arellano, M., and O. Bover, Another look at the instrumental variables estimation of error-components models. Journal of Econometrics, 68(1) (1995) 29-51.

[67] Hall B. H. and J. Mairesse, Estimating the Productivity of Research and Development in French and United States Manufacturing Firms,. NBER Working Paper N. 5501, National Bureau of Economic Research, Inc. Cambridge (MA), 1996.

[68] Griliches Z., Issues in assessing the contribution of research and development to productivity growth, Bell Journal of Economics 10, (1979), 92–116.

Figure 2.1 Annual growth rates of patent applications over time

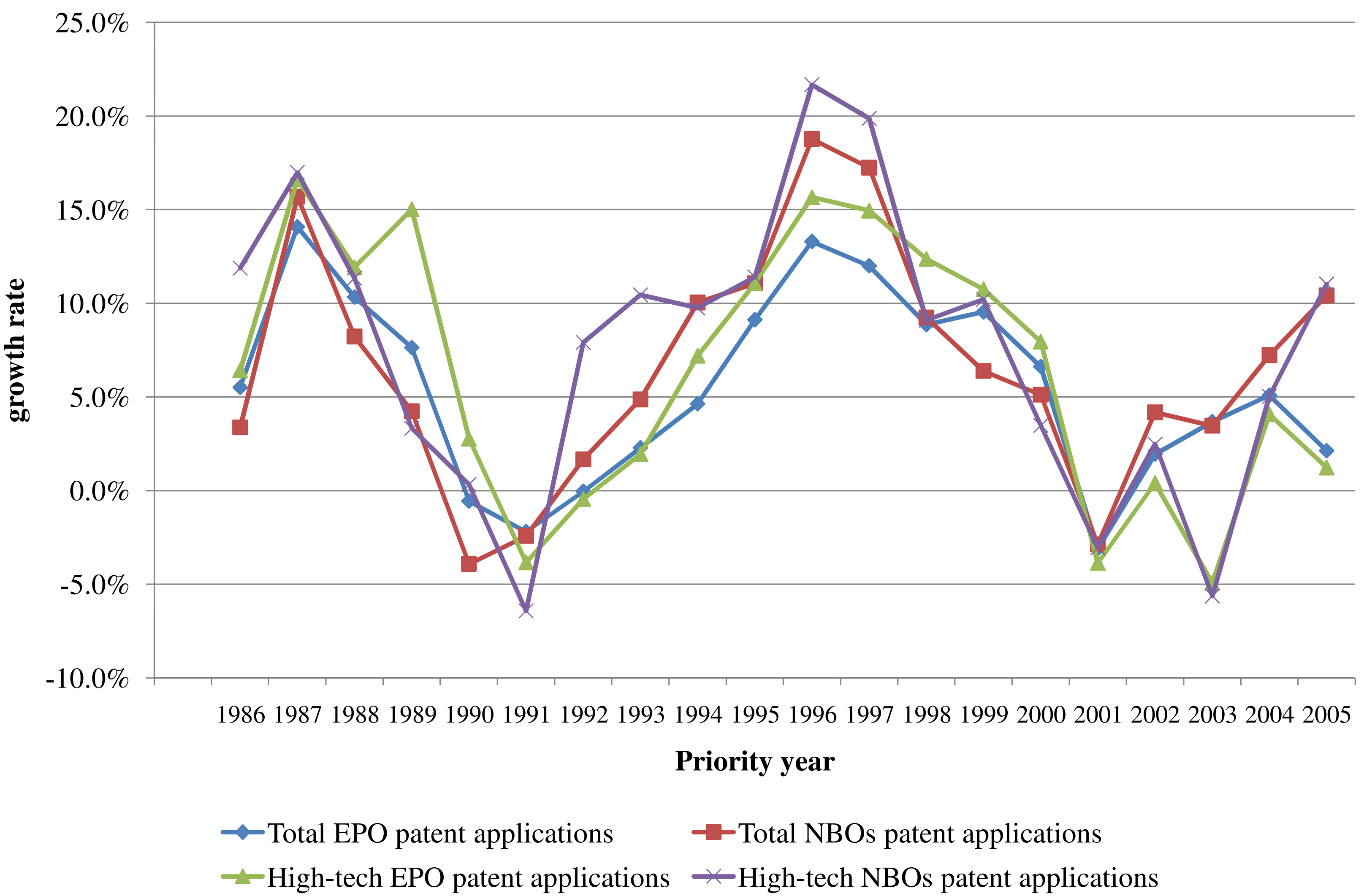
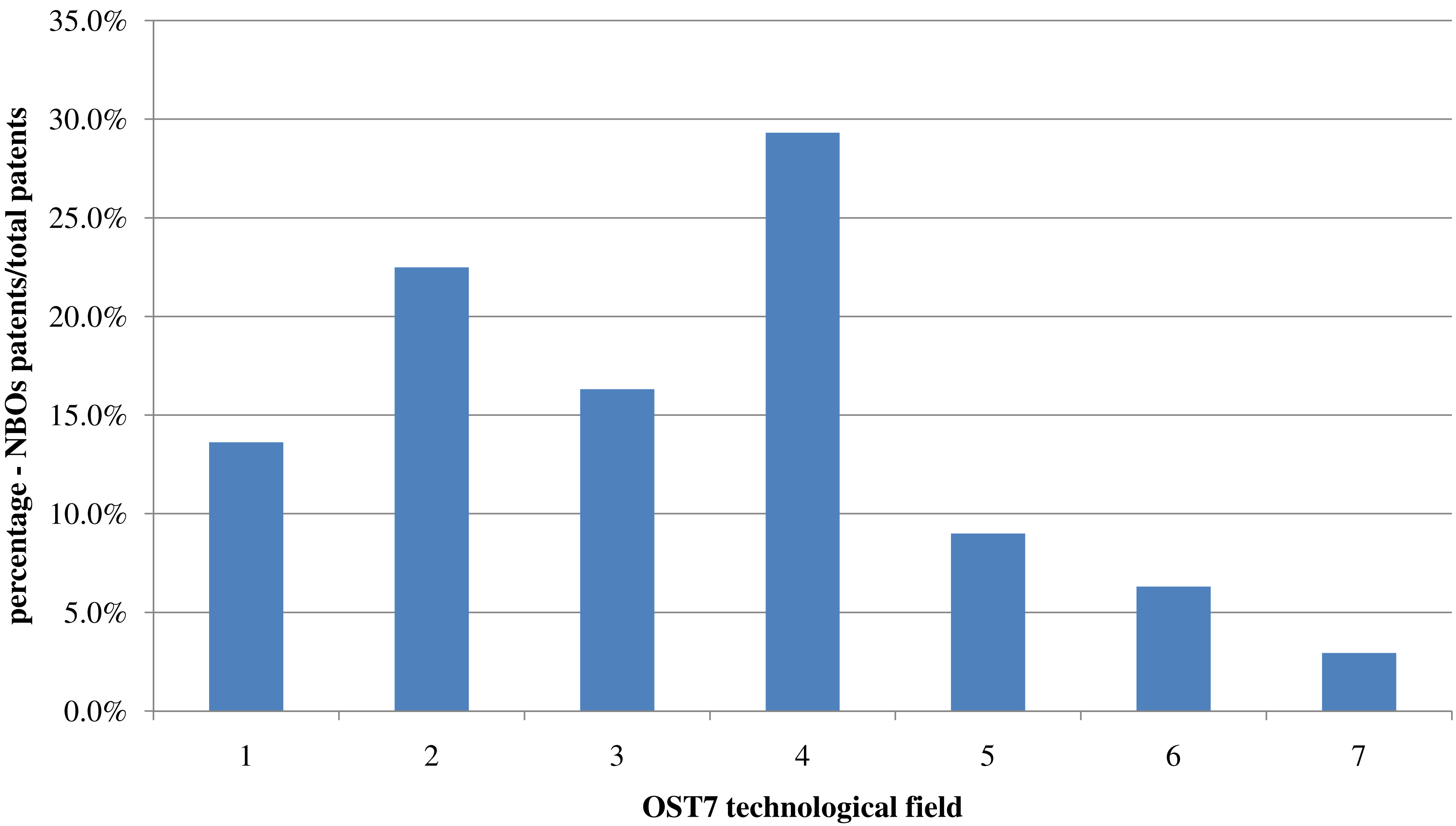


Figure 2.2 NBOs patenting as share of total patenting by technological field



1- electrical-electronics, 2- instruments, 3- chemicals, 4- pharmaceuticals, 5-industrial materials, 6-mechanical technologies, and 7-consumption materials.

Figure 2.3. Share of NBOs patenting by emerging technologies and priority year

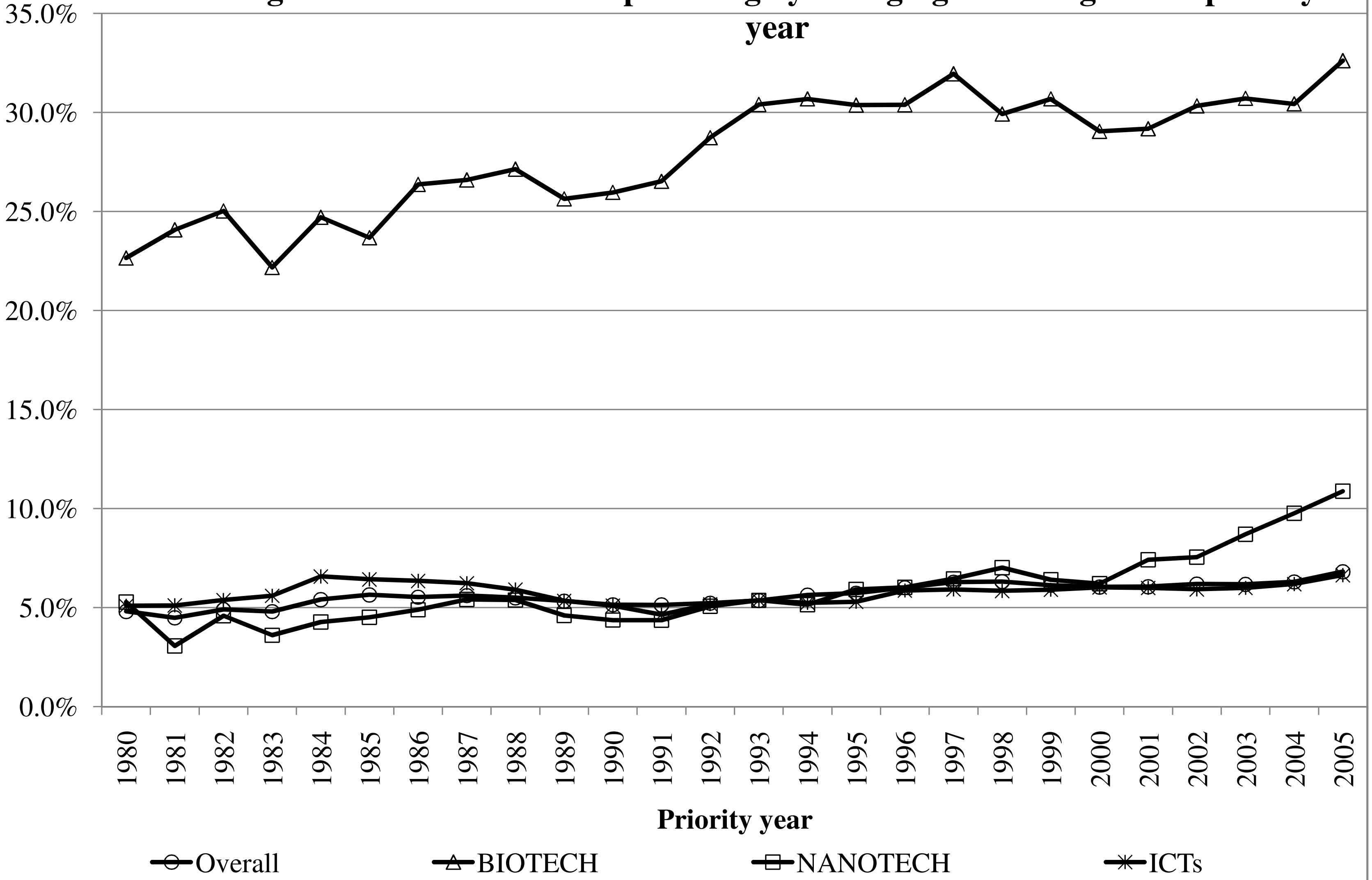


Table 2.1. Distribution of patenting regions by country during 1991-2005

	TL3 Regions				TL2 regions			
Country	*All Sample*	*share %*	*With NBO pats*	*share %*	*All Sample*	*share %*	*With NBO pats*	*share %*
AT	35	0.9%	29	1.4%	9	3.5%	9	3.5%
BE	44	1.2%	44	2.1%	11	4.2%	11	4.3%
DE	429	11.6%	427	20.0%	38	14.7%	38	15.0%
DK	11	0.3%	10	0.5%	5	1.9%	5	2.0%
ES	54	1.5%	45	2.1%	15	5.8%	15	5.9%
FI	20	0.5%	15	0.7%	5	1.9%	4	1.6%
FR	100	2.7%	100	4.7%	26	10.0%	26	10.2%
GR	44	1.2%	19	0.9%	13	5.0%	10	3.9%
IE	8	0.2%	8	0.4%	2	0.8%	2	0.8%
IT	107	2.9%	97	4.6%	21	8.1%	21	8.3%
LU	1	0.0%	1	0.0%	1	0.4%	1	0.4%
NL	40	1.1%	39	1.8%	12	4.6%	12	4.7%
PT	29	0.8%	20	0.9%	7	2.7%	6	2.4%
SE	21	0.6%	19	0.9%	8	3.1%	8	3.1%
UK	126	3.4%	124	5.8%	35	13.5%	35	13.8%
EU15	1,069	29.0%	997	46.8%	208	80.3%	203	79.9%
US	2,621	71.0%	1,134	53.2%	51	19.7%	51	20.1%
Total	3,690	100.0%	2,131	100.0%	259	100.0%	254	98.1%

Table 2.2. NBOs patents by different definitions and their combinations

Union of the three definitions: 126,012

Intersection of the three definitions: 90

	SET A	SET B	SET C
SET A- Classification of the applicant names by type	93,563		
SET B - The identification of the inventor name having the suffix "Prof."	1,412	10,880	
SET C - The analysis of the inventor address revealing the institutional affiliation	10,855	382	8,800
OVERALL	105,830	12,674	20,037

Notes: EPO patent applications with publication date up to December 2009.

Table 2.3 NBO patenting as share of total patenting by country

	DE	ES	FR	GB	IT	NL	US °	other Europe
PATVAL survey	5.0%	9.1%	9.1%	11.5%	5.1%	9.2%	9.5%	-
SET A+B+C	5.5%	9.1%	9.4%	9.5%	3.0%	4.7%	6.5%	4.5%
SET A ^	3.2%	7.8%	9.1%	7.3%	2.7%	4.2%	6.2%	3.5%
SET B ^	2.5%	0.1%	0.1%	0.1%	0.1%	0.2%	0.0%	0.7%
SET C ^	0.2%	3.5%	0.8%	4.1%	0.4%	0.5%	0.8%	0.7%

Notes: Data on PATVAL survey reported in Crespi (2010).

° It relies on US granted patents. Our approximate elaboration based on Crespi et al (2010) and other data. In particular, Crespi et al. estimate that university system in US should account for about 6.5%. From the NBER patent project we computed that other non profit sector in US matters for about other 3% of the overall patenting by US patenters.

^ The three definitions include double counting when a patent is captured by more than one search strategy.

Table 3.1: Co-location of patenting activities by business organizations and NBOs

	Spearman-Rank correlation			
	1991-2005	**1991-95**	**1996-00**	**2001-05**
Overall	61.2%	36.7%	48.0%	52.8%
All regions with more than 2 patents	61.1%	36.7%	47.1%	51.5%
Overall TL2 regions	81.0%	64.0%	67.6%	75.8%
Countries				
DE	54.4%	34.1%	48.0%	42.3%
DE (without East Landers)	53.6%	33.2%	46.3%	44.5%
FR	59.3%	45.6%	55.1%	55.4%
ES	48.6%	-	37.6%	46.5%
GB	64.5%	44.9%	45.1%	60.1%
IT	55.1%	23.4%	50.9%	45.0%
BENELUX	54.8%	-	35.2%	50.2%
US	44.1%	26.6%	34.8%	39.5%
OST7 technological fields				
1- electrical-electronics	75.7%	59.4%	66.8%	71.7%
2- instruments	79.5%	68.1%	71.4%	74.5%
3- chemicals	77.2%	64.4%	68.5%	72.0%
4- pharmaceuticals	77.7%	60.1%	69.5%	73.4%
5- industrial materials	68.3%	48.5%	54.9%	61.3%
6- mechanical technologies	65.1%	45.0%	53.9%	58.5%
7- consumption materials	61.2%	36.7%	48.0%	52.8%

Table 3.2. Co-location of patenting by business organizations and NBOs: conditional correlation of business patenting on NBO patents 1991-2005

	Overall	EU15	USA
Pooled linear estimator	24.050	16.841	30.306
Random effects linear estimator	16.281	12.165	21.537
Fixed effects linear estimator	15.844	11.896	21.024
Number of useful observations	387,450	275,205	112,245
Number of regions	3,690	2,621	1,069

Notes:

(1) A variable of log population has been inluded in all the regressions

(2) It includes country, technology and times dummies

(3) All the coefficients are statistically coefficient at 1% level.

Table 4.1 (a) Descriptive statistics 1991-2005 - Overall - (3,690 TL3 regions)

	Useful Obs	Mean	Std	Min	Max
Entry of new business patenters by region & technology - priority year	387,450	0.336	1.288	0.000	85
Entry of new business patenters by region & technology - founding year	387,450	0.149	0.751	0.000	65
Stock of business patents by region & technology	387,450	7.825	37.393	0.000	3,182
Stock of NBO patents by region & technology	387,450	0.630	3.540	0.000	222
Stock of NBO patents by region & technology - only SET A	387,450	0.520	3.293	0.000	222
Stock of business citation weighted patents by region & technology	387,450	31.551	321.133	0.000	58,589
Stock of NBO citation weighted patents by region & technology	387,450	2.245	21.206	0.000	3,073
Stock of NBO citation weighted patents by region & technology - only SET A	387,450	1.897	20.271	0.000	3,064
Spillovers from the neighbouring regions (TL2 level)	387,450	448.922	2661.750	0.000	106,786

Table 4.1 (b) Descriptive statistics 1991-2005 - United States - (2,621 TL3 regions)

	Useful Obs	Mean	Std	Min	Max
Entry of new business patenters by region & technology - priority year	275,205	0.148	0.954	0.000	85
Entry of new business patenters by region & technology - founding year	275,205	0.068	0.651	0.000	65
Stock of business patents by region & technology	275,205	4.406	33.229	0.000	3,182
Stock of NBO patents by region & technology	275,205	0.364	3.095	0.000	206
Stock of NBO patents by region & technology - only SET A	275,205	0.343	2.997	0.000	204
Stock of business citation weighted patents by region & technology	275,205	30.215	372.308	0.000	58,589
Stock of NBO citation weighted patents by region & technology	275,205	2.045	23.329	0.000	3,073
Stock of NBO citation weighted patents by region & technology - only SET A	275,205	1.911	22.546	0.000	3,064
Spillovers from the neighbouring regions (TL2 level)	275,205	544.601	3137.565	0.000	106,786

Table 4.1 (c) Descriptive statistics 1991-2005 - EU15 countries (1,069 TL3 regions)

	Useful Obs	Mean	Std	Min	Max
Entry of new business patenters by region & technology - priority year	112,245	0.795	1.789	0.000	48
Entry of new business patenters by region & technology - founding year	112,245	0.350	0.921	0.000	39
Stock of business patents by region & technology	112,245	16.207	44.947	0.000	2,910
Stock of NBO patents by region & technology	112,245	1.281	4.379	0.000	222
Stock of NBO patents by region & technology - only SET A	112,245	0.952	3.892	0.000	222
Stock of business citation weighted patents by region & technology	112,245	34.826	126.905	0.000	8,618
Stock of NBO citation weighted patents by region & technology	112,245	2.733	14.750	0.000	1,501
Stock of NBO citation weighted patents by region & technology - only SET A	112,245	1.864	13.119	0.000	1,492
Spillovers from the neighbouring regions (TL2 level)	112,245	214.334	491.837	0.000	8,825

Table 4.2a: Impact of NBO patenting on the entry of new business patenters - region fixed effects panel estimator
Dependent variable: log of first difference of annual entry by region and technology

Reference time of entry: priority year of first patent

(2,621 US TL3 regions and 1,069 EU15 TL3 regions; 7 technologies; annual time periods over years 1991-2005)
(useful observations: all sample 387,450; US = 275,205; EU15 = 112,245)

	All sample		EU15		USA	
Model 1						
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business patents by region & technology	0.002	(0.000)	0.005	(0.000)	0.001	(0.000)
Stock of NBO patents by region & technology	0.002	(0.000)	0.002	(0.000)	0.003	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.046	(0.002)	0.131	(0.011)	0.031	(0.001)
Model 2						
	All sample		**EU15**		**USA**	
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business patents by region & technology	0.002	(0.000)	0.006	(0.000)	0.001	(0.000)
Stock of NBO patents by region & technology - only SET A	0.002	(0.000)	0.002	(0.000)	0.003	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.047	(0.002)	0.133	(0.011)	0.031	(0.001)
Model 3						
	All sample		**EU15**		**USA**	
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business citation weighted patents by region & technology	0.002	(0.000)	0.004	(0.000)	0.001	(0.000)
Stock of NBO citation weighted patents by region & technology	0.002	(0.000)	0.002	(0.000)	0.004	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.045	(0.002)	0.130	(0.011)	0.030	(0.001)
Model 4						
	All sample		**EU15**		**USA**	
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business citation weighted patents by region & technology	0.002	(0.000)	0.005	(0.000)	0.001	(0.000)
Stock of NBO citation weighted patents by region & technology - only SET A	0.002	(0.000)	0.001	(0.000)	0.004	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.045	(0.002)	0.132	(0.011)	0.030	(0.001)

Note: 1) All the regressions include the costant term, population and time, technology fields, and country dummies.

2) All the coefficient are statistically significant at 1% level.

Table 4.2b: Impact of NBO patenting on the entry of new business patenters - region fixed effects panel estimator
Dependent variable: log of first difference of annual entry by region and technology

Reference time of entry: founding year of the company

(2,621 US TL3 regions and 1,069 EU15 TL3 regions; 7 technologies; annual time periods over years 1991-2005)
(useful observations: all sample 387,450; US = 275,205; EU15 = 112,245)

	All sample		EU15		USA	
Model 1						
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business patents by region & technology	0.001	(0.000)	0.002	(0.000)	0.001	(0.000)
Stock of NBO patents by region & technology	0.001	(0.000)	0.001	(0.000)	0.002	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.032	(0.001)	0.093	(0.006)	0.021	(0.001)
Model 2						
	All sample		**EU15**		**USA**	
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business patents by region & technology	0.001	(0.000)	0.002	(0.000)	0.001	(0.000)
Stock of NBO patents by region & technology - only SET A	0.002	(0.000)	0.001	(0.000)	0.002	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.032	(0.001)	0.093	(0.006)	0.021	(0.001)
Model 3						
	All sample		**EU15**		**USA**	
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business citation weighted patents by region & technology	0.001	(0.000)	0.002	(0.000)	0.001	(0.000)
Stock of NBO citation weighted patents by region & technology	0.002	(0.000)	0.001	(0.000)	0.003	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.031	(0.001)	0.091	(0.006)	0.020	(0.001)
Model 4						
	All sample		**EU15**		**USA**	
	coeff.	**std err.**	**coeff.**	**std err.**	**coeff.**	**std err.**
Stock of business citation weighted patents by region & technology	0.001	(0.000)	0.002	(0.000)	0.001	(0.000)
Stock of NBO citation weighted patents by region & technology - only SET A	0.002	(0.000)	0.001	(0.000)	0.003	(0.000)
Spillovers from the neighbouring regions (TL2 level)	0.031	(0.001)	0.091	(0.006)	0.020	(0.001)

Note: 1) All the regressions include the costant term, population and time, technology fields, and country dummies.

2) All the coefficient are statistically significant at 1% level.

Table 4.3 Granger causality tests - at country and technology level

	Reference time of entry: priority year		*Reference time of entry: founding year*	
Estimation information:				
Dep. variable ΔY_t	log(Entry)	log(Entry)	log(Entry)	log(Entry)
Lags of ΔY_t	1	2	1	2
Indep. variable ΔX_t	Log(Stock NBO pats)	Log(Stock NBO pats)	Log(Stock NBO pats)	Log(Stock NBO pats)
Lags of ΔXt	1	2	1	2
Sample information:				
No. of observations	1680	1680	1680	1680
No. of parameters	126	125	126	125
No. of individuals	112	112	112	112
Time series	14	13	14	13
Does X_t cause Y_t ?	11.631(1)***	13.197(2)***	7.638(1)***	7.236(2)**
Estimation information:				
Dep. variable ΔY_t	Log(Stock NBO pats)	Log(Stock NBO pats)	Log(Stock NBO pats)	Log(Stock NBO pats)
Lags of ΔY_t	1	2	1	2
Indep. variable ΔX_t	log(Entry)	log(Entry)	log(Entry)	log(Entry)
Lags of ΔXt	1	2	1	2
Sample information:				
No. of observations	1680	1680	1680	1680
No. of parameters	126	125	126	125
No. of individuals	112	112	112	112
Time series	14	13	14	13
Does X_t cause Y_t ?	1.306(1)	0.968(2)	0.306(1)	1.821(2)

Notes: 1) In addtion to stock of business patents, all regressions include as exogenous variables the costant, spillovers at TL2, time, technology, and locational dummies.

2) *** indicates statistically significant at 1% level; **5% level.

Table 4.4: Impact of NBO patenting on the entry of new business patenters - GMM regression

(2,621 US TL3 regions and 1,069 EU15 TL3 regions; 7 technologies; annual time periods over years 1991-2005)

(useful observations: all sample 387,450; US = 275,205; EU15 = 112,245)

Model 1

	Reference time of entry: priority year				*Reference time of entry: founding year*			
	DPD-DIF		**DPD-SYS**		**DPD-DIF**		**DPD-SYS**	
	coeff.	**p-value**	**coeff.**	**p-value**	**coeff.**	**p-value**	**coeff.**	**p-value**
Entry of new business patenters - Lag 1	0.030	***	0.029	***	0.044	***	0.037	***
	(0.006)		(0.006)		(0.008)		(0.008)	
Stock of business patents by region & technology	0.077	***	0.024	***	-0.004		0.003	***
	(0.008)		(0.002)		(0.005)		(0.001)	
Stock of NBO patents by region & technology	0.091	***	0.015	***	-0.011		0.003	**
	-0.010		(0.002)		(0.006)		(0.001)	
Spillovers from the neighbouring regions (TL2 level)	0.057	**	0.065	**	0.043	**	0.045	**
	(0.024)		(0.029)		(0.021)		(0.023)	

Model 2

	Reference time of entry: priority year				*Reference time of entry: founding year*			
	DPD-DIF		**DPD-SYS**		**DPD-DIF**		**DPD-SYS**	
	coeff.	**p-value**	**coeff.**	**p-value**	**coeff.**	**p-value**	**coeff.**	**p-value**
Entry of new business patenters - Lag 1	0.018	***	0.031	***	0.049	***	0.039	***
	(0.006)		(0.006)		(0.008)		(0.008)	
Stock of business citation weighted patents by region & technology	0.055	***	0.026	***	0.009	***	0.004	***
	(0.005)		(0.002)		(0.003)		(0.001)	
Stock of NBO citation weighted patents by region & technology	0.124	***	0.016	***	0.055	***	0.005	***
	(0.01)		(0.003)		(0.006)		(0.002)	
Spillovers from the neighbouring regions (TL2 level)	0.049	***	0.067	**	0.037	**	0.047	**
	(0.019)		(0.03)		(0.017)		(0.024)	

Note: 1) All the regressions include the costant term, population and time, technology fields, and country dummies.

2) *** indicates statistically significant at 1% level; **5% level.

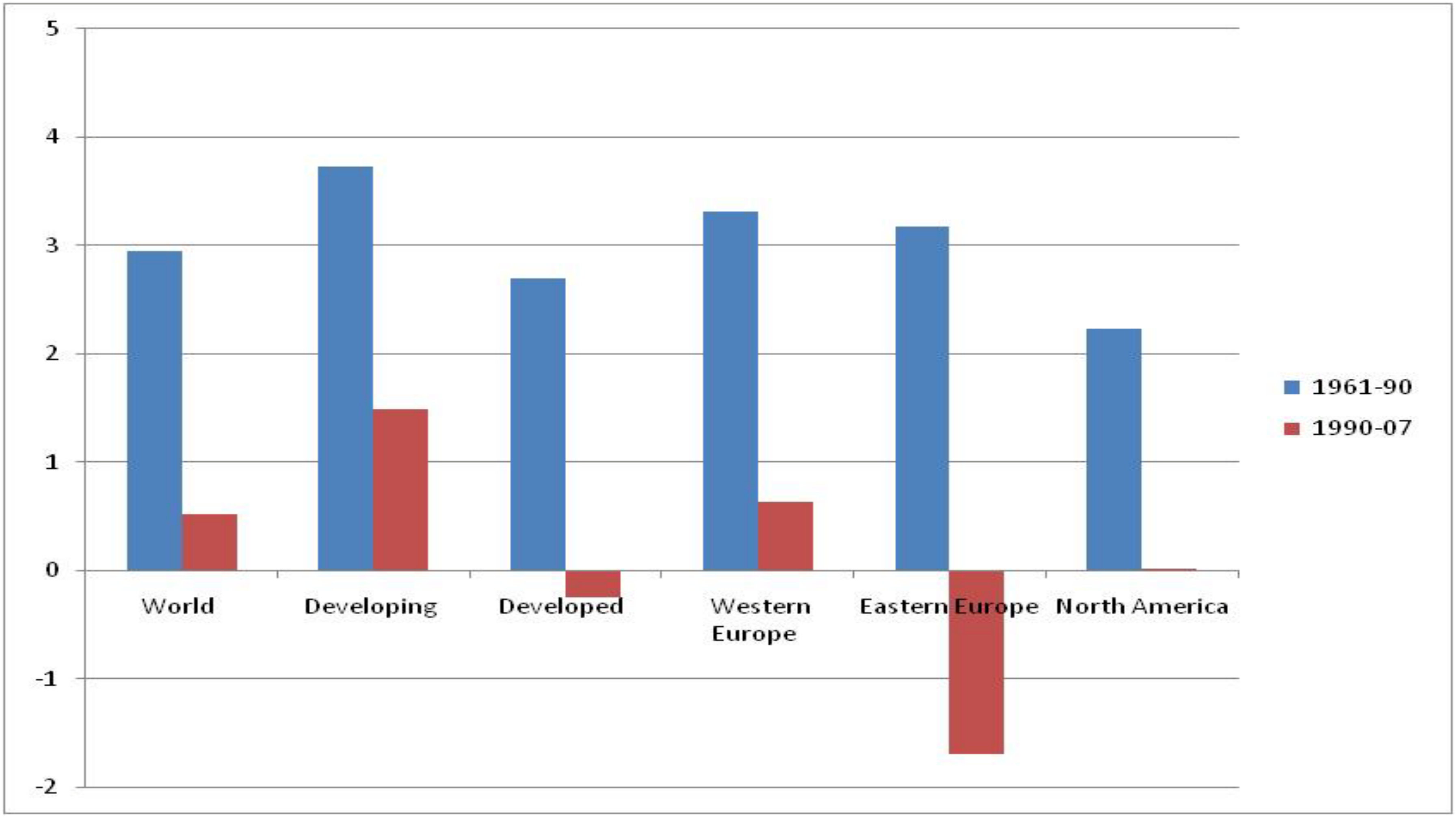
The effect of plant patents on variety innovation

Russell Thomson

Melbourne Institute of Applied Economic and Social Research and the Intellectual Property Research Institute of Australia

THE UNIVERSITY OF MELBOURNE

WHEAT YIELD GROWTH RATES: 1960-2007.



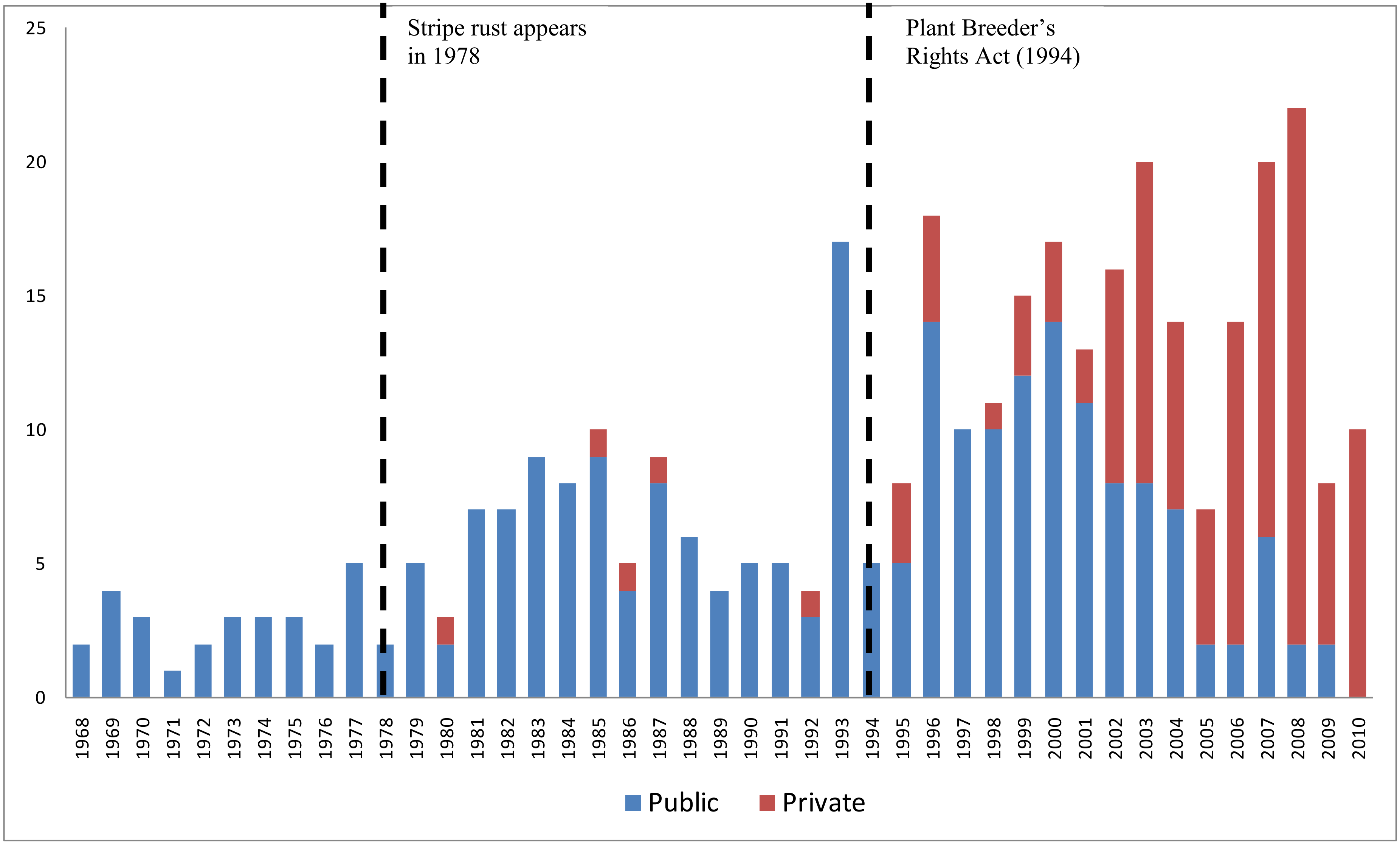
Source: Alston, J & Pardy, P 2010

Wheat Breeding in Australia

- Wheat varieties (cultivars) are a public good (i.e., Non- rival & Non-excludable)
- 1886 selective breeding begins (almost) exclusively public for first 100 years
- 1991 UPOV Convention (~ 'TRIPS for plants')
- 1994 Plant Breeders' Rights Act
  - New private breeders established
  - All formerly government owned breeders privatized.

A natural experiment to study the impact of IPR reform on innovation outcomes

NUMBER OF NEW CULTIVARS RELEASED EACH YEAR (1968-2010)



DATA

Data from scientific variety trials.

- Varieties (260) x environment type (24) x trial year (1968-2010)

- Three dimensions of variety 'quality':
  - Yield (tons/ hectare)
  - Grades (7, Australian Prime Hard -> Feed)
  - Disease resistance (scale 1-5, Immune –> Very Susceptible)

Weighted using prices to produce a single index of value, expressed in $$.

Example: One Environment type (NE NSW) in 2002

Variety Name	Year Released	Private Breeder	PBR	Yield (t/h)	Grade	Rust Resistance	Value
H45	1999	1	1	3.22	B	2.0	$645
Silverstar	1996	0	1	3.09	B	2.0	$625
Petrie	2000	0	1	3.03	A	2.5	$673
Leichhardt	1996	0	1	3.00	B	3.0	$590
Babbler	2000	0	1	3.00	A	3.0	$660
Bowerbird	2001	0	1	3.00	B	3.5	$583
Qt7208	1999	0	1	2.96	F	2.4	$473
Qal 2000	2002	1	1	2.95	D	5.0	$471
Sunlin	1999	1	0	2.94	A	2.0	$659
Wyalkatchem	2002	0	1	2.93	C	2.8	$537
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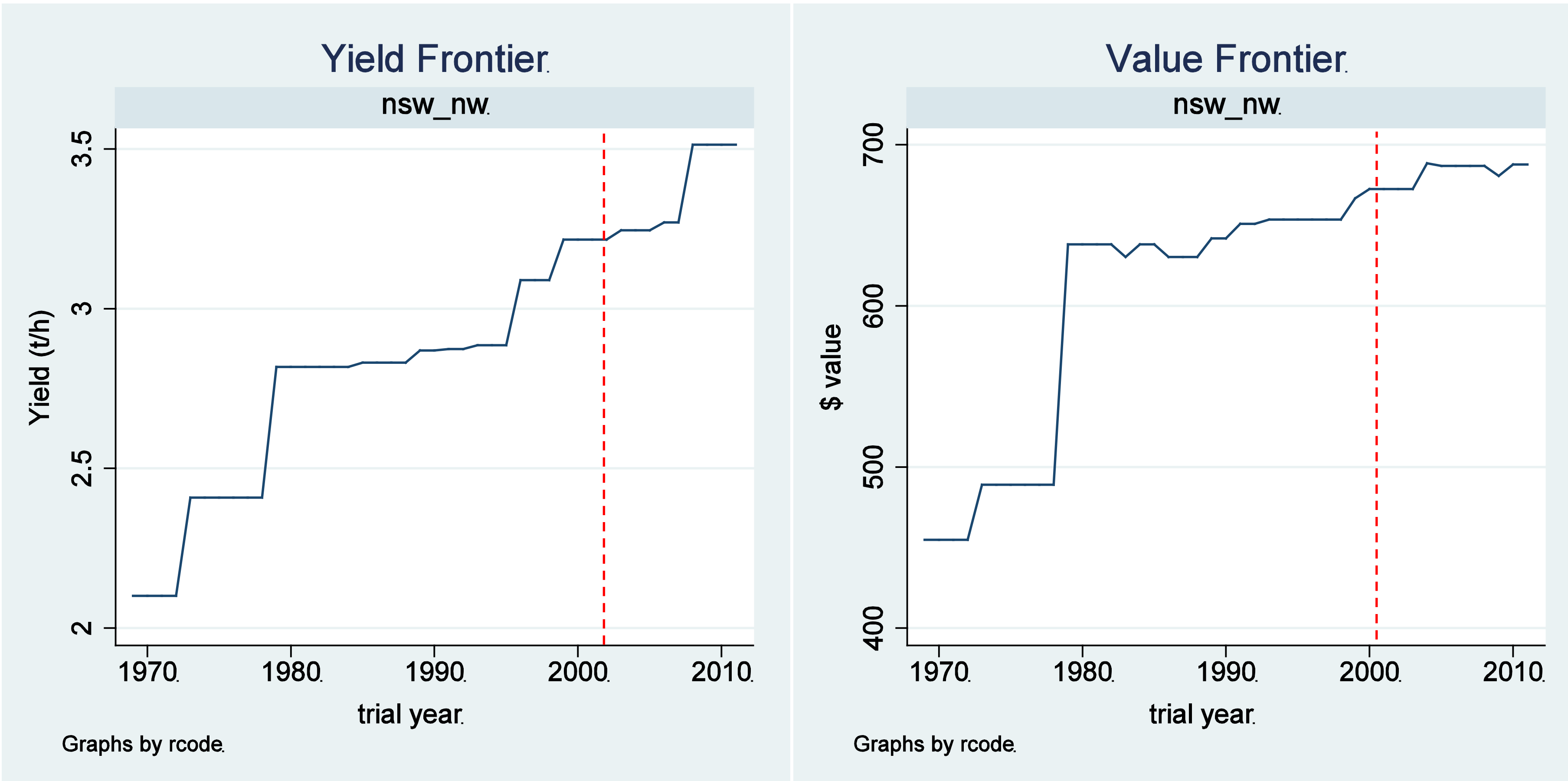
PPF FRONTIER, ENVIRONMENT TYPE (NE NSW), 1968-2011

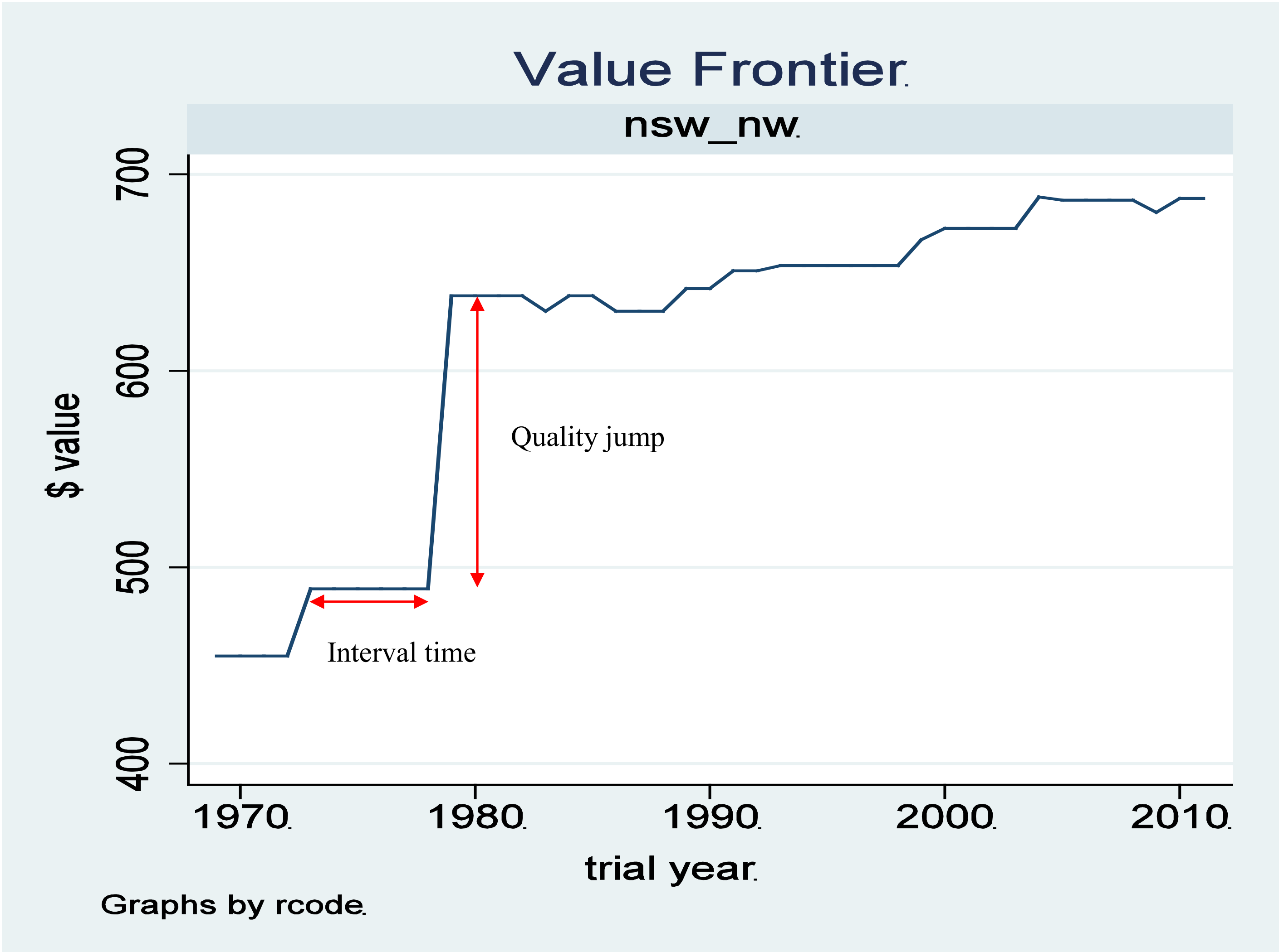


REGRESSION RESULTS:

Dependent variable: $Value_{ij}$ (region x year)

	Frontier			Fuzzy frontier (stacked)		
	(1)	(2)	(3)	(4)	(5)	(6)
PBR Act 1994	-23.08***	-23.01***	-9.91*	-22.96***	-23.00***	-12.55***
	(5.02)	(5.05)	(5.19)	(2.86)	(2.87)	(2.84)
Private firm		0.66	25.04***		-0.55	19.76***
		(4.67)	(5.57)		(2.42)	(2.63)
Time	5.06***	5.05***	9.05***	6.07***	6.08***	11.11***
	(0.22)	(0.24)	(0.58)	(0.13)	(0.13)	(0.32)
Time squared			-0.10***			-0.11***
			(0.01)			(0.01)
Enviro type dummies	Y	Y	Y	Y	Y	Y
Observations	867	867	867	3,973	3,973	3,973
R-squared	0.95	0.95	0.95	0.93	0.93	0.93

APPLICATION II



RESULTS:

	DepVar: Quality jump (proportional)	DepVar: Interval time (in Log)
	(1)	(2)
PBR Act 1994	-0.05***	0.36***
	(0.01)	(0.13)
Private breeder	0.00	-0.41***
	(0.02)	(0.14)
Time	-0.01***	-0.03
	(0.00)	(0.02)
Constant	0.12***	1.63***
	(0.01)	(0.10)
Observations	151	151
R-squared	0.23	0.08

Where to from here?

- Efficiency – take into account input (breeding) costs
- Direction of research – e.g,. are smaller niche environments being neglected?
- Why do some firms not take out PBR?
- What is the impacts globalization?

THANK-YOU

What determines breeder performance –e.g., Why would private firms perform differently?

- Inputs
  - Access to germplasm
  - Choice of parents
- Productivity
  - Better tests (such as for quality) which can be performed on smaller quantities of grain.
  - Two generations per year
  - Choices in screening
- Release Decisions –
  - Possibly requiring less testing, lower performance threshold, IP protection guaranteed

Re-conceptualizing Patents: Open Innovation & Social Responsibility

Keywords: Patents, Patent Law, Licensing Practices, Open Innovation, Social Responsibility

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I. Introduction

Over time, the perspective on patents has evolved from the medieval conceptualization of patents as state or royal privileges granted by the sovereign (Walterscheid, 1994; Machlup & Penrose, 1950) to a ''utilitarian'' conceptualization of patents as exclusive property rights. Recently, several scholars have argued in favor of a "re-conceptualization" of patents as temporary duty-bearing privileges and regulatory tools (e.g. van Zimmeren, 2011; Van Overwalle, 2010; Ghosh, 2008; Ghosh, 2004; Drahos, 1996). In part, this re-conceptualization seems to be a response to some restrictive exploitation strategies, such as hold-ups, adopted by patent owners in various sectors. However, the theoretical legal discourse regarding the conceptualization of patents also seems to be triggered by broader developments in the economic and social context.

Patent law and legal theory concerning patent law do not operate within a vacuum. Law has an intimate relationship with the economic and social environment: the legal system determines the organization of the economic and social reality and, in turn, the legal system also needs to reflect economic and social conditions. In this respect, a better understanding of the growing importance of the concepts of open innovation and social responsibility is crucial to feed the theoretical legal discourse concerning patents. By reviewing open innovation and social responsibility from a legal perspective and providing some examples on how these notions could be better accommodated, I attempt to contribute to the development of the patent paradigm.

The paper begins with an analysis of the concepts of open innovation and social responsibility. Here, I start form the assumption that the interest in these two concepts is increasing and the ideas are being implemented by firms without entering into a normative assessment of the two concepts. Given that these concepts are widely adopted, the legal infrastructure should be responsive to these socio-economic trends. This analysis is followed by an exploration of patents as temporary duty bearing privileges and regulatory tools. I conclude by examining the link between open innovation and social responsibility, on the one hand, with new perspectives regarding patents, on the other hand. This examination includes some thoughts on how different stakeholders could pursue these ideas in terms of patent management and licensing practices. The focus of the paper is not restricted to a certain country. Its level of analysis is primarily international or European and the analysis contains both descriptive and normative components. Throughout the paper, examples and best practices are derived from the biomedical sector, where both open innovation and social responsibility are progressively gaining ground.

II. Open Innovation

In the following sections, I will first define and characterize the notion of open innovation and then provide a more detailed examination of the way open innovation may operate in the biomedical sector.

1. The Concept

Whereas the idea of open innovation as such is not new, the term was coined by Chesbrough in his groundbreaking article in Sloan Management Review (Chesbrough, 2003) and in his book “Open Innovation: The New Imperative for Creating And Profiting from Technology” (Chesbrough, 2006). In these publications he described a general development from closed to open innovation. Traditionally, companies mainly invested in large R&D departments. They aimed at maximizing innovation and nurturing their competitiveness and growth through the incremental improvement of existing products, processes and services and through the introduction of some radically new ones. The central tenet of this closed approach was that successful innovation requires *control* (Chesbrough, 2003). In other words, companies must generate their own ideas, develop these ideas, build them, market them, distribute them, service them, finance them, and support them on their own. Heavy investments in internal R&D resulted in major innovations protected by aggressively controlling patents to prevent competitors from exploiting them. However, this closed framework has become no longer sustainable in sectors, where a number of “erosion factors” are in place, i.e. the growing mobility of the workforce, the increasing role of venture capital, rapid advances in technology development and the creation of a market for technology (Chesbrough, 2003).

From here, a more open approach has emerged that "assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology" (Chesbrough, 2006). This approach is based on the recognition that valuable technologies may originate both from within and outside the boundaries of the company, and that innovation can be exploited both internally and externally. The central idea behind open innovation is that in a world of widely distributed knowledge, companies cannot afford to rely entirely on their own research, but should instead source ideas, knowledge and technology from other entities. In addition, internal ideas, knowledge and technology, which are not being used in a firm's business should be taken outside the firm. Thus, the boundaries between a firm and its environment become more permeable and innovations can easily transfer resulting in a new market for knowledge. Hence, open innovation can be defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation (Chesbrough, Vanhaverbeke & West, 2008) with the primary goal of creating and capturing value from innovation by the firm. Opening up to external organizations in order to access their technical and scientific competences is generally called "inbound open innovation". Establishing relationships to exploit internal innovation externally concerns "outbound open innovation". These two flows of knowledge are complementary. However, much of the available research has focused on inbound open innovation (see e.g. Lichtenthaler, 2010).

Open innovation relates to a wide range of *external partners* – customers, suppliers, competitors, consultants, universities, public research organizations, investors, intermediaries etc. – and can be facilitated through a wide range of *organizational modes* – start-ups, in- and out-licensing agreements, R&D alliances, joint-ventures, purchase and supply agreements of scientific services, mergers and acquisitions, consortia, networks, clusters and open campus models. Case studies and experimentation with open innovation models show that they may be especially appropriate in a *multidisciplinary, pre-competitive* context. In such a context generally a wide variety of players may be involved ranging for instance from pharmaceutical companies to IT companies. Firms will seek for expertise beyond their own core activities to partner up to explore new opportunities. *Pre-competitive* environments, may involve significant risks, but may also offer many opportunities for differentiation for the various partners. Collaborative efforts could reduce R&D costs, allow access to (complementary) technology, build a greater technical critical mass, enable sharing risks and liabilities, improve access to capital, increase flexibility, facilitate access to marketing/distribution strengths and smoothen the standardization process (see e.g. Trott & Hartmann, 2009).

However, opening up organizational boundaries for innovation purposes also entails some risks and organizational costs (e.g. Knudsen & Mortensen, 2011). For instance, investing in technology alliances with different kinds of partners may bring along substantial managerial costs which may exceed the benefits of these strategies in the short term (Faems, et al., 2010). Moreover, successfully adopting open innovation models requires substantial investment in partnership and knowledge management systems, sufficient internal absorptive capacity and significant changes in the internal organization (e.g. Chiaroni, Chiesa & Frattini, 2011; Di Minin, et al., 2011). Finally, prices may be distorted due to informational asymmetries and large disparities in the size, level of sophistication and the financial status of the partners. All these considerations involve new balancing acts to appropriate value and improve performance. Therefore, any company that decides to implement open innovation as part of its business strategy needs a strong, long-term commitment at the top management level and strict alignment (van Zimmeren, 2011; Chiaroni, Chiesa & Frattini, 2011).

Obviously, innovation strategies should be carefully designed and not every technology or product will be prone to open innovation models. Companies will focus on areas of unmet need where they think open innovation can have the greatest impact. Strategies should be flexible and should allow for a variety of organizational modes to accommodate open innovation. The choice for a particular organizational mode and type of partner (e.g. universities, research institutes, consultants, competitors, suppliers) may also vary substantially along the phases of the R&D process (Bianchi, et al., 2011). In this respect, open innovation appears to reflect much less a dichotomy (open v. closed) than a *continuum* of innovation strategies with varying degrees of openness (Huizingh, 2011).

2. Open Innovation in the Biomedical Sector

Traditionally, apart from deals with universities large pharmaceutical companies have used proficiency in internal R&D as an entry barrier to competitors. For many biotechnology companies a large part of their innovation pipeline was always catalyzed through more open models. Lately the biopharmaceutical business model is showing some fatigue. This is reflected in skyrocketing developments costs, patent cliffs, empty pipelines, difficulties in raising venture capital, regulatory challenges, high payer expectations, pricing pressures, technological challenges and intense (generic) competition. Many pharma companies have tried to overcome these problems by mega-mergers and acquisitions. However, one might doubt to what extent these activities actually had the desired positive impact on their pipelines. In fact, companies that have been heavily involved in M&As tend to have lower R&D productivity and, hence, lower rates of new drug output than those that have not (LaMattina, 2011; Munos, 2009). Furthermore, the integration of two R&D organizations often results in the combined organization being less productive (Dixon, Lawton & Machin, 2009). Open innovation is one of the alternatives that may be employed to deal with the current challenges.

Bianchi et al. carried out a study on open innovation organizational modes in the biopharmaceutical sector for the period 2000-2007. This study revealed that pharma companies especially engage in more traditional organizational modes, such as alliances, licensing agreements and purchase and supply agreements of technical and scientific services (Bianchi, et al., 2011). Many of these organizational modes concern *late stage deals*. However, the number of available technologies is limited and promising targets are becoming expensive. Various authors contend that the current challenges require the exploration of more *radical* open innovation organizational modes (Hunter & Stephens, 2010; Munos, 2009; Melese, et al., 2009). Indeed, some pharmaceutical companies have started to drastically rethink their *early stage* development and are considering more open models. Individual companies are already experimenting with some more complex open innovation models, such as the patent pool for neglected diseases initiated by GSK and the open campus model adopted by Johnson & Johnson. For pre-competitive research, companies sometimes engage in large consortia, such as IMI,[1] and the Centre for Translational Molecular Medicine[2]. Ideally, these consortia also include some a-typical partners, such as patient organizations and regulatory agencies to speed up the wide uptake of new technologies and methods in the sector.

III. (Corporate) Social Responsibility

[1] IMI is a public-private partnership between the European Commission and the European Federation of Pharmaceutical Industries and Associations (EFPIA), a so-called European Joint Technology Initiative. It aims at providing a framework for the conduct of pre-competitive collaborative research to develop new tools and technologies for safety assessment, efficacy evaluation, knowledge management and education in order to increase the efficiency of drug discovery and development. The European Commission contributes €1 billion to the IMI research program. That amount is matched by mainly in-kind contributions (consisting mostly of research activities) worth at least another €1 billion from member companies of EFPIA. See also: http://www.imi-europe.org/.

[2] A Dutch public-private consortium that comprises a multidisciplinary group of parties - universities, academic medical centers, medical technology enterprises and chemical and pharmaceutical companies. It is dedicated to the development of medical technologies enabling the design of new and "personalized" treatments for the main causes of mortality and diminished quality of life (cancer and cardiovascular diseases and, to a lesser extent, neurodegenerative and infectious diseases) and the rapid translation of these treatments to the patient. See also: http://www.ctmm.nl/.

This current section starts with an explanation of the concept of social responsibility, followed by an examination of several standards and platforms that have been developed to elaborate the concept and some insights on the practices in the biomedical sector.

1. The Concept

The concept of Corporate Social Responsibility (CSR) prescribes that companies have a responsibility to pursue societal objectives advancing the interests of all "stakeholders" affected by their activities, not just shareholders, but also employees, consumers, suppliers, creditors and local communities (Campbell & Vick, 2007). This obligation goes beyond the minimum requirements imposed by formal legal rules, but is itself a non-binding social norm. There is no consensus on a more detailed definition of CSR, but it is clear that the principle manifests itself in many different spheres, such as corporate ethics, legal compliance, labor and employment practices, taxes, human rights, health and safety, environment, corruption, procurement and consumer protection. CSR principles apply broadly to business activities, both locally and globally. The promotion of an ethos of CSR is also strongly supported by governments.[3]

Companies do not necessarily see CSR as a hurdle. Some of them positively embrace the concept as an opportunity to be seized in the pursuit of competitive advantage, in terms of marketing, brand enhancement, the opening of new markets and cost savings (the so-called "business case of CSR", cf. "shared value" below) (McBarnett, 2007). In this light, CSR has also attracted quite some skepticism (McBarnett, 2007). First, some opponents argue that companies should be 'ethical' regardless of the positive "business case of CSR". Second, social responsibility principles may conflict with profit maximizing goals. So the question arises whether we can depend on voluntary policies or whether we need legislation to impose socially responsible behavior to prevent conflicts. Third, how many and what type of organizations actually adopt such practices? Are only large companies that can profit from CSR committing themselves to CSR or SMEs as well? Fourth, CSR activities often set business against society, even though they are clearly interdependent. How could this be improved? Finally, companies tend to

[3] See e.g.: US President Obama heralded the need for "a new era of responsibility" (Obama, B., 2009) and the European Commission has a robust, extensive policy on CSR (European Commission, 2007; European Commission, 2002; European Commission, 2001). At the occasion of the 2009 CSR Forum, EU Commissioner Verheugen stated: "Clearly, in a market economy, business has to make profit. However, a genuinely European view holds that to achieve this objective in a sustainable way, the economic activities must ultimately serve the interests of society. Enterprises do this through the wealth they generate, the jobs they provide, and the goods and services they offer, while taking care of the environment and local communities where they operate. But the issue goes a step further – it is a question of ethical behavior, of ethical standards. The financial turmoil has revealed to us an unexpected degree of selfishness and greed existing in our society. This must be changed. Not by legislation, as ethical behavior cannot be decreed by law. Instead, we must put in place an environment where such behavior is not tolerated but punished." (Verheugen, 2009).

be pressured into CSR programs and are implementing it in generic ways. Would it not be possible to figure out ways which are most appropriate to each firm's strategy (McBarnett, 2007; Porter & Kramer, 2006)?

Porter and Kramer seek to overcome some of this skepticism by openly linking CSR to competitive advantage and by proposing the principle of shared value (Porter & Kramer, 2011; Porter & Kramer, 2006). The central idea of shared value is that companies can go beyond mere CSR by adopting policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which they operate (Porter & Kramer, 2011; Porter & Kramer, 2006). The concept of shared value is not about personal values or "sharing" the value already created by companies – a redistributive approach. In contrast, it recognizes that societal needs define markets similar to conventional economic needs. Societal harms or weaknesses frequently create internal costs for companies as well (e.g. wasted energy, accidents, low quality education systems). Addressing these harms and constraints does not automatically raise costs for the companies concerned, because they can innovate by using new technologies, operating methods and management approaches and as a result increase their productivity and expand their markets while society benefits as well (Porter & Kramer, 2011).

Instead of setting up a hodge-podge of philanthropic activities disconnected from the company's strategy to showcase their CSR commitment, companies must integrate the social perspective into the core strategic framework they are already using to guide their business strategy. Corporations are not responsible for all the global problems, nor do they have the resources to solve them all. Each company should identify the particular set of societal problems that it is best equipped to help resolve and from which, at the same time, it can gain the greatest competitive benefit.

Linking business and social needs requires adjustments in the organization, reporting relationships and incentives. Few companies have developed a strategic CSR approach. Most got stuck with piecemeal philanthropic projects. Only exceptionally, companies have embedded a social dimension in their core value proposition. Companies must shift from a fragmented, defensive posture on CSR to a pro-active, integrated, affirmative shared value approach (Porter & Kramer, 2006). Porter and Kramer identify 5 steps for fully integrating the concept of shared value into a company. First, companies should try to identify the points of interdependence between the company and society. In this first step, they distinguish two dimensions: an inside-out linkage concerning the impact of the company upon society through its normal course of business (value chain) and an outside-in linkage relating to the competitive context which significantly affects a firm's ability to carry out a long term business strategy. Second, companies should select societal issues that intersect with their particular business. Third, they should create a pro-active, well-tailored corporate social agenda. Fourth, they should integrate value chain practices (inside-out) and investments in the competitive context as far as possible. Fifth, they should create a social dimension in their value proposition, making social impact integral to the overall business strategy (Porter & Kramer, 2006).

Social responsibility can be regarded as an amplification of CSR (see also Ward, 2011). Social responsibility entails that *every* entity (not only companies!) – whether it is a state or an international organ, a company, another type of organization or an individual – has a responsibility to society, which goes beyond what the law requires. Social responsibility is, hence, distinguished from corporate social responsibility by extending the concept beyond the business context as a kind of "organizational" social responsibility, which is applicable to all types of organizations. In the remainder of the current paper, I use the broader term social responsibility instead of CSR and shared value. Nonetheless, in applying this organizational notion of social responsibility I strongly align with Porter and Kramer who emphasize the importance of *integrating* the social objective in the business strategy, the need for *proactive* tailoring of the process and for identifying areas where the company can employ its strengths and where both social and business benefits can be large and distinctive.

2. Social Responsibility Tools

The principle of social responsibility is a social norm, not a legal principle. However, non-legal principles may also "enter" into law as a consequence of the dominant legal discourse (Aarnio, 1997). When such a principle receives the necessary institutional support, it may receive legal relevance and may then be recognized as a ground for the decision-making praxis. Hence, organizations would then be *obliged* to apply this principle throughout their activities. Social responsibility has indeed received a more formal status by way of its incorporation in several international instruments, such as the ISO 26000 International Guidance Standard on Social Responsibility, an international standard set by the International Organization for Standardization (ISO),[4] the famous "Protect, Respect and Remedy" framework proposed by Professor John Ruggie, Special Representative of the UN Secretary-General for

[4] ISO 26000 outlines seven principles of social responsibility: (1) accountability; (2) transparency; (3) ethical behavior; (4) respect for stakeholder interests; (5) respect for the rule of law; (6) respect for international norms of behavior, and (7) respect for human rights (Clause 4). It contains substantive guidance on seven "core objects": (1) organizational governance; (2) human rights; (3) labor practices; (4) the environment; (5) fair operating practices; (6) consumer issues, and (7) community involvement and development (Clause 6).

Business and Human Rights (UNSRSG) (Ruggie, 2008) and the Organization for Economic Co-operation and Development (OECD) Guidelines of Multinational Enterprises (OECD, 2011)

In particular, the ISO standard is quite fascinating. First, the consensus-based standard is the result of negotiations between a wide variety of stakeholder groups, including consumers, government, industry, labor, non-governmental organizations and other organizations (such as academics, consultants and national standards bodies). This shows that the principle of social responsibility is widely supported. Second, ISO 26000 explicitly focuses on organizational social responsibility, which is relevant to all organizations, including public sector actors, and not only for corporations. Third, different from other ISO standards, ISO 26000 is not a management system standard and is not intended or appropriate for certifications purposes or regulatory or contractual use (Clause 1).

The negotiations on ISO 26000 took place in the shadow of the discussions on the “Protect, Respect and Remedy” framework. The “Protect, Respect and Remedy” framework (the UN Framework) comprises three distinct but interrelated pillars: (1) the state duty to protect against human rights abuses by third parties, including business, through appropriate policies, regulation and adjudication; (2) the *corporate responsibility* to respect human rights, in essence meaning to act with due diligence to avoid infringing on the rights of others; and (3) the need for greater access by victims to effective access to judicial and non-judicial remedies. In March 2011, Professor Ruggie published the final version of the Guiding Principles for the implementation of the framework, for consideration by the UN Human Rights Council in June (Ruggie, 2011). These guidelines were endorsed by the UN Human Rights Council (UN Human Rights Council, 2011), but do not include the same broad base of stakeholders as ISO 26000. Moreover, its mandate was limited to the specific issue of business and human rights, whereas social responsibility covers a broader range of topics. Yet, the framework’s function as the global reference point for further work on business and human rights is undisputed.

In May 2011, an updated version of the OECD Guidelines of Multinational Enterprises was launched. The OECD Guidelines are a non-binding code of conduct containing recommendations for responsible business conduct in a global context. The countries that adhere to the Guidelines agree to promote the guidelines among the business sector. Notably, the revised OECD Guidelines reflect a new focus on business and human rights. The revisions to the OECD Guidelines reflect the influence of the “Protect, Respect, and Remedy” framework and guiding principles. The revised version also contains a chapter on science and technology with several provisions on intellectual property rights.

Complementary to these social responsibility standards, the UN Global Compact (http://www.unglobalcompact.org/) is offering a platform for companies that are voluntarily engaging in social responsibility. Participating companies commit to aligning their operations and strategies with ten universally accepted principles[5] in the areas of human rights, labor, environment and anti-corruption. The primary aim is to ensure that markets, commerce, technology and finance advance in ways that benefit economies and societies everywhere. It is a practical framework for the development, implementation, and disclosure of sustainability policies and practices and offers participants a wide spectrum of best practices in terms of work streams, management tools and resources. The Global Compact's rapid growth (in 10 years time it gathered over 8700 corporate participants and other stakeholders from over 130 countries) shows that many companies have come to recognize the need to collaborate in this area and to partner with governments, civil society and the United Nations.

This collection of norms in combination with the UN Global Compact is meant to instill a culture of corporate leadership and innovation in pursuit of responsible behavior by embedding the principle of social responsibility in the business strategy, decision-making and day-to-day operations. Such initiatives may secure a more positive place for companies in society by helping them build trust and confidence in communities and economies.

3. Social Responsibility in the Biomedical Sector

Considering the significant contributions biopharmaceutical companies can provide to the health and well-being of citizens, it is necessary to ensure that their business strategies are in line with the societal needs and that all partners exercise their responsibilities. Therefore, various institutional forums have launched special initiatives on corporate responsibility in the biomedical sector. For instance, the EU has initiated a process on corporate responsibility in the pharmaceutical industry, including three platforms on ethics and transparency, access to medicines in Africa and access to medicines in Europe (European Commission, 2010). The International Bioethics Committee (IBC) of UNESCO has issued a report that deals with Article 14 of the Universal Declaration on Bioethics and Human Rights, which introduces the principle of social responsibility and health in the field of bioethics. The Report presents a sample of possible concrete strategies and courses of action for states and industry in order to translate

[5] Human Rights: Principle 1: Businesses should support and respect the protection of internationally proclaimed human rights; and Principle 2: make sure that they are not complicit in human rights abuses. Labor: Principle 3: Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining; Principle 4: the elimination of all forms of forced and compulsory labor; Principle 5: the effective abolition of child labor; and Principle 6: the elimination of discrimination in respect of employment and occupation. Environment: Principle 7: Businesses should support a precautionary approach to environmental challenges; Principle 8: undertake initiatives to promote greater environmental responsibility; and Principle 9: encourage the development and diffusion of environmentally friendly technologies. Anti-Corruption: Principle 10: Businesses should work against corruption in all its forms, including extortion and bribery.

the principle of social responsibility and health into specific policy applications (UNESCO-IBC, 2010). The Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health of the UN, Paul Hunt, has especially made some important progress in guiding the biomedical sector. He developed Human Rights Guidelines for Pharmaceutical Companies in Relation to Access to Medicines (UN General Assembly, 2008) and made a formal UN right-to-health mission to GSK (UN General Assembly, 2009) to identify good practices and obstacles[6] in terms of access to medicines.

In his report, the Special Rapporteur clarifies that access to medicines is a "shared responsibility" (UN General Assembly, 2009). Numerous national and international, public and private actors have a vital role to play. Pharmaceutical and biotechnology companies are among those who share this responsibility. One of the Special Rapporteur's major concerns is the lack of accessible, effective, transparent and independent accountability mechanisms for CSR-practices on access to medicines (UN General Assembly, 2009; UN General Assembly, 2008). Most reporting is self-reporting, with some exceptions such as the Access to Medicine Index (see below). The Special Rapporteur also provides some tailored guidance for companies that hold patents on medicines or diagnostic tests that address unmet medical needs (see Section V).

The Access to Medicine Index (http://www.accesstomedicineindex.org/) is apparently quite effective in further enhancing CSR in the biopharmaceutical market. First published in 2008, the Index quickly garnered the interest of the media, the pharmaceutical industry, NGO's and institutional investors and financial supporters. Several institutional investors have decided to use the index as a tool to help assess the long-term value of pharmaceutical companies. The index measures many different factors concerning access to medicines, including transparency, the commitment of top management to social responsibility and access to medicines, R&D activity, research collaborations, competitive conduct, sharing of IP and other patenting and licensing practices. The latest report shows that European pharmaceutical companies out-compete their US counterparts in making medicines available to patients in developing countries, but their lead is shrinking (Access to Medicine Foundation, 2010). GSK, Merck & Co. and Novartis emerged as the top three ranking companies (Access to Medicine Foundation, 2010).

It is interesting to learn from the Index that the number of programs aimed at improving access to medicines has been increasing exponentially. Indeed, half of the on-going research programs for diseases unique to the developing world are funded by drug companies. Firms routinely offer medicines

[6] Important obstacles are weak health systems, weak regulatory systems, corruption, distribution channels, reference pricing and leakage or diversion (UN General Assembly, 2009).

against particular tropical and rare, orphan diseases at a steep discount or for free. Companies also engage in public-private partnerships like the International AIDS Vaccine Initiative and the Global Alliance for TB Drug Development. Under these initiatives companies receive grants to develop new medicines. They retain their patent rights, but agree to supply the final products at a small margin over costs with no royalties due. This type of partnerships are an interesting model for responsible risk-sharing respecting the dynamics of market incentives while fulfilling important social needs.

Most of the current efforts in the biomedical sector focus on *corporate* social responsibility. It would be wise to extend this focus to the public sector. Public sector organizations, such as funding agencies, health insurers (public or private) and universities need to commit explicitly to socially responsible practices. Moreover, individuals, such as inventors and scientists or groups of stakeholders, such as students, patients, scientists, physicians, could collaborate to boost socially desirable behavior (see Section V).

IV. Re-conceptualization of Patents

Before explaining in more detail how open innovation and social responsibility can be linked to and integrated with patent licensing strategies, I briefly turn to patent theory. Some recent scholarship on the nature of patents seems to offer more fertile ground to seed open innovation and social responsibility than the traditional exclusive property rights view would provide. In fact, the latter starts from a strong focus on *control* (often combined with adversarial positions), whereas open innovation and social responsibility require *flexibility*, *strategic openness*, *collaboration*, *trust* and *reciprocity*.

Historically, manufacturing privileges were granted by “letters patent” issued by the English Crown to industrialists to promote the economic development (Walterscheid, 1994). As the grant of monopolies, privileges, licenses and other letters patent were often abused by the Crown, the “Statute of Monopolies” (1623) declared such acts void, except for the grant of patents to inventors of a manner of new manufactures. Nowadays, patents are mostly regarded as exclusive property rights granted by patent agencies to stimulate R&D, reward inventors and to induce inventors to disclose their inventions. These exclusive property rights allow the patent owner to exclude others from making, using, offering for sale, selling, or importing the patented product without his consent (Article 28(1)(a) TRIPs).

In contrast with this common perspective of patents as exclusive property rights, an increasing number of legal scholars seem to be in favor of re-conceptualizing patents. Some call for a return to patents as "privileges" albeit with a different reading than the medieval concept (van Zimmeren, 2011; Van Overwalle, 2010; Drahos, 1996), but rather in terms of Hohfeld's conceptual scheme on fundamental legal conceptions (Hohfield, 1919). But patents may also be regarded as regulatory tools (Van Overwalle & van Zimmeren, 2009; Ghosh, 2008). Hereinafter, I will describe each of these re-conceptualizations in somewhat more detail.

1. Patents as Duty-bearing Privileges

Hohfeld noticed that even respected lawyers and legal scholars conflate various meanings of the term "right". In order to facilitate reasoning and clarify rulings, Hohfeld attempted to clarify the term "rights" by breaking it into eight distinct concepts. He defined these terms relative to one another, grouping them into four pairs of so-called "Jural Opposites" (right/no-right; privilege/duty; power/disability; immunity/liability) and four pairs of "Jural Correlatives" (right/duty; privilege/no-right; power/liability; immunity/disability). According to Hohfeld, a right regarding a certain matter signifies one's affirmative claim against another, i.e., that the other is under a duty to refrain from acting on the matter. A privilege, on the other hand, stresses one's freedom from the right or claim of another. For instance, a "privileged witness" is a witness who has *no duty* to testify as to certain things

Translating Hohfeld's terminology into the patent context, Drahos proposes to look at patents as *temporary liberty-inhibiting privileges* accompanied by several *duties* that circumscribe the exercise of the privilege (Drahos, 1996). Drahos believes that intellectual property rights, in particular patents, have become an indispensable form of capital and a source of power. Boundaries of patents are often unclear. Patent owners seek to use this weakness in ways that defeat the collective interest and conflict with the original intent of the patent system. In order to safeguard access to important knowledge and limit the costs of opportunistic behavior by patent owners, patents should no longer be portrayed as strong exclusive (control) rights with a correlative duty for others, but as privileges that entail certain duties for the holder of the privileged position. Patent owners are obliged not to exercise their privilege in a way that defeats the purpose for which the privilege was granted in the first place and to use it in a responsible way. It does not appear too far-fetched to require a holder of a privilege to use the privilege according to the objectives for which it was granted (e.g. stimulation of R&D, reward for investments) and not to waste the reward. Duties which may logically be derived from the objectives of patent law could include (1) a duty not to harm innovation; (2) a duty to properly disclose the invention; (3) a duty to commercialize the invention, and (4) a duty not to harm consumer welfare (van Zimmeren, 2011). In practice, this means for instance that in a patent system aimed at the diffusion of knowledge, a patent owner is not free to leave the invention unexploited; lying on 'a shelve'.

2. Patents as Regulatory Tools

Recently, various scholars from different disciplines have started examining patents from a regulatory, administrative perspective that goes beyond the private nature of patents (e.g. Murray & van Zimmeren, 2011; Drahos, 2010; Schneider, 2009; Van Overwalle & van Zimmeren, 2009; Ghosh, 2008; Murray, 2008; Ghosh, 2004; Rai, 2003). These scholars start from the premise that patents are not 'simply' a form of property necessary to reward labor or innovation, to induce inventions or disclosure. Patents also fulfill a regulatory function. Patents regulate the relations between the authorities and citizens, and amongst citizens (Van Overwalle & van Zimmeren, 2009). This regulatory function fosters the *social* objective of patents. Patents are "the means to a social end beyond the protection of individual self-interest" (Ghosh, 2008).

Patents are tools that regulate the private ordering and its major aim is to assure *reciprocity* and to promote *trust* in market and other institutions (Ghosh, 2004). Appropriate patent regulation will assure inventors that others will not free-ride on their R&D efforts. They will prefer to disclose rather than keep their inventions secret, because they trust that others will also share their inventions and thus synergies can be realized (Ghosh, 2008; Ghosh, 2004). By promoting reciprocity, patents would enable the market to function more efficiently. Patent law should be designed in such a way that it assures individuals that the market for innovation and R&D is reliable; it should safeguard the "market integrity" (Ghosh, 2004). By setting rules that apply across different markets and industries, patent law can seed norms that become incorporated into social behavior. For instance, a well-designed and reliable patent system would institute a practice such as searching the patent landscape before starting new R&D projects. Tendencies to ignore the patent norm or strategic patenting and "patent wars" delaying R&D by others seriously violate such ideas about trust and reciprocity.

V. Linking Patents to Open Innovation and Social Responsibility

A strategic approach towards open innovation and social responsibility requires the integration of these principles throughout the organization, including in the patent strategy. The two concepts may find their way into patent prosecution processes and exploitation strategies crystallized in a re-conceptualization of patents as duty-bearing privileges and regulatory tools.

Open innovation puts substantial pressure on a patent paradigm based on *control* and freedom for patent owners. Open innovation requires active involvement and knowledge spill-over between companies, customers, suppliers, universities, research institutes, consortia and start-ups. How could the patent system contribute to these flows of knowledge? Open innovation does not require giving away patents for free. Actually, one barrier to the adoption of open innovation models has been the misconception that open innovation is synonymous to open access and that it undermines the concept of patent protection. This view is not correct. Open innovation actually heavily depends on patents, but underlines the idea that the sole existence of a patent and strong enforcement mechanisms do not automatically lead to successful products (Hunter & Stephens, 2010). In practice, many patents remain 'shelved' without being commercialized. Pro-active patent management suggests the need to reevaluate these patents and to determine whether they may be better exploited by 'sharing' them with others: a kind of "strategic openness". Sharing could happen by using traditional appropriation mechanisms, such as licensing the patents (or only a certain field of use), selling them, launching a collaborative research effort or spinning out a new company. All these exploitation mechanisms would fuel the dissemination of knowledge and open up new opportunities. Yet, they do require vigilant patent protection strategies.

Open innovation will likely further influence the design of patent exploitation strategies: new types of deals, new types of partnerships, new financing sources also require new, innovative patent strategies. In the past, it may have been assumed too easily that *control* and exclusivity is the key. What actually matters is promoting innovation and – for industry – appropriating profits from innovation. Doing this in an effective way in some circumstances may require different, more open strategies (Huizingh, 2011). Traditional, closed approaches may still do for companies' core activities, where all the necessary expertise is available internally. However, in pre-competitive, multidisciplinary environments a more collaborative attitude is necessary and the legal framework should not frustrate the negotiations to set up open innovation models. The legal strategy should be designed in such a way that it optimizes external and internal knowledge flows and facilitate transfer of knowledge and commercialization of early-stage inventions. This will be all but easy: patents continue to pose a significant challenge for cultivating collaborative environments (see e.g. Huizingh, 2011; Melese, et al., 2009).[7]

[7] *See* e.g. the debate about IMI's IP policy. Universities were reluctant to accept the proposed IP policy, as they feared loosing control of the research use and commercial use of their inventions (EUA et al., 2010; De Rijck & M. Goldman, 2010).

In the context of open, socially responsible patent management, the same legal framework applies as in closed settings. Although some concerns may be more vital in a complex, open innovation context (e.g. a consortium or an open campus model) than in a traditional collaborative environment, in principle the same rules apply. Also concerns regarding confidentiality, patent ownership, liabilities, labor law, tax law and competition law, may be similar but require a *proactive* and more *flexible* legal infrastructure to enable an open R&D culture that generates trust. Otherwise the legal framework may frustrate many fruitful collaborative efforts. Preferably legal experts should 'build' the legal infrastructure before the open innovation models are launched. With an infrastructure consisting of standard contracts dealing with confidentiality, publication requirements an IP ownership and use, legal issues would not lead to unbearable delays.

Complex open innovation initiatives, such as networks and consortia gathering many different players, require tailored and creative IP policies. These IP policies should reflect the open innovation commitment, but still leave ample opportunities for commercialization and competition for all the participants. For instance, for a consortium aimed at pre-competitive research, setting non-exclusive licenses as the default rule for IP generated by the consortium (so-called "foreground IP") seems reasonable. Such licenses should also be "sliced", their field of application being limited to a specific field of use. This approach would allow others to exploit other fields. "Background IP" – prior IP included by the partners in the consortium – which is essential for the exploitation of the newly generated IP could later be bundled together for out-licensing purposes. In this respect, collaborative licensing models, such as patent pools and clearinghouses, operating as one-stop-licensing platforms for the inventions generated by the consortium may be useful alternatives for burdensome one-on-one bilateral licenses (van Zimmeren, 2011).

The Access to Medicines Index uses a company's support for models that facilitate open innovation and social responsibility as one of the parameters to assess company performance (Access to Medicine Foundation, 2010). The Index confirms certain trends in patenting and licensing practices in the biomedical industry. First, the Index points to an increase in the number of collaborations between originator companies[8] and originator and generic companies[9] with a strong societal impact. Second, the Index underlines the importance of PDPs and collaborations with the Medicines for Malaria Venture and DNDi in order to stimulate further R&D in neglected diseases. Third, it shows that a clear and strong commitment from management, allocation of resources and monitoring is essential to realize initiatives

[8] E.g.: agreements on sharing and screening of compound libraries (a database of small molecules, often patented, with proven activity against a disease) with (public) third parties and joint R&D (e.g. ViiV Health of Pfizer and GSK).

[9] E.g.: voluntary licensing agreements with global and local generic manufacturers.

in the field. Such a strong commitment to open innovation and social responsibility was, for example, strongly expressed by Andrew Witty in two of his public speeches (Witty, 2010; Witty, 2009). The Index is, hence, one of the few available metrics for business and patent strategies that takes the social impact into account.

The Special Rapporteur also gives some instructions on firms' right-to-health duties for companies holding significant numbers of patents in his guidelines (UN General Assembly, 2008) and his report on GSK (UN General Assembly, 2009). Interestingly, in these instructions one clearly recognizes a combination of a utilitarian, exclusive property rights reasoning with a "duty-bearing privileges" approach. The Special Rapporteur reiterates that pharmaceutical companies perform a vitally important "medical, public health, and right-to-health function" (UN General Assembly, 2009). They deserve a reward for fulfilling this critically important function, which is the grant of limited exclusive rights enabling the company to make a profit, enhance shareholder value, and invest in further R&D. However, the company is granted such rights under express and implied terms (UN General Assembly, 2009). Society has some legitimate expectations vis-à-vis a company holding a patent on a life-saving medicine based. The "social contract" between society and patent holders of a life-saving medicine grants privileges to, and places responsibilities on, those patent holders. These responsibilities are even more fundamental when the underlying R&D was publicly funded (UN General Assembly, 2009).

The Special Rapporteur argues that while companies should not be prevented from making a reasonable profit and enhance shareholder value under a viable business model, they have the duty to use all the arrangements at their disposal to make medicines as accessible as possible, as soon as possible to all those in need. One may think of a wide variety of instruments, such as non-exclusive commercial voluntary licenses, non-commercial voluntary licenses, public-private partnerships, patent pools,[10] donation programs and differential pricing. These instruments generally also fit within a line of thinking based on open innovation and social responsibility. If the patent is worked without taking such steps, the patent owner would breach his right-to-health responsibilities.

The Special Rapporteur notes that the image in the biomedical sector that patents are a company's "crown jewels" may distort the way companies take up this responsibility (UN General Assembly, 2009). Indeed, the Special Rapporteur comes to the conclusion that currently companies in the biomedical sector are not doing everything possible to fulfill their social function and responsibilities within the

[10] Yet, it is not clear from these data to what extent companies are also willing to use similar open and responsible practices beyond the humanitarian dimension in a for-profit context. Sharing of IP is less straightforward in a for-profit context; even if the collaboration is focused on pre-competitive research.

limitations of a viable business model. He further suggests that if this would change, it would force other stakeholders to create the necessary environment that companies need to enter into arrangements that accord with their responsibilities (UN General Assembly, 2009). The Special Rapporteur, hence, imposes a sense of reciprocity, which would generate a different culture and trust and which starts with companies. Although I agree with the rest of the reasoning of the Special Rapporteur, in my view, the chain of socially responsible behavior, reciprocity and trust does not necessarily start with industry. It should be fostered by legislators and policymakers, moving to funding agencies and donors over public and private research organizations and universities to industry. The principle of social responsibility should be applied consistently throughout this chain.

Let us briefly review some other stakeholders in terms of their compliance with principles of open innovation and social responsibility. Do universities generally adopt patenting and licensing strategies that maximize the social impact and access to medicines and diagnostic tests? Traditionally, the university mission is based on ideals of open and free dissemination of scientific knowledge; deploying research results for social impact and public benefit. However, nowadays there is an increasing pressure on universities to regard academic knowledge as a target for creating potential income (Van Overwalle, 2006). Traditional metrics used to measure the effectiveness of universities' technology transfer offices are the number of patents, the number of licensing agreements, licensing revenue, equity and the number of start-ups. These metrics tend to ignore the social impact universities' patenting and licensing strategies might have on research and access to technologies or medicines for which there is an unmet need, such as green technologies and medicines for neglected diseases.[11]

In the US, the pressure to maximize licensing revenues has not prevented a growing number of individual universities from adopting more "nuanced" IP management strategies, including socially responsible patenting and licensing programs (e.g. Mimura, 2010). US students have gathered in the "Universities Allied for Essential Medicines" (UAEM) to promote access to medicines for people in developing countries by changing norms and practices around university patenting and licensing. In 2006, they launched the Philadelphia Consensus Statement, which proposed three major changes to university policies on health-related innovations: universities should (1) promote equal access to research; (2) promote R&D for neglected diseases, and (3) measure research success according to

[11] I acknowledge that it is by far not easy to develop appropriate metrics that measure the social impact. UC Berkeley uses reputational gains, research projects funded at the university and industry, medical costs reduced, lives saved, software distributed, research tools shared, collaborations enabled, services, provided, knowledge and expertise transferred and the economic impact. But still a lot of work on social impact metrics is needed (Mimura, 2010).

impact on human welfare.[12] UAEM continues to push US universities to ensure affordable access to medicines discovered on campuses, witness the fact that that it is urging the University of California to finally take action (Chen, et al., 2010). The Association of University Technology Managers (AUTM) and several leading US universities explicitly endorsed some of the principles identified by UAEM. This was confirmed in its "Nine Points to consider" (AUTM, 2007)[13] and its Statement of Principles and Strategies for the Equitable Dissemination of Medical Technologies (AUTM, 2009). Apart from these voluntary commitments, Senator Leahy introduced the "Public Research in the Public Interest Act of 2006" to ensure that innovations developed at federally-funded institutions, such as universities, are made available in developing countries at the lowest possible cost (US Senate, 2006). Unfortunately, Congress did not pass the bill.

In Europe, such initiatives by universities and students are scarce. There may be individual universities that on a case-by-case basis grant humanitarian licenses, but they fail to take a more principled approach (Van Overwalle, 2006). Neither do we find any recommendations on this topic in the EU "Handbook on Responsible Partnering" (European Commission, et al., 2006), although its name might suggest otherwise. Although, the handbook recognizes "the need to ensure that results and inventions resulting from public investment are used in ways that also serve the general public interest", no best practices are specified. The handbook is, thus, a missed opportunity for guidance on more collaboration and socially responsible strategies, such as patent filing strategies and humanitarian licensing.

Apart from universities, what are the other stakeholders doing to sustain collaboration and socially responsible behavior? Are innovation policies, including patent and competition policies compatible with policies that stimulate open innovation and social responsibility? Policies that urge companies and public actors to patent widely, using metrics that focus only on numbers of patents and ignore other types of knowledge flows and social impact do not seem compatible with these two notions. Moreover, are funding agencies doing all they can to create incentives to stimulate collaboration and engage socially responsible practices by way of their funding policies? What about regulatory authorities, patent offices, competition authorities? Do they use their leverage to encourage

[12] Mechanisms proposed to enable these changes include: granting rights to generic companies to manufacture and export university innovations to developing countries, price reductions, non-patenting requirements in low- and middle-income countries, participation in patent pools, engaging with nontraditional partners, such as public-private partnerships or developing country institutions, creating new opportunities for drug development, carving out neglected disease research exemptions in any university patents or licenses and developing new metrics that reflect the importance of social benefit for developing countries (UAEM, 2006).

[13] See point 9: "Consider including provisions that address unmet needs, such as those of neglected patient populations or geographic areas, giving particular attention to improved therapeutics, diagnostics and agricultural technologies for the developing world."

such practices? To what extent can (patient) advocacy groups and professional association add an additional layer of social force?

In the US, the Food and Drug Administration (FDA) and the Patent and Trademark Office (USPTO) have some creative socially responsible policies in place to stimulate R&D in neglected diseases. The FDA can award priority review vouchers to the manufacturer of a newly approved drug or biologic that targets a neglected tropical disease.[14] The voucher entitles the bearer to a priority review for another product within 6 months instead of the standard 10 month review period. For a blockbuster drug accelerated approval could be worth millions of dollars. Inspired by the FDA's vouchers system the USPTO launched a pilot program to incentivize humanitarian technologies (USPTO, 2010). This program renders patent owners, who make their technology available for humanitarian purposes eligible for a voucher, which entitles them to an accelerated re-examination of a patent. The FDA and USPTO vouchers are transferable and can be sold. To my knowledge, there are no counterparts of these programs in other countries.

VI. Concluding Remarks

Both open innovation and social responsibility appear to be trends, which are getting a foothold in the Western world. Similar to Porter and Kramer's proposal regarding "shared value", I suggest an approach that strongly embeds open innovation strategies and social responsibility into business and IP strategies. The use of open innovation models or socially responsible practices should not only act as exemplary showcases, but should be part of the regular set of strategies. In order to do this in an effective way, the new approach needs to be advocated by champions at the chief executive level and at the local level. One needs to feed a culture that invites employees to consider whether a certain project, technology or product is suitable for open innovation or CSR activities.

In the previous section, I discussed various options as to how open innovation and social responsibility could be implemented and integrated into business strategies, university licensing policies, funding and innovation policies. This is not meant to be an exhaustive account of the flexibilities provided by the legal framework. These are some first thoughts, which will be elaborated further in ongoing research. Yet, the examples show that there is already quite some experimentation. Most of these experiments are taking place at the other side of the Atlantic. This is not self-evident. Whereas the

[14] See: §1102 of the Food and Drug 18 Administration Amendments Act of 2007, which adds §524 to the Federal Food, Drug, and Cosmetic Act (21 U.S.C. §360).

name open innovation was first coined in the US, social responsibility seems to have some robust foundations in Europe. Best practices relative to patents should find a fertile soil over here as well. Hereby, I invite legislator, policymakers, funding agencies, universities, inventors, advocacy groups and companies in Europe to quit thinking in terms of control over patents. Selective use of openness and social responsibility could create value and carefully tailored patent strategies would still allow value capture.

To a certain extent, the conceptualization of patents boils down to a debate about the proper role of the state in regulating the marketplace. Whereas patents as property rights generally imply a minimalist role for the state, theories that regard patents as duty-bearing privileges involve a more intrusive role. A regulatory theory of patent law gives an opportunity to identify areas where pure private ordering may not lead to optimal outcomes because of a failure of trust and reciprocity. Yet, the patent system may contribute to a culture of open innovation and social responsibility, by incorporating the necessary metrics and guidelines that encourage a certain type of behavior.

Reference List

Aarnio, A. (1997), *Reason and Authority: A Treatise on the Dynamic Paradigm of Legal Dogmatics*, Aldershot, Ashgate Publishing

Access to Medicine Foundation (2010), *Access to Medicine Index 2010*, Haarlem, Access to Medicine Foundation, June 2010, available at http://www.accesstomedicineindex.org/sites/www.accesstomedicineindex.org/files/general/Access_to_Medicine_Index_2010.pdf

AUTM (2009), *Statement of Principles and Strategies for the Equitable Dissemination of Medical Technologies*, available at http://www.autm.net/AM/Template.cfm?Section=Global_Health&Template=/CM/ContentDisplay.cfm&ContentID=3848

AUTM (2007), *In the Public Interest: Nine Points to Consider in Licensing University Technology*, White Paper, available at http://news-service.stanford.edu/news/2007/march7/gifs/whitepaper.pdf

Bianchi, M., et al. (2011), 'Organisational modes for Open Innovation in the bio-pharmaceutical industry: An exploratory analysis', 31 *Technovation*, 22-33

Campbell, K. & Vick, D. (2007), 'Disclosure law and the market for corporate social responsibility', in: McBarnet, D., Voiculescu, A. & Campbell, T. (eds.), *The New Corporate Accountability: Corporate Social Responsibility and the Law*, New York, Cambridge University Press, 241-278

Chen, C.E., et al. (2010), 'The Silent Epidemic of Exclusive University Licensing Policies on Compounds for Neglected Diseases and Beyond', 4 *PLoS Neglected Tropical Diseases*, e570, 1-4

Chesbrough, H.W., Vanhaverbeke, W. & West, J. (2008), *Open Innovation: Researching a New Paradigm*, Oxford, Oxford University Press

Chesbrough, H.W. (2006), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston (MA), Harvard Business School Press (first published in 2003)

Chesbrough, H.W. (2003), 'The era of open innovation', 44 *MIT Sloan Management Rev.*, 35-41

Chiaroni, D., Chiesa, V. & Frattini, F. (2011), 'The Open Innovation Journey: How firms dynamically implement the emerging innovation management paradigm', 31 *Technovation*, 34-43

De Rijck, K. & Goldman, M. (2010), 'Clarifying knowledge ownership in Europe's medicines initiative', 466 *Nat*., 1040

Di Minin, A., et al. (2011), 'Fiat: Open innovation in a downturn (1993-2003)', 52 Cal. Man. Rev., 131-159.

Dixon, J., Lawton, G. & Machin, P. (2009), 'Vertical disintegration: a strategy for pharmaceutical businesses in 2009?', 8 *Nat. Rev. Drug Discov.*, 435

Drahos, P. (2010), *The Global Governance of Knowledge: Patent Offices and their Clients*, Cambridge, Cambridge University Press

Drahos, P. (1996), *A Philosophy of Intellectual Property*, Aldershot, Dartmouth

European Commission (2010), *Corporate responsibility in the pharmaceutical industry*, Press Release, IP/10/1170, September 24, 2010, available at http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/1170&format=HTML&aged=0&language=EN&guiLanguage=en

European Commission (2007), *Corporate Social Responsibility - National public policies in the European Union*, available at http://ec.europa.eu/employment_social/soc-dial/csr/pdf/csrnationalpolicies2007_en.pdf

European Commission et al. (2006), *Handbook on Responsible Partnering – Joining forces in a world of open innovation: A guide to better practices for collaborative research between science and industry*, ProTon Europe, Brussels, available at http://www.protoneurope.org/reports/plonearticle.2007-07-17.1080437789

European Commission (2002), *Corporate Social Responsibility: A corporate contribution to sustainable development*, COM(2002)347 final, July 2, 2002, available at http://eur-lex.europa.eu/LexUriServ/site/en/com/2002/com2002_0347en01.pdf

European Commission (2001), *Promoting a European Framework for Corporate Social Responsibility*, Green Paper, COM(2001)366 final, July 18, 2001, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2001:0366:FIN:EN:PDF

European Universities Association (EUA), et al. (2010), *Joint Statement on the Innovative Medicines Initiative*, Brussels, EUA, July 6, 2010, available at http://www.eua.be/Libraries/Press/IMI_Statement_press_release_july6.sflb.ashx

Faems, D., et al. (2010), 'Technology Alliance Portfolios and Financial Performance: Value-Enhancing and Cost-Increasing Effects of Open Innovation', 27 *Journal of Product Innovation Management*, 785-796

Ghosh, S. (2008), 'When property is Something Else: Understanding Intellectual Property through the Lens of Regulatory Justice', in: Gosseries, A., Marciano, A. & Strowel, A. (eds.), *Intellectual Property and Theories of Justice*, New York, Palgrave MacMillan, 106-120

Ghosh, S. (2004), 'Patents and the Regulatory State: Rethinking the Patent Bargain Methaphor after *Eldred*', 19 *Berkeley Tech. L. J.,* 1315-1388

Hohfeld, W.N. (1919) *Fundamental Legal Conceptions as Applied in Judicial Reasoning and Other Legal Essays*, The Lawbook Exchange, Ltd., ed. 2010

Hunter, J. & Stephens, S. (2010), 'Is open innovation the way forward for big pharma?', 9 *Nat. Rev. Drug Discov.*, 87-88

Huizingh, E.K.R.E. (2011), 'Open Innovation: State of the art and future perspectives', 31 *Technovation*, 2-9

Knudsen, M.P. & Mortensen, T.B. (2011), 'Some immediate – but negative – effects of openness on product development performance', 31 *Technovation*, 54-64

LaMattina, J.L. (2011), 'The impact of mergers on pharmaceutical R&D', 10 *Nat. Rev. Drug Discov.*, 559-560

Lichtenthaler, U. (2011), 'Open Innovation: Past Research, Current Debates, and Future Directions', 25 Academy of Management Perspectives, 75-93

Melese, T., et al., (2009), 'Open innovation networks between academia and industry: an imperative for breakthrough therapies', 15 *Nat. Med.*, 502-507

McBarnet, D. (2007), 'Corporate social responsibility beyond law, through law, for law: the new corporate accountability', in: McBarnet, D., Voiculescu, A. & Campbell, T. (eds.), *The New Corporate Accountability: Corporate Social Responsibility and the Law*, New York, Cambridge University Press, 9-56

Mimura, C. (2010), 'Nuanced Management of IP Rights: Shaping Industry-University Relationships to Promote Social Impact', in: R.C. Dreyfuss, H. First, D.L. Zimmerman (eds.) *Working Within the Boundaries of Intellectual Property: Innovation Policy for the Knowledge Society*, Oxford, Oxford University Press, 269-295

Munos, B. (2009), 'Lessons from 60 years of pharmaceutical innovation', 8 *Nat. Rev. Drug Discov.*, 959-968

Murray, K.N. & van Zimmeren, E. (2011), 'Dynamic Patent Governance in Europe and the United States: The Myriad Example', 19 *Cardozo J. Int. & Comp. L.*, 287-342

Murray, K. N. (2008), 'First Things, First: A Principled Approach to Patent Administrative Law', 42 *John. Marsh. L. Rev.*, 29-64

Obama, B. (2009), 'President's Message', in: US Executive Office of the President – Office of Management and Budget (2009b), *A New Era of Responsibility: Renewing America's Promise - President's Message*, Washington, D.C., US Government Printing Office, available at http://www.gpoaccess.gov/usbudget/fy10/pdf/fy10-newera.pdf

OECD (2008), *OECD Guidelines for Multinational Enterprises*, OECD, Paris, http://www.oecd.org/dataoecd/56/36/1922428.pdf

Porter, M.E. & Kramer, M.R. (2011), 'Creating Shared Value: How to Reinvent Capitalism - and Unleash a Wave of Innovation and Growth', *Harv. Bus. Rev.*, 62-77

Porter, M.E. & Kramer, M.R. (2006), 'Strategy & Society: The Link Between Competitive Advantage and Corporate Social Responsibility', *Harv. Bus. Rev.*, 78-93

Rai, A.K. (2003), 'Engaging Facts and Policy: A Multi-instutional Approach to Patent System Reform', 103 *Colum. L. Rev.*, 1035-1135

Ruggie, J. (2011), *Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework* - Report of the Special Representative of the Secretary General on the Issue of Human Rights and Transnational Corporations and other Business Enterprises, UN Human Rights Council, A/HRC/17/31

Ruggie, J. (2008), *Protect, Respect and Remedy: a Framework for Business and Human Rights* - Report of the Special Representative of the Secretary General on the Issue of Human Rights and Transnational Corporations and other Business Enterprises, UN Human Rights Council, A/HRC/8/5

Schneider, I. (2009), 'Governing the patent system in Europe: the EPO's supranational autonomy and its need for a regulatory perspective', 36 *Science & Pub. Pol'y*, 619-629

Trott, P. & Hartmann, D. (2009), 'Why 'Open Innovation' is Old Wine in New Bottles', 13 *Int'l J. Innov. Manag.*, 715-736

UAEM (2006), *Philadelphia Consensus Statement*, Annual Conference UAEM, Philadelphia, October 2006, available at http://essentialmedicine.org/cs

UNESCO-IBC (2010), *Report of the International Bioethics Committee (IBC) of UNESCO on Social Responsibility and Health,* Paris, UNESCO, available at http://unesdoc.unesco.org/images/0018/001878/187899E.pdf

UN General Assembly (2009), *Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of health, Paul Hunt - Annex Mission to GlaxoSmithKline*, Human

Rights Council - Promotion and Protection of All Human Rights, Civil, Political, Economic, Social and Cultural Rights, including the Right to Development, 11th Session, Agenda item 3, A/HRC/11/12/Add.2, May 5, 2009

UN General Assembly (2008), *The right to health - Note by the Secretary-General - Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health, Paul Hunt*, Promotion and protection of human rights: human rights questions, including alternative approaches for improving the effective enjoyment of human rights and fundamental freedoms, 36th Session, Agenda Item 67(b) of the provisional agenda, A/63/263, August 11, 2008

UN Human Rights Council (2011), 'New Guiding Principles on Business and human rights endorsed by the UN Human Rights Council', News Release, June 16, 2011

United Nations (2000), *The Global Compact*, available at http://www.unglobalcompact.org/abouttthegc/thetenprinciples/

USPTO (2010), *USPTO Launches Effort to Incentivize Humanitarian Technologies*, Press Release, USPTO, Washington, D.C., September 20, 2010, available at http://www.uspto.gov/news/pr/2010/10_41.jsp

US Senate (2006), *Public Research in the Public Interest Act of 2006*, 109th Congress, 2nd Sess., S. 4040, September 29, 2006

Van Overwalle, G. (2010), 'Turning Patent Swords into Shares', 330 *Science*, 1630-1631

Van Overwalle, G. (2006), 'Reconciling Patent policies with the University Mission', 13 *Eth. Persp.*, 231-247

van Zimmeren, E. (2011), *Towards a New Patent Paradigm in the Biomedical Sector? Facilitating Access, Open Innovation and Social Responsibility in Patent Law in the US, Europe and Japan*, PhD-thesis, K.U.Leuven, Law Faculty, PhD defense May 16, 2011

Verheugen, G. (2009), *Corporate Social Responsibility Essential for Public Trust in Business*, Brussels, European Commission, CSR Forum, SPEECH/09/53, February 10, 2009, available at http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/09/53&format=HTML&aged=0&language=EN&guiLanguage=en.

Ward, H. (2011), 'The ISO 26000 International Guidance Standard on Social Responsibility: Implications for Public Policy and Transnational Democracy', 12 *Theoretical Inquiries L.*, Article 10

Witty, A. (2010), 'Open Labs, Open Minds: Breaking Down Barriers to Innovation and access to Medicines and Vaccines in the Developing World', Remarks delivered to the Council on Foreign Relations, New York, January 20, 2010, available at http://www.gsk.com/media/Open-innovation-strategy-transcript-English-20jan2010.pdf

Witty, A. (2009), 'Big Pharma as a Catalyst for Change', Speech to Harvard Medical School, Boston, MA, February 13, 2009, available at http://www.gsk.com/media/Witty-Harvard-Speech-Summary.pdf

Always one step Ahead?

Firms' Strategy's Impact on Susceptibility to Copy of Intellectual Property

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Abstract

This paper analyzes the impact of a firm's competitive strategy on the susceptibility to infringement or unauthorized copy of intellectual property (IP). Using data from the Mannheimer Innovation Panel we show that companies engaged in product development and differentiation are an attractive target for product pirates. However, cost leaders aiming at providing good quality at a low price are less affected.

Our findings suggest that cost leaders can safely rely on legal protection methods for technology if they ensure their enforcement at the same time. Companies aiming at product differentiation should focus more on keeping their knowledge and technology secret as patents enable product pirates with the necessary knowledge for copying. Notwithstanding, trademarks and registered designs are an effective tool to protect IP of both groups of companies.

Copy of IP (often referred to by product piracy) is a serious threat for innovative companies and is, consequently, at the same time a threat for innovative economies. Hence, policy makers should aim at the effectiveness of IPR regimes with respect to easy and fast enforcement of patents and utility models. At the same time a high degree of reliability of the patents' validity should be guaranteed.

1. Introduction

This paper examines the interdependencies of a firm's general competitive strategy (cost strategy versus differentiation strategy) with its vulnerability to copy or infringement of IP. According to the OECD (OECD, 2008) copy of IP regarding tangibles[1] causes severe damage which is steadily increasing: in 2005, the damage caused on a worldwide level amounted up to USD 200 billion and grew steadily up to USD 250 billion in 2007. As the total amount increases, so does the relative share of pirated products in world trade (1.95% in 2007; OECD, 2009). However, despite the severe damage caused by copy or infringement of IP(R), this topic is not well researched and remains on the agenda for analysis. Apart from the already mentioned studies, industry reports are most frequently cited (BSA, 2008; Kingston, 2000). However, all of them a "lack transparent methodological setting as well as a comprehensive theoretical framework" (Blind et al., 2010). The scientific literature is mostly dealing theoretically with the impact of copy or infringement of IP(R) on the effected firms while empirical studies are still very scarce. Moreover, factors influencing a firm's susceptibility to copy or infringement of IP(R) are not yet in the focus of the scientific literature and only few scholars draw their attention to that issue (e.g. Blind et al., 2010), which is why it still remains an important research topic. Consequently, a general theoretical framework for a firm's susceptibility towards product pirates is still missing. This article attempts to provide one cornerstone of such a framework. First, we derive a general set of indicators for analyzing whether a firm can be regarded as a cost leader or a leader in product innovations by focusing mainly on their innovative activities regarding products and processes and their cost structure. In doing so, we rely on Porter's work on competitive strategy (Porter, 2004). The next step is the analysis of the impact of the respective strategy on the firm's susceptibility to infringement or copy of IP(R).

We hypothesize leaders in product innovations to be less susceptible to product pirates compared to price leaders. The reasoning behind this is given by earlier work on innovative activities by Utterback and Abernathy (1975). They claim process innovations and cost reductions to become important after the dominant design has already been established. We assume pirating to be most profitable for products for which the dominant design is established and known. In such cases no risk is taken by the pirates regarding the possible inability to sell the product as the dominant design might shift towards another technical solution. Hence, pirates focus on products with an established dominant design for which

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[1] Media piracy regarding books, movies, music, etc. is not included. The OECD uses the term „product

firms already engage in cost reduction processes. Leaders in product innovations, however, focus more on creating and inventing new solutions for customer needs and are focusing less on cost reduction, i.e. process innovations (Utterback and Abernathy, 1975).

Another possible outcome of our analysis, however, is that leaders in product differentiation are more prone to be affected by product pirates. Generally, margins for new products are higher which might compensate the risk of litigation and of following a dead-end innovation which might be overthrown by the dominant design established afterwards. This, obviously, requires high technological capabilities which are generally said to lack product pirates. Hence, our analysis contributes to this discussion revealing critical information on which competitive strategy is more susceptible to infringement or copy of IP(R).

The outcomes of our analysis have implications for management; low price companies should focus on establishing and defending their IP rights while leaders in product innovations can invest more into developing their products further in order to maintain their leadership in product innovations. The strategies of both firm types differ also regarding their IP management. For leaders in product innovations, informal protection methods can already be very effective to defend their strategic market position (e.g. time to market). In turn, the price leaders' strategy is more prone to direct IP infringements and, hence, price leaders should focus on formal protection methods in order to be able to defend their rights with legal means.

Our paper empirically analyzes our hypothesis and tests it with data taken from the Mannheimer Innovation Panel[2], which contains information about innovative companies in Germany. For the purpose of our study we merge two waves containing on the one hand information about possible indicators for price or leadership in product innovations and on the other hand information about the infringement of IP. Numbers of patents and European trademarks are matched on firm level. We test intra- and inter-sectorial differences between price and leaders in product innovations and can derive important differences between certain sectors. The overall result is a typology of companies regarding their strategy (price or leadership in product innovations) and their susceptibility towards IP infringements by third-parties.

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2 German Comunity Innovation Survey (CIS) using a larger questionnaire compared to the standard CIS questionnaire.

2. Literature Review

Copy and infringement of IP(R) and especially regarding tangibles is a not very well-researched economic and managerial issue whereas literature dealing with the narrow case of counterfeiting[3] is more widely spread. The OECD (2008) names "product piracy"[4] as one crucial threat for economy going hand in hand with crime while Karaganis (2011) contradicts this findings regarding media piracy: piracy regarding media mainly is stated to be a pricing problem and not an outcome of organized crime. However, the OECD report does not focus on media piracy and, hence, both findings may be valid. Nonetheless, this contradiction on the first view clearly shows the ongoing debate in the field of copy and infringement of IP(R). Moreover, existing reports (such as BSA, 2008; Karaganis, 2011; Kingston, 2000; OECD, 2008, 2009) are more hands-on in their approach and there for are not clear regarding the methods employed while lacking a "comprehensive theoretical framework"(Blind et al., 2010).

Notwithstanding, such reports contain valuable and interesting information regarding possible damage infringement or copy of IP(R) (regarding tangibles) may cause. The OECD study (OECD, 2008) contains figures regarding "product piracy" and counterfeiting mainly for custom seized goods.[5] The 2008 study estimates a possible damage of up to 200 bn US-$, the updated study (OECD, 2009) speaks of a volume up to 250 bn US-$. The share of such products in world trade is calculated to "have increased from 1.85% in 2000 to 1.95% in 2007" (OECD, 2009). Both studies stress the role of pirated products in world trade and also highlight the possible damage done by product pirates.

Nonetheless, the real damage caused by copy and infringement of IP(R) is more difficult to assess than by looking at the value of the seized goods. Karaganis (Karaganis, 2011) highlight in their report the pricing problem of goods sold in developing and transition countries and attribute media piracy[6] mainly to exorbitant high prices in such countries. This pricing issue is identified as the main driver for media piracy and organized crime is found not to be of any importance. Hence, the original products might not get sold even if the prices were not

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3 Counterfeiting only refers to trademark infringement.

4 Compare footnote 1.

5 The study is not completely clear in its approach. It takes a mixed approach relying on custom data and on data of the UN-Comtrade database regarding commodity trade statistics. These figures do not contain products which are produced and consumed in the same country, non-tangible digital products and products sold over the internet.

6 Media piracy contains mainly goods underlying the copyright, e.g. movies, software, music, etc. The study also contains a short chapter regarding piracy of books.

heavily undercut by pirate-goods. Even though (Karaganis, 2011, Karaganis deal only with media piracy in their report, the pricing issue might also be of importance in other industries.

Literature on counterfeiting (i.e. infringement of trademarks) highlights the effects and impact on general welfare in theoretical terms. By counterfeiting, different groups get harmed: consumers may be misled by counterfeits and may buy them unintentionally; the companies producing the original product suffer from illegal competition by counterfeiters and might be forced to adjust their prices and, hence, to lower their margins; on the other hand, global welfare might also profit from counterfeiting if the companies producing the original rise their quality in order to fight the counterfeiters (Grossman and Shapiro, 1988).[7] The last point is underlined and further explored by Raustiala and Sprigman (2009) who claim that innovative activities in sectors like music and fashion are accelerated by copy or infringement ("Piracy Paradox") which clearly supports Grossman and Shapiro (1988) stating that infringement or copy also might enhance global welfare by spurring innovation. This aspect is further stressed if one takes positive network effects (Katz and Shapiro, 1994) possibly induced by infringement or copy into account that might help innovators to successful position their products in the market; consumers would in turn profit from lower prices if the original producer decides against protection in order to take advantage of the mentioned effect (Conner and Rumelt, 1991)[8]. However, other studies speak of copy or infringement (by users) as the "worst problem facing the (..) industry today"[9] (Givon et al., 1995). Givon et al. (1995) explain the massive thread from copy or infringement by the lost user base and, hence, less profits. Moreover, they also take into account that future revenues might be smaller as cross-selling and marketing campaigns for new software cannot be directed at users lost due to infringement or copy. Nevertheless, the positive impact of infringement or copy regarding software as a network good is also stressed in the article and the importance of "creative marketing mechanisms to convert shadow diffusion [i.e. copy/infringement] to their advantage" (Givon et al., 1995).

A further differentiation of the damage copy or infringement of IP(R) can cause, is the distinction between primary and secondary market. The primary market in "product piracy" is defined (OECD, 2008) as customers who purchase the "piracy" product even though they want to buy the original and are misled by the (almost) perfect copy. Contrasting, the

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7 Another study of the authors points out Grossman and Shapiro (1988) that the two aspects of status and quality connected to brand-name products are disconnected by the act of counterfeiting.

8 Conner and Rumelt (1991) analyse the positive network effects for the software industry.

9 The mentioned study only focuses the software industry.

secondary market comprises all customers who purposely buy the copycat knowing (and not caring) that it infringes or might infringe the original producers IP. The damage done by copy or infringement is more severe in the primary market as it cannibalizes the original producer's products and, hence, diminishes his/her profits. On the contrary, copy or infringement only focusing on the secondary market does not harm the original producer directly, as those customers would not have bought the original product anyways. On this differentiation, de Castro et al. (2008) postulate the different harm and good copy and infringement of IP(R) can cause for entrepreneurial firms. They claim, that the "net impact of (…) [copy/infringement] depends on the overlap between the markets (…): the less overlap, the greater the benefits" (de Castro et al., 2008). In this context, they stress the importance of quality differences between legal products and illegal copies, the network effects and bandwagon effects copy or infringement of IP(R) can have.

Other studies focus more on the consumer behavior and analyze the factors that could have an influence on the consumer decisions to willingly buy counterfeits. Influencing factors are the price and the branding of the purchased good; interestingly, the awareness of selling counterfeits to be illegal does not influence the buying decision (Cordell et al., 1996). Further studies focus on the mechanisms of counterfeiting strategies and give insight into the relevance of knowledge leaks that tend to reveal relevant information to competitors within 12-18 months (Harvey and Ronkainen, 1985; Mansfield, 1985).

Other parts of the copy and infringement literature focus the connection along the value chain and emphasize the importance of continuous monitoring of sales channels to approach the copy/infringement risk in (potentially) threaded markets (Olsen and Granzin, 1992). The second study[10] existent to our knowledge which pursues an approach which is quite similar to ours was conducted by Weatherall and Webster (2010) and analyzes the infringement cases of inventors from Australia. Their findings comprise a ratio of 28% of infringement and correlations between incidents of infringement and ex post estimates of the kind of innovation (incremental vs. radical), exports and the value of the respective patents. However, we make use of the German Community Innovation Survey which is larger than the Australian sample and do not focus on inventors but on companies owning the respective IP.

[10] The other paper with a similar approach on which this work is based is Blind et al. (2010)

2.1. Appropriability

As stated by many scholars (Audretsch, 1995, 1995; Fagerberg and Verspagen, 2003; Grossman and Helpman, 1990; Grossman and Shapiro, 1988; Segerstrom, 1991) innovation drives growth and is, hence, beneficial for a country's economy. Consequently, governments are interested in fostering growth by stimulating R&D expenses. One means to ensure high R&D expenditures is to guarantee the appropriability of the expected rents from those expenditures. As stated by Teece (1986) imitation of innovation (e.g. due to limited appropriation mechanisms) can reduce the innovation effort of firms. Firms are consequently interested to protect their innovations from (simple) copying of their competitors. As will be further explained in chapter 2.2, innovation can be a means to compete in markets and to obtain higher margins for one's products. This rational can be the driving factor to innovate. However, without suitable protection the innovation effort might be in vain if competitors closely follow the innovator as imitators and are able to rip off some of the innovation's profit, which would belong to the innovator if he protected his or her innovation.

There are different possibilities to protect one's innovational efforts, among them are legal protection methods like patents, trademarks, utility models, copyright, registered designs, geographical indicators, etc. (European Commission) and informal protection methods such as lead time, secrecy, usage of complementary assets, etc. (Cohen et al., 2000; Cohen et al., 2002; Teece, 1986). An effective IP management makes use of different measures in order to ensure a holistic approach. Still, legal protection rights can be violated by competitors and informal measures might not work out.

However, only innovative companies care about protection for innovation and being innovative is part of their competitive strategy. Consequently, the IP strategy of a company is closely linked to its competitive behavior. In this article we analyze the connection between competitive strategy and imitation by competitors[11] and control for the IP strategy a company is following

2.2. Competition Strategies

Companies aiming at free-riding on other companies' success by copying certain parts of or even whole products can be regarded as competitors for those firms even though they might compete on what generally may perceived as unfair conditions. However, they still compete

[11] Imitation by competitors is differentiated into two types: violation of a legal protection right and unauthorized copy of legally unprotected IP.

against the companies from whose success, knowledge and technological capabilities they profit. Therefore, product pirates can be regarded as competitors to the producers of the original products.

Regarding their competition strategy, companies have different options to react. If a company wants to compete in a market, different strategies, so called competitive strategies, can be employed. Michael Porter (Porter, 2004), known for his extensive work on this subject, differentiates between three main types of competitive strategies: comprehensive cost leadership, differentiation and concentration on core areas meaning hereby the segmentation strategy. For the purpose of this article, we basically follow Porter's competitive strategies and analyze the possible impact of the different strategies on the susceptibility to infringement or copy regarding tangibles. In this paper we only discuss cost leadership and differentiation strategy; segmentation strategy focusing on both strategies within a comparably narrow market scope is not analyzed in this article because it is hardly possible to proof whether the company is really applying the segmentation strategy and is not using a split strategic approach for different products or industries. Moreover, the incidences of possible segmentation strategy in our sample are too small as robust statistical results could be achieved.

2.2.1.Cost Leadership

One possible competitive strategy is comprehensive cost leadership. Companies aiming at this strategy try to undercut the costs of their competitors in order to generate a competitive advantage (Porter, 2004). Even if the competition in the respective market gets more intense, the cost leader's income, in theory, always remains higher than its marginal costs, as the price will not fall below the marginal costs of its competitors (Porter, 2004).[12] Hence, the cost leader is theoretically always able to lower the price under the competitors' best offer and this way maintains its market power.

Cost leadership is based on several economic principles. Firstly, economies of scale and the effects of experience or learning curves (firstly described by Wright, 1936 regarding the cost reduction in the aeronautic industry and applied and further developed since then) are concepts that help to find possibilities to cut costs. Economies of scale predict fix costs per unit of production to decrease as the number of production units increases. Hence, the costs of

[12] However, quality, service and other aspects are still important as the product itself must be a viable alternative for the competitors‘ products.

production per unit trend to the marginal cost of production per unit if the number of production units is increasing infinitely.[13] The effect of experience, on the contrary, also affects the variable costs of production, reducing the total production costs by 20-30% if the output is doubled (Wright, 1936). Both effects help to cut costs if the company following a strategy of cost leadership is investing heavily in big production sites and at the same time rules a large market share to ensure that the produced goods are bought by customers instead of overproduction in a saturated market (Porter, 2004). Moreover, Porter (2004) lists cost minimizations in R&D, service, sales forces and marketing. Hence, the characteristics of cost leaders are the following: they possess a large market share and mainly invest in assets and not in R&D. They focus more on cost reduction process innovations than on product innovations and tend to introduce less new products into the market than companies not pursuing a cost leadership strategy.

2.2.2. Differentiation

The second competitive strategy developed by Porter already 30 years ago (Porter, 1980), is differentiation. The main aim of this strategy is to create something (e.g. a product) completely new to the entire industry (Porter, 2004). Porter (2004) names different directions to which this kind of strategy can head; examples are differentiation in design or by trademarks, technology, after-sales and distribution networks. An ideal and comprehensive differentiation strategy is done on different levels at the same time. Important to note, however, is that costs in this strategy play a minor role but are not to be ignored completely as the products' price must meet somehow customers' expectations. Yet, costs are not the focus of the differentiation strategy. The main typical characteristics of a firm following a differentiation strategy are strength in (basic) research and development, high quality, a leading position regarding technology and capabilities in product engineering.

2.2.3. Codification of Characteristics for Competitive Strategies

For our study, we need to differentiate between the different competitive strategies. As already mentioned before, we take Porter's approach (Porter, 2004) in order to distinguish between differentiation, cost and focus strategy. As Porter explains in his analysis, the "commonly required skills and resources" (Porter, 2004) differ for each competitive strategy.

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[13] This is only theoretically the case. In reality, there will be the need of new production sites, additional investments goods (machines etc.) meaning that the fix cost might increase at a certain point of the augmentation of production.

Table 1: Capabilities, means and organizational requirements for competitive strategies (based on Porter, 2008).

Variables for Cost Strategy	Variables for Differentiation Strategy
Company has improved processes by process innovation	Company has done a product innovation
Company has reduced costs	Company has introduced a completely new product to the market
Market share is at least 20%	Product portfolio of company consists of at least 15% new products

For our analysis, we take the variables indicated in Table 1 in order to distinguish the competitive strategies. This means, if a company fulfills all characteristics as indicated in the variable columns, it will be defined as following the respective strategy. As mentioned beforehand, both analyzed strategies, cost and differentiation, are present in our sample, whereas the focus strategy (combining all capabilities, means and organizational requirements and directing them at a specific target) is not.

2.2.4.Competition Strategies and Susceptibility to IP(R) Infringement

As stated in the previous chapters, the unauthorized usage of IP comes with a potential risk of being sued (more probable in case of infringement) and with the risk of not being able to successfully imitate the features which incorporate the respective IP (more probable in case of unauthorized copy). As stated in previous literature (Blind et al., 2010), IPR provide an enabling effect, especially in case of technical IPR (patents and utility models) as they reveal detailed, critical knowledge necessary and sufficient to copy the invention.[14] Consequently, it gets far easier to copy an invention if the invention is patented. However, the patent (or the utility model) also provides protection as it offers the right of exclusion. Hence, to infringe upon a patent comes with the risk of getting involved in a law suit. This risk is higher in case of IP protection by a suitable IP right. However, even unauthorized copy has the risk of infringement if a trade secret is involved. Generally, it is more difficult to prove the infringement of a trade secret than the infringement of a patent or utility model as the trade secret is not a registered and examined right. This is why the risk of being suit is smaller with regard to trade secrets. Moreover, this only applies to technical IP (patentable or applicable for utility model), not to registered design and brands as their nature impedes the usage of

[14] „The description shall disclose the invention in a manner sufficiently clear and complete for the invention to be carried out by a person skilled in the art.“ World Intellectual Property Organization

trade secrets. A summary of the potential risks attached to unauthorized IP(R) usage is given in Table 2.

Table 2: Risks of unauthorized IP Usage

<table>
<tr><th colspan="2"></th><th>Infringement</th><th>Potential Risk</th><th>Unauthorized Copy</th><th>Potential Risk</th></tr>
<tr><td rowspan="2">Technical IP</td><td>Patent</td><td rowspan="4">Risk of being accused of infringement → possible law suit</td><td>High</td><td>Trade secret; imitation difficult</td><td rowspan="2">Depends on the complexity of the invention and on the existence of a trade secret</td></tr>
<tr><td>Utility Model</td><td>Medium (unexamined)</td><td>Trade secret; imitation difficult</td></tr>
<tr><td colspan="2">Design</td><td rowspan="2">High</td><td rowspan="2">n/a</td><td rowspan="2">n/a</td></tr>
<tr><td colspan="2">Brand</td></tr>
</table>

The research question we propose in this article is whether the competitive strategy has an influence on the likelihood of being infringed or copied. An infringer or copier has to take the potential benefits and risk into account before s/he decides for or against an unauthorized IP usage. If the benefits are bigger than the risks, a rational economic agent (risk-neutral) will decide for the unauthorized usage. Depending on the legal form of the company and on the market knowledge of the copying party, the product pirate is more or less able to analyze the competitive behavior of his or her competitors. Competitive strategies in this context might have a signaling value, which possibly influences the copying decision. If a company is following successfully a competitive strategy, a product pirate could interpret this market as attractive (in terms of possible rents) enough to run the risk of copying IP. However, cost leadership and differentiation strategy differ in their approach to achieve their profits (compare chapter 2.2). An overview of the arguments for and against copying IP of both, cost leaders and differentiating firms, is provided in Table 3. The arguments are more deeply discussed in the following paragraphs.

Table 3: Arguments for and Against Copy of IP

Strategy	Pro	Contra
Cost Leader	• Dominant design established • Knowledge more mature and easier to copy	• Only small rents expected • Market may be saturated
Differentiation	• High margins • New market with unsaturated consumers	• Difficult to copy • Dominant design not (yet) established

The margins in the market of cost leaders are already very thin and cost leaders are able to obtain their profits by rigorously monitoring their costs. However, for product pirates the anticipation of small rents from copying (processes or products) compared to the risks (Table 2) can discourage them from freeriding of the invention and ideas of others. However, cost leaders normally act in more mature markets in which the shift from product to process innovation has already been carried out by the market participants (Utterback and Abernathy, 1975). Consequently, the knowledge employed in this market also is more mature and might be easier to copy compared to very recent developments in more innovative markets regarding product innovations. Moreover, the dominant design is already established in markets in which cost leaders are active. This reduces the risk of producing a good which does not fit the needs and expectations of the consumers.

Contrasting, the arguments for and against copying of IP from a company with differentiation strategy are the following. First, companies might be attracted by the comparatively high margins which can be attained in markets differentiating firms are targeting. These high margins can set-off the risk attached to the copy of IP. Moreover, the respective markets are not yet saturated and entering them is less risky than entering an established, saturated one. Despite that, there are also reasons not to copy IP of differentiating companies. Initially, the respective IP might be difficult to copy as it is very recent knowledge and even with the encoded knowledge of a patent one might need capabilities in product design and development in order to successfully copy the IP and include it in a successful product. This comes with cost and lowers the profits from copying. Moreover, in new markets the dominant design is not yet established which carries the risk of copying a technology or a product which in the end will not achieve full acceptance in the market because the dominant design does not include it.

In order to hypothesize which competitive strategy is more likely to become a victim of copy or infringement regarding tangibles, further knowledge about the nature of product pirates and their abilities would be necessary. This is the very heart of our study: we still do not know how capable product pirates are and what they are targeting at. Hence, we do not propose any hypothesis in our article but instead regard all possible outcomes of equal value. Our approach is, hence, more of an explorative nature.

3. Data and Methods

For our study we are making use of the Mannheimer Innovation Panel (MIP), ZEW, Mannheim, and merge two different waves containing information about the characteristics for the competitive strategy (MIP 2007) and information regarding the infringement and unauthorized copy of IP(R) (MIP 2008). Moreover, information regarding patent stock, trademark stock and utility model stock is added to the data set. Since we use data of two independent waves, we are confident to avoid endogeneity issues as the infringement or unauthorized copy indeed can be tracked down to a certain competitive strategy but do not correlate with the error term. The matching of the two waves is done on a 1:1 basis by a variable ("lfdnr") identifying each company throughout the MIP waves with a distinctive number as is the matching of the numbers of patents, community trademarks and utility models.[15] The merged data set contains 6110 randomly chosen German companies of different size, both innovative and non-innovative. In our analysis, however, we focus on those companies that follow a competitive strategy (either cost or differentiation strategy).

3.1. Methodological Approach

Our methodological approach is influenced by our research question and by the characteristics of the data employed. In this paper, we analyze the susceptibility to infringement or unauthorized copy of IP which is, in its methodological essence, very similar to the susceptibility of smokers to lung cancer, or of genetic predisposed patients to Alzheimer. Hence, we choose logistic regressions as our depended variables (infringement or unauthorized copy) are binary (either there is infringement (=1) or no infringement (=0)) and make use of odds-ratios in order to compute the likelihood of infringement or unauthorized copying as it is frequently done in medical research regarding diseases (Hendrickse et al., 1992; Sawyer et al., 2007). This approach has two advantages: first, we are able to compute the general influence (negative or positive) of variables on incidences of infringement or unauthorized copy. Second, by employing odds-ratios we can exactly tell how strong the influence is in lowering or increasing the likelihood (in percentage) of being (or becoming) a victim of product pirates. This enables us to derive interpretable and comprehensive evidence for economic implications and to give recommendations for management. The employed variables are shown in Table 4. We estimate our models against the background of both, innovative and non-innovative companies without competitive strategy. Our aim is to understand the influence of the competitive strategy on the susceptibility to copy or infringement of IP(R). Hence, we include in our models both, innovative and non-innovative companies.

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15 Information on the amount of copyright for the different companies is not available as the copyright is not to be registered contrasting to other IPR. Data for registered designs unfortunately were not feasably available and hence miss in our study.

Table 4: Overview Variables

Dependent Variables	**Measurement**	**Mean**	**S.D.**	**Min**	**Max**
Infringement of Technical IPR	Dummy	0.0460251	0.2095882	0	1
Infringement of Trademarks	Dummy	0.0356306	0.1854108	0	1
Infringement of Registered Designs	Dummy	0.0210477	0.143577	0	1
General Infringement	Dummy	0.0766423	0.2660838	0	1
Copy of Technical IPR	Dummy	0.0269122	0.161865	0	1
Copy of Brands	Dummy	0.0152454	0.1225565	0	1
Copy of Designs	Dummy	0.0384798	0.1923972	0	1
General Copy	Dummy	0.0653383	0.2471791	0	1
IP Violation of Technical IPR	Dummy	0.0823199	0.2749158	0	1
IP Violation of Brands	Dummy	0.0621762	0.2415321	0	1
IP Violation of Designs	Dummy	0.0695816	0.2545003	0	1
General IP Violation	Dummy	0.1471681	0.3543556	0	1
Independent Variables					
Cost Strategy	Dummy	0.057938	0.2336794	0	1
Differentiation Strategy	Dummy	0.0419708	0.2005682	0	1
Control Variables					
No. Employees (ln)	Integer	3.827012	1.604988	0	12.5
Exports '06 (% Turnover)	Dummy	0.151454	0.23852	0	1
No. Of Technical IPR	Integer	1.418205	22.70091	0	1008
No. Of Trademarks	Integer	0.3488678	3.64416	0	144

4. Descriptive Analyses

The following section gives a first impression of the employed data set. In order to draw a comprehensive picture of the analyzed firms, Figure 1 shows the mean of key figures (Turnover, Number of Employees, relative Exports, relative R&D Spendings) for the different company categories according to their competitive strategy. Starting off with companies engaged in differentiation, they clearly are smaller companies in terms of both, turnover and employees. Furthermore, they tend to spend four times more of their turnover on R&D than firm without strategy. Contrasting, cost leaders tend to be larger firms, export relatively more than firms without strategy (as do firms focusing on differentiation) and spend less on R&D than firms with a differentiation strategy (only 2% of their turnover).

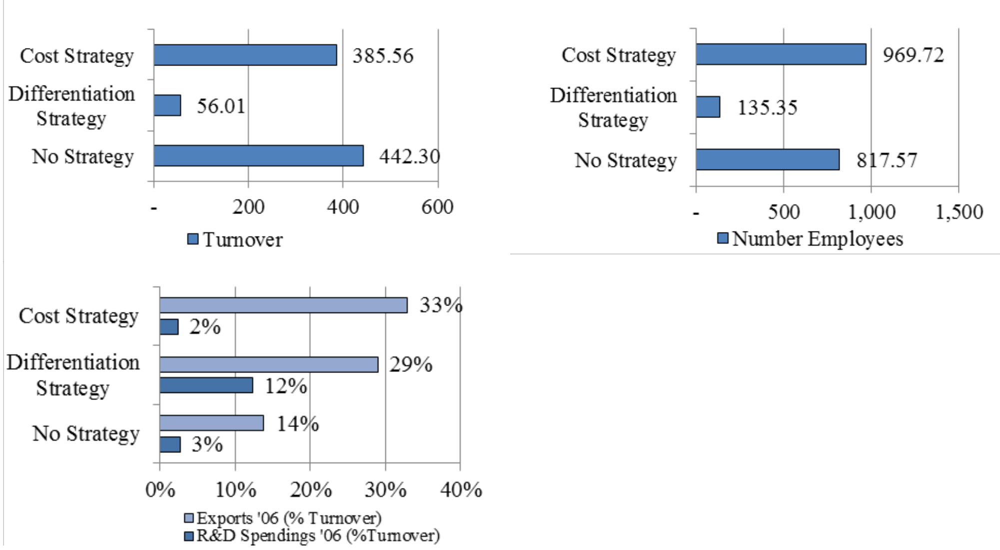

Figure 1: Means of key Figures for Strategic and non-Strategic Acting Companies

As this article deals with infringement (Figure 2), unauthorized copy (Figure 3) or generally with the adversely affection (violation, Figure 4) of IP(R), it is worthwhile to have a look at descriptive statistics to what extent companies following different (or none) competitive strategies struggle with IP(R) violation. Obviously, companies with a competitive strategy are clearly more often affected by vitiation of IP(R) than IP of companies without a competitive strategy. Obviously, the highest infringement incidences are reported for technical IP. At least every tenth patent or utility model of companies with competitive strategy is infringed upon compared to only 3% of all technical IP of companies without strategy. Trademarks and registered designs are less infringed upon; however, relatively more trademarks and registered designs of companies with competitive strategy are infringed upon.

Even more affected is IP without legal protection: between 14% and 16% of unprotected technical IP of companies with competitive strategy is copied without authorization compared to only 5% of IP of firms without. Similarly, unregistered brands are also relatively more affected by copying compared to trademarks. Contrasting, a huge difference between infringement and copying is found for (registered) designs: 9-12% more unregistered designs are copied without authorization (compared to infringement incidences) regarding companies with strategy. The first impression given by this descriptive data suggests that companies with a competitive strategy are exposed to a higher risk regarding IP violation than companies without such a strategy. This impression will be further checked and elaborated with logistic regression in chapter 5 (p 16).

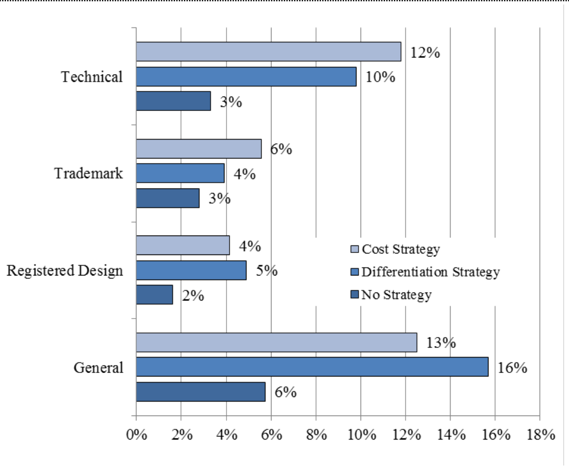

Figure 2: Incidences of Infringement

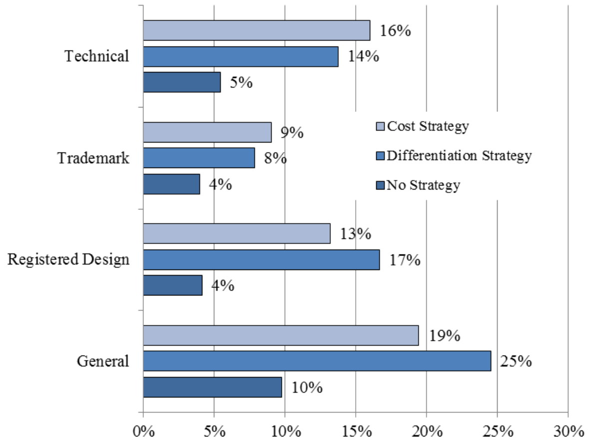

Figure 3: Incidences of Unauthorized Copy

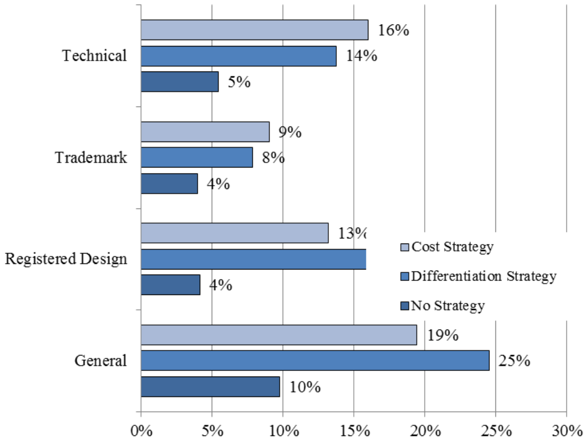

Figure 4: Incidences of IP Violation

Apart from that, descriptive statistics (Table 5) reveal interesting information on the incidences of adversely IP interference.[16] All figures show the percentage of affected companies by companies from specific countries (means). Asia is the most prominent continent for companies violating IP(R): virtually every company reporting this information states that the IP(R) violating companies come mainly from Asia and the figures only slightly change depending on the type of IP. However, also infringement of European countries is frequently reported suggesting that IP(R) violation is not only a problem caused by companies from the Far East. Important to note, however, is the small number of answers to this question: only between 83 and 132 companies did give particulars regarding that part of the

[16] This question was phrased as an open question in the questionnaire: "Has any IP of your company been adversely affected by other companies, from which countries came those companies mainly, and was your IP legaly protected?" The countries were named in an open field; multiple answers were possible. Countries are displayed if they account for at least 5% of companies; companies with less than 5% are summed up in the respective cateogory (Asisa, Europe, Else).

question. However, the figures still reveal an interesting picture of where the infringing or copying party comes from and the data is, from a descriptive perspective, still interpretable as the picture is backed by the statistics of the EU customs: they also state Asia to be the main violating continent whereas violation inside of the EU is not detected [17] (European Commission and Taxation and Customs Union, 2009).

Table 5: Means of Infringement or Copy of IP for Countries (Highest Mean in Bold)

Technical IP	Country	Cost Strategy	Differentiation Strategy	None	All
	Europe	0.3421	0.3704	0.0000	0.7125
	USA	0.0263	0.0000	0.1818	0.2081
	Asia (else)	**0.5526**	**0.4815**	**0.4545**	**1.4887**
	China	0.0000	0.0000	0.0909	0.0909
	India	0.0789	0.0741	0.0000	0.1530
	Else	0.2105	0.2222	**0.4545**	0.8873
Trademarks/Brands					
	Europe	0.4000	0.5000	0.1429	1.0429
	USA	0.0000	0.0000	0.0000	0.0000
	Asia (else)	**0.6000**	**0.7000**	**0.5714**	**1.8714**
	China	0.0667	0.1000	0.0000	0.1667
	India	0.0000	0.0000	0.1429	0.1429
	Else	0.0667	0.1000	0.1429	0.3095
(Registered) Designs					
	Europe	0.3704	0.3333	**0.5833**	1.2870
	USA	0.0000	0.0667	0.0000	0.0667
	Asia (else)	**0.5432**	**0.6667**	0.5000	**1.7099**
	China	0.0494	0.0000	0.0000	0.0494
	India	0.0370	0.0000	0.0000	0.0370
	Else	0.0370	0.0000	0.0000	0.0370

The main conclusion we draw from the descriptive statistics are, first, companies aligned to a competitive strategy seem to be a favored target for IP(R) infringers or copier and, second, infringement and unauthorized copy are also practiced in the EU and other western countries (e.g. USA) and are not only a thread of the Far East. In the following chapter we will further discuss these conclusions and test them with multivariate analyses.

5. Results

Each logistic estimation includes a variable indicating infringement, unauthorized copy or violation of a certain IP(R) type as depend variable. The cost leaders and the differentiators are the independent variables whereas the scope of business (regional), the number of employees, relative exports and the number of legal protection rights (patents, utility models and trademarks) are included as control variables. An overview for all variables is provided in

[17] EU customs only control goods entering the EU. Goods violating IP(R) inside the EU can, hence, not be detected.

Table 4. As already mentioned and reasoned in chapter 3, we employ logistic estimations. Regarding the depending variables, we differentiate between IPR infringement, unauthorized copy of IP and a general term named “IP Violation” which comprises both, infringement and copy of IP(R). Hence, this chapter is structured along these different depending variables.

5.1. IPR Infringement

The multivariate results for IPR infringement are summarized in Table 6(coefficients) and Table 7 (odds ratios). Regarding the coefficients, positive coefficients indicate a positive influence of the respective variable on IPR infringement as negative coefficients show a negative influence. However, the coefficients do not give any information on how strong the respective influence is. This information is provided by the odds ratios (Table 7). The first impression of the coefficients is the influence some of the control variables have. The intensity of exports[18], and the number of employees as an indicator for firm size are significant in throughout the models. Obviously, larger firms are more affected, as well as companies with a high export rate. The export rate and the company size are directly influencing the diffusion of the products and the embodied IP within them in the world. Therefore, we have expected these results and included these variables as control variables. Moreover, the trademark and the stock of technical IPR show significances in the respective models.[19] Concluding, Table 6 shows that all estimated models are highly significant and explain between 7.2% and 24.5% of the respective variances.[20] Hence, the models have a high fit and degree of explanation. Regarding the studied variables cost strategy and differentiation strategy our models provide a mixed picture. In one case the cost strategy variable is significant (infringement of technical IPR) and positive. Contrasting, differentiation strategy reveals two significant and positive coefficients (infringement of technical IPR and general infringement).

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18 Exports are meassured relativele to turnover

19 We included the trademark stock for all models with infringement/unauthorized copy/violation of trademarks as depending variable and the stock of technical IPR for all models with infringement/unauthorized copy/violation of technical IPR.

20 Compare Pseudo R^2

Table 6: Logistic Regression IPR Infringement: Coefficients

	Infringement of Technical IPR	Infringement of Trademarks	Infringement of Registered Designs	General Infringement
Cost Strategy	0.554*	-0.393	-0.155	-0.0513
	(0.334)	(0.482)	(0.556)	(0.309)
Differentiation Strategy	1.230***	0.210	0.421	0.878***
	(0.368)	(0.542)	(0.626)	(0.312)
No. Employees (ln)	0.353***	0.272***	0.344***	0.304***
	(0.0716)	(0.0732)	(0.0891)	(0.0565)
Exports '06 (% Turnover)	2.963***	1.897***	1.543***	2.463***
	(0.381)	(0.416)	(0.533)	(0.296)
No. Of Technical IPR	0.0438***			0.0307**
	(0.0128)			(0.0123)
No. Of Trademarks		0.132***		0.0650*
		(0.0345)		(0.0356)
Constant	-5.693***	-4.972***	-5.686***	-4.541***
	(0.380)	(0.354)	(0.447)	(0.274)
Observations	2,151	2,133	2,138	2,192
Log Likelihood	-302.9	-291.8	-202.5	-491.4
Chi²	197.1	72.53	31.45	203.0
Pseudeo R²	0.245	0.111	0.0720	0.171
Prob > chi2	0	0	2.48e-06	0

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The impressions of the mere coefficients are further distinguished by the odds ratio showing the susceptibility to infringement as likelihood. Patent and utility model infringement is more likely if the firm is a cost leader (74% more) and even more likely in case for differentiators (242% more). That means that the likelihood of patent or utility model rises by the factor 1.7 for cost leaders and by the factor 3.4 for companies with differentiation strategy. Companies pursuing a competitive strategy are obviously more exposed to patent or utility model infringement compared to companies not focusing on an explicit competitive strategy. Moreover, the odds ratio of differentiators is also very high (2.4) for infringement of any IPR.[21]

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[21] Not significant though lower than one are the odds ratios of cost leaders for trademarks and design infringement. That indicates a negative influence as do the coefficients. However, as the coefficients lack the significance the results are not robust enough to justify a thorough research interpretation.

Table 7: Logistic Regression IPR Infringement: Odds Ratios

	Infringement of Technical IPR	Infringement of Trademarks	Infringement of Registered Designs	General Infringement
Cost Strategy	1.741*	0.675	0.856	0.950
	(0.581)	(0.325)	(0.476)	(0.293)
Differentiation Strategy	3.423***	1.233	1.523	2.406***
	(1.260)	(0.668)	(0.953)	(0.752)
No. Employees (ln)	1.424***	1.312***	1.411***	1.355***
	(0.102)	(0.0960)	(0.126)	(0.0765)
Exports '06 (% Turnover)	19.35***	6.669***	4.679***	11.74***
	(7.364)	(2.775)	(2.495)	(3.480)
No. Of Technical IPR	1.045***			1.031**
	(0.0134)			(0.0127)
No. Of Trademarks		1.141***		1.067*
		(0.0394)		(0.0380)
Observations	2,151	2,133	2,138	2,192
Log Likelihood	-302.9	-291.8	-202.5	-491.4
Chi²	197.1	72.53	31.45	203.0
Pseudeo R²	0.245	0.111	0.0720	0.171
Prob > chi2	0.000	0.000	0.000	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2. Unauthorized Copy

The second set of estimation uses incidences of unauthorized copying as depending variables. Unauthorized copy differs from infringement in the fact that infringement is only possible if the respective IP is protected by IPR. Unauthorized copy means the unauthorized use of IP while the IP is not protected by an IPR.

First indications of the competitive strategies' influence are given by the coefficients of the logistic estimations (Table 8). The first notably difference to infringement is that the control variables for trademark and technical IPR stock are not significant and do not influence the copying incidences. This means, the signal function of those stocks is limited. Contrasting, the amount of exports positively influences the susceptibility to copying,[22] which draws a similar pattern to infringement. Regarding the competitive strategies, differentiation seems to be more susceptible than cost strategy: regarding designs and generally (copy of any IPR) differentiators have significant and positive coefficients. In contrast, cost leaders only face unauthorized copy of designs and reveal a significant coefficient of general unauthorized

[22] With the exception of copy of brands.

copy. Regarding the models in general, most are significant on the 1% level[23] and explain between 4.2% and 8.6%.

Table 8: Logistic Regression Unauthorized Copy: Coefficients

	Copy of Technical IPR	Copy of Brands	Copy of Designs	General Copy
Cost Strategy	0.706	0.436	0.883***	0.598**
	(0.438)	(0.568)	(0.342)	(0.294)
Differentiation Strategy	0.574	1.036	1.216***	1.023***
	(0.497)	(0.632)	(0.377)	(0.304)
No. Employees (ln)	-0.0542	0.305***	0.152**	0.0876
	(0.0895)	(0.109)	(0.0720)	(0.0582)
Exports '06 (% Turnover)	1.942***	0.597	1.974***	1.839***
	(0.458)	(0.689)	(0.397)	(0.312)
No. Of Technical IPR	-0.00230			-0.000331
	(0.0115)			(0.00669)
No. Of Trademarks		-0.0285		-0.0357
		(0.0971)		(0.0608)
Constant	-3.887***	-5.678***	-4.472***	-3.515***
	(0.365)	(0.519)	(0.331)	(0.251)
Observations	2,118	2,099	2,105	2,158
Log Likelihood	-251.2	-158.4	-313.9	-488.8
Chi²	22.22	14.50	58.74	64.25
Pseudeo R²	0.0424	0.0438	0.0855	0.0617
Prob > chi2	0.001	0.0127	0.000	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

More information on the influence's degree is provided by the odds ratios in Table 9. Regarding registered designs, both competitive strategies increase the risk of infringement by the factor 2.4 (cost strategy) and factor 3.4 (differentiation). Similarly, differentiators are more heavily affected in general (factor 2.8 compared to 1.8 for cost strategy). Summing up, the differentiation strategy is, once again, more susceptible compared to cost strategy. However, companies with a competitive strategy are in general (compared to companies without) more affected by unauthorized copy of their IP.

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[23] Exception: copy of brands with significance level of 5%.

Table 9: Logistic Regression Unauthorized Copy: Odds Ratios

	Copy of Technical IPR	Copy of Brands	Copy of Designs	General Copy
Cost Strategy	2.027	1.547	2.419***	1.819**
	(0.888)	(0.878)	(0.827)	(0.535)
Differentiation Strategy	1.774	2.817	3.374***	2.780***
	(0.883)	(1.779)	(1.271)	(0.846)
No. Employees (ln)	0.947	1.356***	1.165**	1.092
	(0.0848)	(0.148)	(0.0838)	(0.0636)
Exports '06 (% Turnover)	6.976***	1.816	7.197***	6.292***
	(3.195)	(1.251)	(2.860)	(1.960)
No. Of Technical IPR	0.998			1.000
	(0.0115)			(0.00669)
No. Of Trademarks		0.972		0.965
		(0.0944)		(0.0587)
Observations	2,118	2,099	2,105	2,158
Log Likelihood	-251.2	-158.4	-313.9	-488.8
Chi²	22.22	14.50	58.74	64.25
Pseudeo R²	0.0424	0.0438	0.0855	0.0617
Prob > chi2	0.001	0.0127	0.000	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.3. IP Violation

The third and last set of models estimates relations between the competitive strategies and incidences of IP violation. The term IP violation refers to both, infringement *and* unauthorized copy and shows the general susceptibility of companies with competitive strategies to infringement/copy of technical IP or counterfeiting. Looking at the coefficients (Table 10), IP violation is significantly higher in case of patentable IP and designs for both competitive strategies. Contrasting, only differentiation strategy shows significant coefficients for brands. Likewise, IP violation in general is reported to be significant only for differentiation strategy.

Table 10: Logistic Regression IP Violation: Coefficients

	IP Violation of Technical IPR	IP Violation of Brands	IP Violation of Designs	General IP Violation
Cost Strategy	0.751***	0.0470	0.744***	0.277
	(0.259)	(0.334)	(0.269)	(0.234)
Differentiation Strategy	1.022***	0.696*	1.063***	0.954***
	(0.303)	(0.363)	(0.315)	(0.257)
No. Employees (ln)	0.192***	0.260***	0.231***	0.190***
	(0.0542)	(0.0584)	(0.0545)	(0.0434)
Exports '06 (% Turnover)	2.608***	1.540***	1.872***	2.382***
	(0.291)	(0.332)	(0.310)	(0.236)
No. Of Technical IPR	0.0445***			0.0285**
	(0.0131)			(0.0123)
No. Of Trademarks		0.111***		0.0520
		(0.0327)		(0.0329)
Constant	-4.086***	-4.255***	-4.116***	-3.188***
	(0.256)	(0.274)	(0.256)	(0.193)
Observations	2,138	2,123	2,127	2,154
Log Likelihood	-501.6	-447.5	-485.5	-781.3
Chi²	213.0	93.86	103.4	237.1
Pseudeo R²	0.175	0.0949	0.0962	0.132
Prob > chi2	0.000	0.000	0.000	0.000

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

In order to analyze the magnitude of the impact, odds ratios are reported (Table 11). Differentiating companies reveal to be more susceptible to IP violation: they are affected 2 to 2.9 times more often compared to other companies. Contrasting, companies following the cost strategies are only in case of IP violation of technical IP (factor 2.1) and of designs (factor 2.1) more often affected. Regarding the models in general, all models are highly significant on the 1% level and explain between 11.1% and 20.1%.

Table 11: Logistic Regression IP Violation: Odds Ratios

	IP Violation of Technical IPR	IP Violation of Brands	IP Violation of Designs	General IP Violation
Cost Strategy	2.119***	1.048	2.105***	1.319
	(0.549)	(0.350)	(0.566)	(0.308)
Differentiation Strategy	2.780***	2.006*	2.896***	2.597***
	(0.841)	(0.729)	(0.913)	(0.667)
No. Employees (ln)	1.211***	1.297***	1.260***	1.210***
	(0.0657)	(0.0757)	(0.0686)	(0.0526)
Exports '06 (% Turnover)	13.58***	4.665***	6.501***	10.82***
	(3.946)	(1.551)	(2.013)	(2.550)
No. Of Technical IPR	1.046***			1.029**
	(0.0137)			(0.0127)
No. Of Trademarks		1.117***		1.053
		(0.0366)		(0.0346)
Observations	2,138	2,123	2,127	2,158
Log Likelihood	-501.6	-447.5	-485.5	-488.8
Chi²	213.0	93.86	103.4	64.25
Pseudeo R^2	0.175	0.0949	0.0962	0.0617
Prob > chi2	0.000	0.000	0.000	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Discussion

The results of our estimation show that the effect of legal protection of IP differs with respect to the affected type of IP. Interestingly, patent and utility model protection do not frighten off companies willing to copy the IP described in them. The trade-off between the risk of a possible legal action taken by the infringed party is more than set-off by the perceived possibilities of reaping some of the cost leader's or differentiator's profits. The likelihood of infringement for differentiators is far higher than for cost leaders. This suggests that the infringing parties are willing and capable to copy the IP of the patent or utility model in at least such a manner that their product infringes upon the respective IPR. This is an indication that product pirates are – contrasting to common believe[24] – capable to make use of published results of R&D and to incorporate the technology into their products. However, the degree to which the infringers' products do substitute or replace the original products remains unclear as the acceptance rate among customers is not subject of our research. Concluding, companies trying to compete through differentiation from their competitors are highly susceptible to infringement of patents and utility models. Also cost leaders face infringement

[24] This believe is also stressed in literature OECD (2008).

of their patents and utility models while the likelihood of infringement is not as drastically high as for differentiating companies as is the degree of significance.

While patents and utility models do not discourage companies from using the underlying technology without permission, IP of companies with competitive strategy applicable for patents or utility models is not more likely to be copied compared to companies without competition strategy. This leaves room for interpretation. The enabling effect of patents and utility models seems to make infringers to be able to copy or use the technology. However, without the detailed description of the publication their still seem to lack the crucial capacities to reverse engineer the target products. Another effect not discussed, is the signaling effect of patents. The simple assumption of infringers could be that important or even path breaking technology is more likely to be patented and hence they concentrate more on legally protected technology. However, another explanation could be that the technical IP without protection simply is outdated (e.g., the legal protection right might simply have expired) and therefore not attractive to copy. However, we know from discussions with IP managers[25] that IP of outdated patents is often copied – bearing that in mind, it is obvious that the technical IP without protection of companies with differentiation strategy is not an attractive target for copying. Hence, the above argumentation holds. The fact that standardization efforts often are connected with patent pools might also increase the attractiveness of legally protected technology.

Consequently, for companies engaged in innovation and differentiation an interesting option of IP management could be to focus less on patents and more on keeping the knowledge necessary for copying secret. The results of our estimation show that legally protected technology of differentiating companies is more likely to be infringed as unprotected technology is likely to be unauthorized copied. On the other hand, the rising patent propensity over the last years would then be a result of misled management.

Compared with technology, other forms of IP like, e.g., design and brands behave completely contrarily. While unprotected brands and designs of companies with a competition strategy are highly likely to be copied, trademarks and registered designs are not likely to be subject of infringement. The reasons for the polar opposite are various. First, trademarks and registered designs do not provide the enabling effect like patents and utility models. It is possible to imitated designs and brands without access to a registry entry. Moreover, it is

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[25] In a future case study we investigate the mechanisms of companies to fight IPR infringement and unauthorized copy. Some interviews have already been conducted.

easier to enforce registered designs and trademarks[26] as for the proof of infringement no technological experts are necessary and, hence, he proof is easier. Consequently, it can be fairly assumed that trademark and registered design infringement are more likely to be sued as the probability of a favorable outcome of the legal action for the infringed party might be more likely compared to patent or utility model infringement suits. The threat of legal action in case of trademark or registered design infringement is like the “Sword of Damocles” and does more than offset the possible rents from counterfeiting. This is, however, not the case if the brand or design is not legally protected. In this case it is perfectly legal to imitate it. Especially for companies engaged in differentiation this information is of high value as registering brands as trademarks and designs largely fends off counterfeiting targeting explicitly such companies.

More generally, our results clearly show that product pirates are a severe threat to companies engaged in differentiation and, hence, to one of the cornerstones of an innovative economy. Cost leaders are also a favorite target of product pirates, however, they still are less likely to be affected by infringement or unauthorized copy of IP compared to companies engaged in differentiation. Dealing with product pirates therefore is one of the important topics to be addressed by policy makers and managers alike.

7. Conclusion

The results of our research show that companies whose business model firmly base on innovation are not exempted from unauthorized copy or infringement of their IP(R) but instead a favorite target of “product pirates”. Companies relying on differentiation of their products are even more affected than companies focusing on cost leadership while providing a sufficiently high quality.

Further, our results indicate that cost leaders can rely on using patents and utility models if they look after the enforcement of these legal rights. Although, if the technology is also protectable by informal measures (e.g., secrecy or complex technology), patenting is not recommended. At the same time, their brands and designs are less likely to be copied and a lean IPR management regarding trademarks and registered designs is possible.

With respect to companies engaging in differentiation, product pirates indeed are a severe threat. A clear recommendation is not possible. However, our results suggest that informal measures are less prone to attract pirates compared to formal protection measures regarding

[26] We assume that trademarks and registered designs are correctly and professionaly filed for.

technology. Hence, we recommend to take a two-step approach; first, the decision for and against patenting ought to be strongly linked to the willingness of enforcement of the patent. If the willingness or the ability of enforcement not sufficient, patenting is not recommended. In the second step, the company decides for a suitable alternative protection measure, such as secrecy, complex technology, destandardization or the like. Notwithstanding, legal protection of trademarks and designs is very effective in frightening off product pirates. A combination of strictly enforced trademarks and designs and informal measures for protection of technology is an effective strategy against product pirates. However, keeping the leading position in product development and design is not enough, if a suitable IP strategy is missing. The effectiveness of such strategies is not within the scope of this article and remains on the agenda for further analysis.

Regarding policy recommendations, our results have shown that the IP regime regarding technology is doing good and harm at the same time. On the one hand, the publication of the patent enables companies to copy the technology. However, on the other hand, the IPR regime offers the legal enforcement of patents. Our results show that trademark and registered design protection indeed keeps others from illegal usage. Patents and utility models do not likewise. This finding gives concern as it suggests that companies infringing upon patens or utility models do not worry about the legal enforcement – at least not as much as about the legal enforcement of trademarks and registered designs. Possibly, the reasons for this behavior are rooted in the difficulty of patent enforcement. One recommendation for policy would consequently be to ensure fast and easy enforcement of patents while at the same time guarantying a high degree of reliability of the patents' validity.

Further research should focus on the effectiveness of strategies against product pirates and work on a deeper understanding of characteristics signaling attractiveness for copy or infringement of their IP(R). Moreover, differences between the different IPR regimes should be analyzed and the likelihood of infringement in certain countries be taken into account.

Our study provides a first indication that copy and infringement of IP(R) indeed is a threat for all companies whether or not they are relying on top edge technology. Being the technology leader in a field and providing highly differentiated products is no longer enough.

References

Audretsch, D.B., 1995. Innovation, growth and survival: The Post-Entry Performance of Firms. International Journal of Industrial Organization 13 (4), 441–457.

Blind, K., Cuntz, A., Köhler, F., 2010. Risk Factors and Mechanisms of Product Piracy - A First Empirical Approach. Working Paper.

BSA, 2008. 5th Annual BSA and IDC Global Piracy Study, Washington, D.C.

Castro, J.O. de, Balkin, D.B., Shepherd, D.A., 2008. Can entrepreneurial firms benefit from product piracy? Journal of Business Venturing 23 (1), 75–90.

Cohen, W.M., Goto, A., Nagata, A., Nelson, R.R., Walsh, J.P., 2002. R&D spillovers, patents and the incentives to innovate in Japan and the United States. Research Policy 31 (8-9), 1349–1367.

Cohen, W.M., Nelson, R.R., Walsh, J., 2000. Protecting their intellectual assets: appropriability conditions and why US manufacturing firms patent (or not). Working Paper, SSRN No. 214952.

Conner, K.R., Rumelt, R.P., 1991. Software piracy: an analysis of protection strategies. Management Science 37 (2), 125–139.

Cordell, V.V., Wongtada, N., Kieschnick, R.L., 1996. Counterfeit purchase intentions: Role of lawfulness attitudes and product traits as determinants. Journal of Business Research 35 (1), 41–53.

European Commission. COM(2011) 287 final: A Single Market for Intellectual Property Rights. Boosting creativity and innovation to provide economic growth, high quality jobs and first class products and services in Europe.

European Commission, Taxation and Customs Union, 2009. Report on EU Customs: Enforcement of Intellectual Property Rights. Results at the EU Border - 2009. Taxation and Customs Union.

Fagerberg, J., Verspagen, B., 2003. Innovation, growth and economic development: Why some countries succeed and others don’t. Working Paper.

Givon, M., Mahajan, V., Muller, E., 1995. Software piracy: Estimation of lost sales and the impact on software diffusion. Journal of Marketing 59 (1), 29.

Grossman, G.M., Helpman, E., 1990. Trade, Innovation, and Growth. The American Economic Review 80 (2), 86–91.

Grossman, G.M., Shapiro, C., 1988. Counterfeit-Product Trade. The American Economic Review 78 (1), 59–75.

Grossman, G.M., Shapiro, C., 1988. Foreign Counterfeiting of Status Goods. The Quarterly Journal of Economics 103 (1), 79–100.

Harvey, M.G., Ronkainen, I.A., 1985. International Counterfeiters: Marketing Success Without the Cost and the Risk. Columbia Journal of World Business 20 (3), 37–45.

Hendrickse, M.T., Thuluvath, P.J., Triger, D.R., 1992. Natural history of autonomic neuropathy in chronic liver disease. The Lancet 339 (8807), 1462–1464.

Karaganis, J., 2011. Media piracy in emerging economies. Social Science Research Council, New York, NY, p. cm.

Katz, M.L., Shapiro, C., 1994. Systems Competition and Network Effects. The Journal of Economic Perspectives 8 (2), 93–115.

Kingston, W., 2000. Enforcing small firms' patent rights. European Commission, DG Enterprise.

Mansfield, E., 1985. How Rapidly Does New Industrial Technology Leak Out? The Journal of Industrial Economics 34 (2), 217–223.

OECD, 2008. The economic impact of counterfeiting and piracy. OECD, Paris, 395 pp.

OECD, 2009. Magnitude of Counterfeiting and Piracy of Tangible Products: an Update.

Olsen, J.E., Granzin, K.L., 1992. Gaining Retailers' Assistance in Fighting Counterfeiting: Conceptualization and Empirical Test of a Helping Model. Journal of Retailing 68 (1), 90.

Porter, M.E., 1980. Competitive strategy: Techniques for analyzing industries and competitors. Free Press, New York, xx, 396.

Porter, M.E., 2004. Competitive strategy: Techniques for analyzing industries and competitors, New Edition ed. Free Press, New York, NY, XXVIII, 396 S.

Porter, M.E., 2008. Wettbewerbsstrategie: Methoden zur Analyse von Branchen und Konkurrenten, 11., durchges ed. Campus, Frankfurt am Main, 484 S. ;

Raustiala, K., Sprigman, C., 2009. The piracy paradox revisited. Stanford Law Review 61, 1206–1209.

Sawyer, P., Lillis, J.P., Bodner, E.V., Allman, R.M., 2007. Substantial Daily Pain Among Nursing Home Residents. Journal of the American Medical Directors Association 8 (3), 158–165.

Segerstrom, P.S., 1991. Innovation, Imitation, and Economic Growth. The Journal of Political Economy 99 (4), 807–827.

Teece, D.J., 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy 15 (6), 285–305.

Utterback, J.M., Abernathy, W.J., 1975. A dynamic model of process and product innovation. Omega 3 (6), 639–656.

Weatherall, K.G., Webster, E.M., 2010. Patent infringement in Australia: Results from a survey. Federal Law Review 38 (1), 21–70.

World Intellectual Property Organization. Patent Cooperation Treaty: PCT.

Wright, T., 1936. Factors affecting the cost of airplanes. Journal of Aeronautical Science 3 (2).

Blocking Patents and Product Commercialization: Evidence from the Pharmaceutical Industry

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Firms that seek to commercialize new products often build on existing technological knowledge that is protected by patent rights. The prior literature has argued that if firms need to access knowledge that has been patented by other firms or institutions a variety of problems can emerge. The nature of the problems depends on the nature of the underlying technology: for "complex" products, such as semiconductors or telecommunications,[2] patent thickets increase transaction costs in accessing external technology as well as create hold-up situations among rivals in the field (Shapiro, 2000); meanwhile, for discrete products a "tragedy of the anti-commons" can emerge in which valuable inventions are under-exploited because patent holders block each other from using their inventions (Heller *et al.*, 1998). Moreover, the literature argues that the "explosion" of patent rights in the past few decades has dramatically increased the potential for conflict in both discrete and complex areas, which these commentators claim is seriously impeding innovation and product commercialization. At the same time, it has also pointed to various actions that organizations can take in the technology market (or "patent space") to alleviate conflict. In technologies where complex products prevail, Shapiro (2000) has shown that patent pools, standardization and cross-licensing agreements allow organizations to efficiently contract access to external (and potentially fragmented) knowledge. In discrete areas, Walsh *et al.* (2003) found evidence that university researchers use pragmatic solutions such licensing, inventing around, and simply using the technology without a license (i.e., infringement) to get around blocking patents.

However, while the prior literature has raised the specter of a "patent problem" and highlighted a range of actions in the technology market that organizations might use to alleviate this problem, there is little empirical evidence on the extent to which the problem and its solutions actually impact product commercialization. In this paper we examine how the existence of blocking patents affects product commercialization. Moreover, we study how the identity of the blocking patentee affects whether the product is commercialized and/or whether the parties are able to overcome the conflict in the patent space through licensing. To do this, we have built a unique dataset that contains both the clinical development/product commercialization history and detailed information on the primary patents covering the product for approximately 8500 products developed in the pharmaceutical industry. The primary data source for the product-level information is IMS R&D Focus, which provides both a detailed history of clinical development, licensing, and marketing/commercialization events as well as information on the main patents covering the products. We have then matched the patent-level information from IMS R&D Focus to more detailed patent information in PATSTAT, particularly the EPO data on blocking patents identified in the prior art referenced during the examination of the patent application (Harhoff *et al.*, 2008).

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[2] Cohen, Nelson and Walsh (2000) distinguish between discrete and complex products by "whether a new, commercializable product or process is comprised of numerous separately patentable elements versus relatively few". Areas where new products comprise numerous patents are deemed to be complex; areas where new products comprise only few patents are deemed to be discrete.

We choose to do this in the context of the pharmaceutical industry, for various reasons. First, obtaining a clear and unencumbered patent position is essential for commercializing an innovation in the pharmaceutical industry. Patent rights in this industry are generally strong, and hence the holder of a "blocking" patent is often in a position to stop the commercialization of the innovation – or at least negotiate a cut of the revenues. Moreover, firms involved in commercializing pharmaceutical innovation have considerably less flexibility than universities to ignore patent issues, and licensing (or cross-licensing) provides the main if not the only alternative for these firms to overcome these issues. Second, the discrete nature of pharmaceutical products allows us to clearly identify relationships between firms that seek to commercialize a novel product and organizations that hold a potentially blocking patent right. This enables us to directly examine to what extent problems in the technology or patent market impact product-market outcomes. Focusing on complex technologies would make such a clear identification more difficult.

We model the impact of blocking patents on product-market outcomes using a multivariate survival analysis in which the dependent variable is the hazard of product commercialization. Survival – or hazard-rate – analysis is especially appropriate in this context since patent-term limits necessitate that firms get products to market as quickly as possible. The primary explanatory variables are those which signify the existence of blocking patents in the references cited on the focal patent. Our regression also includes variables that capture product, firm, and market characteristics in order to control for alternative determinants of the hazard of product commercialization. Our preliminary results show a negative relationship between the speed of commercialization in EPO countries and the number of blocking patents references in the prior art.

Keywords: blocking patents, product commercialization, licensing

References

Cohen WM, Nelson RR, Walsh JP. 2000. Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not). In *NBER Working Paper.* National Bureau of Economic Research, Inc.

Harhoff D, Hoisl K, Webb C. 2008. European patent citations: How to count and how to interpret them. In *LMU Discussion Papers.* Munich.

Heller MA, Eisenberg RS. 1998. Can Patents Deter Innovation? The Anticommons in Biomedical Research. *Science* **280**(5364): 698-701.

Shapiro C. 2000. Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting. *Innovation Policy and the Economy* **1**(2000): 119-150.

Walsh JP, Cohen WM, Arora A. 2003. Working Through the Patent Problem. *Science* **299**(5609): 1021.

Legal Regulation of Ambush Marketing: Where Is the Base?

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Introduction

The first reported 'ambush marketing' incident appeared at the 1984 Los Angeles Olympics where Fuji Photo Film USA was the official 35mm film of the Games, and Kodak countered by paying considerably less to sponsor the US track and field trials and ABC's broadcast of the Games. Till today, there is still no unified definition of ambush marketing. The International Olympic Committee (IOC) and International Cricket Council (ICC) are by far the most active advocate for ambush marketing control. According to the IOC, "[a]mbush marketing refers to any attempt by non-Olympic sponsors to create a false or unauthorised association with the Olympic Movement and the Olympic Games."[1] ICC, categorises ambush marketing as two sets: first "ambush marketing by association", which refers to that ambushers mislead the public into thinking that they are legitimate sponsors of an event, and "ambush marketing by intrusion", by which "the ambusher does not seek to suggest a connection with the event but rather to give his own brand or other insignia exposure through the medium of the publicity attracted by the event and without the authorization of the event organiser". Reading literally, the IOC definition does not appear to conform to the ICC one. The former appears to indicate a narrower scope than the latter. There are also definitions from other organisations or jurisdictions[2] which are worded differently.

Despite the existence of varied versions of definitions, there are two things about ambush marketing that have been widely agreed. Firstly, ambush marketing "involve 'a spectrum of behaviour, from glaringly obvious to the ambiguous and subtle'."[3] (Longdin 2009, p.726). Meenaghan (1994), who was a pioneer scholar in researching ambush marketing, observes that ambush marketing exists in both a narrow sense and a broad sense. He suggests that in a narrow sense ambush marketing refers to "the activities of those companies who sought to associate themselves with an event, without paying the requisite fee to the event owner" (p.79) and in a broad sense ambush marketing refers to "methods of intruding upon public consciousness surrounding an event" (ibid). ICC's categorization of ambush marketing by association and by intrusion is in line with ambush marketing in a narrow sense and a broad sense respectively. This article thus will adopt ICC categorization as the definition for ambush marketing.

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[1] IOC 2008, IOC Marketing Media Guide, http://multimedia.olympic.org/pdf/en_report_1329.pdf
[2] Fro example, in Major Events Management Act 2007 (New Zealand), although the definition of ambush marketing by association is not given, association is defined as "a relationship of connection, whether direct or implied, such as an approval, authorisation, sponsorship, or commercial arrangement and includes offering, giving away, or selling a ticket to a major event activity in connection with the promotion of goods or services" (Part I s4).
[3]

Secondly Ambush marketing is viewed as a serious danger first to the sponsors and secondly to the events owners (Payne 1998 and Townley et al. 1998). It is alleged to deflect the audience's awareness from sponsors to the ambushers, and in its worst form ambush marketing engenders confusion and misleads the audience to consider the ambushers as the official sponsors (Meenaghan 1994). The impairment of the effectiveness of the sponsorship as a communication tool indicates the decline of the value of the sponsorship (Meenaghan 1996 and Townley et al 1998). Once the event owners can not guarantee the value of the sponsorship they sell, they cannot maintain the sponsorship revenue in the long term (Meenaghan 1996; Payne 1998; and Townley et al. 1998). Companies might withdraw from sponsorship, or at least will demand a reduction in sponsorship fees[4]. All these are detrimental to the economic well-being of the events.

There is limited literature on how ambush marketing diminishes the effectiveness of sponsorship. Based on the study of the commercial functions of sponsorship, Part One identifies that ambush marketing interferes with consumer awareness generation and image enhancement, the two essential functions of sponsorship, and give rise to the audience's association and confusion respectively. The confusion and association are the essential elements of the two types of ambush marketing: by association and by intrusion respectively. The existence of confusion and association in theory can jeopardise the commercial functions of sponsorship.

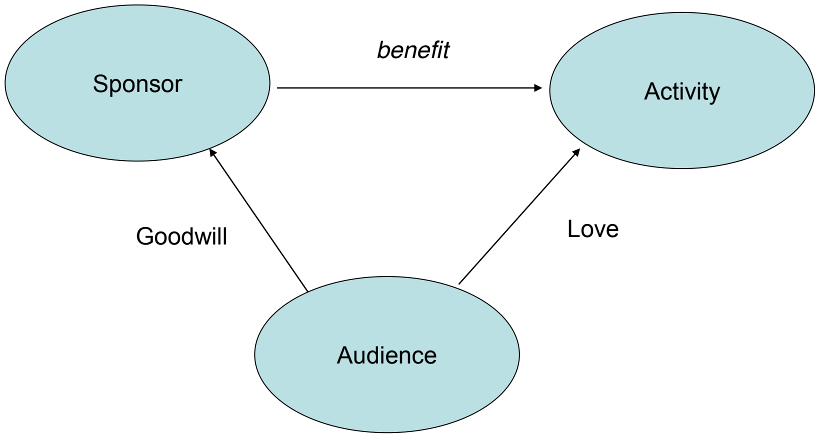
Part Two then explores whether (and if so, to what extent,) the incidents categorized as ambush marketing by the event owners have actually caused the confusion and association of the audience. An empirical study has been conducted based on the ambush marketing incidents collected by the Athens Olympic Organising Committee in 2004. The analysis regarding whether audience confusion or association exists in the incidents is conducted through the perception of average viewer modelled after average consumer test mainly adopted in the EU trade mark decisions.

Empirical evidence shows that all of the alleged incidents contain either the confusion or association of the audience. Should marketing behaviours which give rise to the confusion and association of the audience be outlawed? Existing law such as trade mark law, passing off and fair trading law in certain countries has provided remedy for marketing behaviour which gives rise to audience confusion based on the rationale of consumer protection. Accordingly ambush marketing by association which gives rise to audience confusion in theory can be regulated by the existing law. The law however is much more ambiguous when dealing with marketing behaviour which gives rise to consumer association. Trade mark dilution law is a typical example. So the question can be formulated in particular as: Is the regulation of ambush marketing by intrusion which gives rise to audience association an over expansion of IP law? As will find in Part Three, special legislation such as London Olympic Games Act 2006 enacted by host countries of the mega sporting events for ambush marketing control purpose have in effect outlawed ambush marketing by intrusion. It has been argued that some special legislation disregard "sound policy considerations that underpins marketing and IP law and placed unreasonable limits on the human rights to freedom of speech and association that are not justifiable in a free and democratic society"

[4] 2006 FIFA world cup, Germany faces the request from sponsors on the 20% reduction of sponsorship fees because of its ineffective ambush marketing control.

(Cobett and Roy 2010). In response to this criticism, Part Three examines whether there is sound justification for regulating ambush marketing by intrusion based on the comparison with trade mark dilution law.

Part One: Ambush marketing and commercial function of sponsorship



Sponsor-audience-activity Axis (Meenghan 1998)

All the sponsorship functions are based on the "fan involvement", referring to a phenomenon that each event creates its own audience who hold a varying degree of corresponding loyalty and attachment and the audience, to a varying extent, identifies with or is motivated by their engagement and affiliation with a particular event (Meenaghan 1996). "In a sponsor/sponsored-activity relationship there is positive orientation toward the sponsor who bestows benefit on the consumer's favoured activity. This is mediated by the intensity of fan involvement, and in turn forms the basis of consumer reaction to the sponsor" (Meenaghan 2001, p.6).

As a marketing communication tool, sponsorship in general has three main functions: the creation of consumer awareness, enhancing sponsors' image and promoting consumers' action (Sleight 1989), which means "a company wishes to communicate in order to make its audience aware of the company, feel good about it, and act on the information and their feelings to achieve a particular end result" Sleight (p.33). Promoting consumers' action is, in most cases, not the direct objective of sponsorship although the bottom line sales results are sometimes explicitly sought (Meenaghan, 1998; Walliser 2003) and therefore will be ignored in this article. Another important reason that some companies, in particular, high profile companies, invest in sponsorship is to exclude the competitors of the sponsors out of the marketing opportunities created by the events (Sleight 1989). This article will focus on how ambush marketing intervenes the sponsorship functions in terms of awareness creation, image enhancement and competition.

Awareness generation

Awareness can be measured at the general and specific level. Awareness at the general level measures the extent that audience are aware of the existence of the sponsor as a commercial entity. In other words, it is about how much sponsors have won the attention of the audience. Awareness at the specific level measures the extent that audience are aware of the fact the company have sponsored the event.
In other words, it is about how much audience can correctly recognise the sponsors. (Walliser 2003). When ambushers pass themselves off as the sponsors, they cause the confusion among the public regarding who are the sponsors and accordingly the awareness function at the specific level has been diminished. What is more subtle is how awareness function at the general level is interfered by ambush marketing.

Awareness is created as events and consequently sponsors, intrude on the consciousness of event audiences (Meenaghan 1998). Through the exposure to the event audience, sponsors intrude upon the event audiences' consciousness. Exposure potential that an event can generate in terms of audience numbers is one of the two essential things that a sponsor is buying[5] (Meenaghan 1991, p.36). This exposure potential is also expressed as publicity generated by the event. Through the exposure, the sponsors acquired the audience' attention, although their sponsorship status is not necessarily recognised by the audience. Likewise, awareness has been generated for ambush marketers when ambush marketing by intrusion happens. Ambush marketers here do not pass themselves off as sponsors or as having supported the event somehow. Therefore the audience are not confused with the relationship between the ambushers and the event. Instead, by seeking their exposure, the ambushers acquire the audience attention. The awareness that ambushers have created among the audience is in effect an association which makes the audience associate ambushers with the event even though they know ambushers haven't supported the event.

Association, the psychological link that audience hold between ambushers and the event exists because the role that the event plays in the process that awareness is created. The sponsored event functions as "marketing communications medium in that it simultaneously attracts, and provides access to, an audience." "The event generates the audience while concurrently transmitting the message to that audience in terms of the image values embodied in the event itself." Therefore, although the awareness function is about that sponsors capture the audience's attention (Meenaghan 1998), there is a psychological link between the sponsor and the sponsored event on the part of the audience. In other words, the audience associate the sponsor with the event. In effect, it is this link that differentiates sponsorship from advertising as a marketing communication tool.[6] In the case of ambush marketing, when awareness has been created for ambushers, audience generates the same link, i.e., association, between ambushers and the event.

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[5] Another thing is the image associated with that activity in terms of how it is perceived, which will be discussed later.

[6] It [a sponsored event] differs from conventional advertising in that both message and medium are inextricably linked in sponsorship. (p. 307, Meenaghan 1998b)

Although ambush marketing has been commented for deflecting the audience's awareness from sponsors to the ambushers (Meenaghan 1994), which implies that the awareness that ambushers gain is at the price of what sponsors can gain, the study of sponsorship theory does not directly confirm the amount of awareness that sponsors can gain will be reduced by ambush marketing. Sponsors can still take advantage of their sponsorship rights to create as many exposures for themselves as they like. Ambushers simply create their own awareness among the audience, just like adding another dimension of the exploitation of commercial opportunities that an event can bring. In certain circumstance ambush marketers can even argue that they promote the event. For example, if Pepsi come out with advertisement "Enjoy a cool summer at London 2012 with Pepsi", this advertisement will make the message of the London 2012 Olympics (which is sponsored by Coca Cola) reach the Pepsi consumers, some of them might not be aware of the Games before.

On the other hand, sponsors can argue that the effect of the audience' awareness of sponsors might have been weakened. As mentioned, the difference between the awareness generated by pure advertisement and the one generated by sponsorship is that the latter use the sponsored event as medium and thereby generates a psychological link between the sponsor and the sponsored event on the part of the audience. When there are only exposures of the sponsors, the exposures would impress upon the audience's consciousness deeper than when the exposures of ambushers add in. In other words, exposure that ambushers gain produces dispersion on the psychological hold upon the audience's mind between the sponsors and the event. This is arguably detrimental to the awareness function that a sponsor expects to achieve.[7]

Image enhancement

Sponsorship effectiveness on image enhancement occurs through 'image by association' effect, which is a well established marketing theory (Meenaghan 1991). The theory proposes that "each sponsored activity has its own distinct personality and a transfer of the image values occurs from the sponsored activity to the sponsor" through the sponsors' association with the activity (ibid). Here, association refers to a supporting relationship between sponsors and the events in the public's view. Image effect of sponsorship is specified as image improvement, and as image differentiation (Barker 2001). Both image improvement and differentiation are further discussed below.

Image improvement

Every sport has its unique image value, combining many basic characteristics, such as strength and speed, mental discipline, physical prowess, the will to win or team spirit. When companies become associated with the sports, an association may be made by the marketing audience between the company's name or brand and glamorous aspects represented by the sports. This may result in an improved status of the company's corporate and brand image (Barker 2001). An IOC survey reported that 53% of the

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[7] There is no such discussion in the sponsorship literature. This detriment to the sponsorship function is an analogue to the blurring in trade mark dilution.

respondents stated they felt more favourable towards a company if it was associated with the Olympic movement (Mintel 2004 cited CIM 2004).

Image differentiation

Differentiation is a major objective of branding. Sports sponsorship has an advantage in achieving this goal with sports where competition in the same industry is intense and it is difficult to project a unique image. For example, the brands of beers and spirits are widely available and familiar from retailing and advertising exposure. Sponsorship is often used as a means to projecting a favourable, unique image for a brand of beer or spirits and to differentiate itself from over and above that of competitors. Sponsorship has been strategically used for the same purpose in industry subsections including banking, insurance, utilities (power and gas companies) and, increasingly, computing and telecommunications companies (Barker 2001). A successful example is that of Cornhill, which has differentiated its brand from other insurance companies via its cricket sponsorship (Sleight 1989).

However, sponsors cannot achieve image effectiveness if their association with events cannot be recognised by the public. When ambush marketers misrepresent an association with events, they elicit the goodwill on the part of audience (Meenaghan 1998). When the audience are misled to take ambush marketers as sponsors, the goodwill of audience will be turned towards ambush marketers rather than sponsors. Consequently the sponsors cannot achieve effective image enhancement as mentioned above. Instead, ambush marketers will benefit from 'image by association'. Therefore, associated ambush marketing jeopardises the sponsorship effectiveness on image enhancement. By contrast, intrusion ambush marketing would not cause this type of damage, since by such intrusion ambush marketers do not show misrepresent any concrete connection with events.

Competition

Sponsorship can facilitate sponsors in competition for market share. In major sporting events there is often category exclusivity in sponsorship, which means that in one product or service sponsorship category, there is only one sponsor. For example, an event will take only one company from the soft drink industry as sponsor in soft drink category. This offers exclusive sponsorship rights to a company in its industry and enables the company to keep its competitors out of the marketing opportunity arising from the event. Some high-profile companies invest in sponsorship mainly for the competitive advantage the sponsorship can bring.

For such companies, the awareness of their companies or brands has already been very high and the corporate and brand images have been well-established. These are based on extensive consumer experience of their products or the companies themselves, reinforced by continuous advertising and sales promotion activities. In this case, sponsorship "is limited to, at best, marginally affecting general awareness or achieving increased awareness within relatively small or specialist target groups" (Sleight 1989, p.68). Likewise, the sponsorship is only of marginal effects for the image enhancement of these companies. As mentioned above, the main reason for firms to engage in sponsorship is to keep their competitors out of the marketing opportunities arising from the event. In the battle between Kodak and Fuji for an international market share, both parties alternatively used the sponsorship vehicle of the Olympic Games as a competition weapon. The competing rivals purchased Olympic sponsorship in turn, as a means to exclude each other from the marketing opportunities related to the Olympic Games (Finnerty 2000).

For those who engage in sponsorship activities, such companies focus on whether or not their competitors will benefit from the events at their expense. Thus their commercial rivals' ambush marketing (either by intrusion or by association), will irritate the former, and hamper them achieving the competitive advantage they expect. Competition, however, is the designed function of the sponsorship and accordingly does not provide a legitimate reason for regulating ambush marketing. Arguably, it is these deep pocketed sponsors who push events owners such as the IOC most to take tight approach in regulating ambush marketing.

Part Two Evidence of the existence of audience confusion and association

The existence of the audience confusion and association will in theory be detrimental to the sponsorship function. In reality, do the incidents which are categorised as ambush marketing by the events owners give rise to such mental reaction of the audience? To search for the answer, this article will analyse the ambush marketing incidents which happened at the Athens 2004 Olympics.

The incidents adopted in this article were collected by the Athens Olympics Organising Committee (ATHOC) with the guidance from the IOC. There are three reasons for adopting the ATHOC collection. First, Athens 2004 was an international mega sporting event with good global image[8] and great exposure in terms of the audience number[9] and was a primary and lucrative target for ambush marketers. Second, as the most important event owner in the world, and a long term active advocate for ambush marketing control, the way that the IOC identify ambush marketing incidents is presumably a benchmark for other event owners. In other words, the incidents which are categorised as ambush marketing by the IOC are likely to be taken as so by other events owners such as FIFA. Last but not least, there was a powerful and sophisticated monitoring and reporting system for capturing ambush marketing incidents at the Athens 2004.[10]

Altogether, ATHOC has collected *** incidents among which *** have been categorised as ambush marketing. Due to the confidential nature of this collection[11], details of the individual incidents which are not in the public domain will not be mentioned[12].

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[8] Mintel (2004) research showed audience view positively the companies who sponsor the Olympics.
[9] This is evident from the audience base (number) of the Olympic Games.
[10] The monitoring and reporting system of the Athens Olympics consisted of three strategies: monitoring by the Brand Protection Office (BPO); outdoor violation monitoring and television monitoring. The BPO was responsible for branding protection. Regardless of the type of ambush marketing incidents, all the branding protection matters were handled by the BPO. The Outdoor Violation (monitoring) Section monitored all the advertising billboards and banners within the exclusion zone and the TV (monitoring) section monitored the broadcasting by all Greek television channels.
[11] The author has signed the confidentiality agreement with the IOC in order to access this collection.
[12] For some incidents which were widely reported by the media, the author will not be restricted by the terms of the confidentiality agreement.

Analysis methodology: average viewer

The incidents will be analysed through the perception of the "average audience/viewer" to assess in each individual incident whether the alleged ambush marketing will generate the confusion or association on the part of average audience. This test is modelled after the test of "average consumer" which is widely adopted in the law regarding trade mark and misleading advertising in the European courts and the courts of its member states.

"Average consumer" is an extension of the "reasonable man" test adopted in Torts. The courts create a notional individual, "average consumer", as a yardstick, and make assessment through the perception of this individual. It is a normative way of making assumptions about the possible opinion of the public (Pfluger 2008). At the early stage, the test was largely used in cases involving misleading advertising. However, by the late 1990s, the test has been increasingly adopted in trade mark cases (Davis 2005).

Although the attributes of "average consumer" on the whole are often criticised as ambiguous (Bently 2009), the test has been stably applied since the late 1990s in the case law involving the assessment of the distinctiveness of trade mark and the likelihood of confusion. Through this process certain characteristics of the "average consumer" has clearly emerged. In *Gut Springenheide*,[13] the case which is "generally cited as having given authoritative birth to the hypothetical average consumer" (Davis 2005), the notional individual was expected to be reasonably well-informed and reasonably observant and circumspect[14]. Such presumed expectations of an average consumer have been adopted by ECJ when assessing the distinctiveness of a shape mark in *Philips*.[15] In *Sabel*[16], ECJ confirmed "the perception of marks in the mind of the average consumer of the type of goods or services in question plays a decisive role in the global appreciation of the likelihood of confusion", and then carry on to assume that "the average consumer normally perceives a mark as a whole and does not proceed to analyse its various details." [23] In *Lloyd*[17], ECJ further elaborates that "average consumer only rarely has the chance to make a direct comparison between the different marks but must place his trust in the imperfect picture of them that he has kept in his mind". The court also decided that "the average consumer's level of attention is likely to vary according to the category of goods or services in question" [26].

Through the average consumer test, the court put itself in a position of being capable of making the decision itself. The judges base their decision making competence on their pragmatic experience. In the assessment of deception in competition law, judges rely on not only their personal participation in the market as a member of the relevant public, but also the insights they obtained in previous proceedings, by decisions by other bodies, and by the market observation that unavoidably takes place continuously for competition-law purposes (Eichmann 2000). Similar type of pragmatic experience

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[13] [1998] E.C.R. I-46577 (ECJ).
[14] Ibid, [31].
[15] *Koninklijke Philips Electronics NV v Remington Consumer Products Ltd* [2002] 2 C.M.L.R. (ECJ) [52], [65].
[16] *Sabel BV v Puma AG, and Rudolf Dassler Sport* [1998] 1 C.M.L.R. 445 (ECJ).
[17] *Lloyd Schuhfabrik Meyer & Co GmbH v Klijsen Handel BV* [1999] 2 C.M.L.R. 1343 (ECJ).

also underpinned the judges' decision making competence for dealing with other type of cases such as trade mark ones. Therefore the judges can make decisions themselves, and "save in these particular cases, it was sufficient to judge the expectations of the average consumer, 'without ordering an expert's report or commissioning a consumer research poll'" (Davis 2005).

The average consumer test has been widely applied in the cases involving trade mark and misleading advertising. In trade mark field, the test has become a mature approach for courts to make assumptions about the public opinions and the courts has imposed some clear default characterises on the notional individual. The judges make decision based on their pragmatic experience without acquiring external evidence, the utility of the average consumer test is evident. This is an important reason why average audience/viewer, an equivalent test to the average consumer test will be applied for analysing the Athens collection of ambush marketing incidents. In *New Zealand Olympic and Commonwealth Games Association Inc v Telecom New Zealand Ltd*,[18] a New Zealand high court decision involving ambush marketing, the court in effect applied the test of an average reader.

Average viewer test vs. Surveys

Relying on the judges' pragmatic experience to make decisions show the utility of the average consumer test. On the other hand, it renders this test to be potentially biased in that the decisions are based on "judicial common sense". Judges are idiosyncratic owing to their education and class position and their perception does not necessarily reflect the public opinion in reality (Davis 2005). By contrast, empirical methods through which judges make their decisions based on representative data and on legally relevant facts (Pfluger 2008), seemingly overcome the weakness of the average consumer test.

Judiciary has provided justification of applying average consumer model in Lord Diplock's judgment in 1972 in *GE Trade Mark*[19]. According to Lord Diplock, in assessing the likelihood of deception or confusion in relation to goods which are normally sold to the general public, the judge's approach should be the same as that of a jury, since, "[h]e too, would be a potential buyer of the goods". The judge, "should of course be alert to the danger of allowing his own idiosyncratic knowledge or temperament to influence his decision, but the whole of his training in the practice of the law should have accustomed him to this, and this should provide the safety which in the case of a jury is provided by their number" (Lord Diplock 1972 cited Davis 2005). Later the Courts of Appeal in *Reed Executive Plc v Reed Business Information Ltd*[20] suggests average consumer test conforms to the reality the same way as the empirical methods do. There after admitting the difference between the average consumer model and the substantial proportion test involves a statistical assessment, Jacob LJ came to the conclusion that "in the end I think they come to the same thing. For if a "substantial proportion" of the relevant consumers are likely be confused, so will the notional average consumer and vice versa". These comments can also be

[18] [1996] F.S.R. 757 (New Zealand High Court)
[19] *GE Trade Mark* [1972] F.S.R. 225(HL).
[20] [2004] R.P.C. 40

elaborated as that the two different approaches can be reconciled. Indeed, ECJ's judgement in *Philips*[21] accepted the coexistence of both approaches [65].

Case law in the trade mark field since the late 1990s shows the average consumer test is a widely acceptable within the European judiciary. In fact, the European courts still favours the test more than empirical methods although they have not ruled out the application of the latter. Empirical methods were traditionally popular in the USA and Germany. In *Gut Springenheide*, ECJ recommended the German legal practice should adopt average consumer test as a new approach instead of the traditional empirical methods of "ordering an expert's report or commissioning a consumer research poll" [31]. Although the application of empirical methods haven't been ruled out [33, 35 and 36], it is only where it has particular difficulty in appraising the misleading nature of the brand name that, national court should employ empirical methods as guidance for its judgment [22].

Since *Gut Springenheide*, average consumer model has become "a uniform criterion of general application" for determining the misleading nature of advertisement[23]. The ECJ's judgement in *Estee lauder* followed this approach. In *Mag Instrument*, Advocate General Colomer decided since the assessment of distinctiveness of a sign can be assessed on the basis of average consumer model, "it would seem to be unnecessary to undertake further investigations, analytical or comparative studies, expert's opinions or statistical research". He added "nor, further, do any of those forms of evidence by their existence relieve the Examiner or the Court of the need to exercise their own discretion based on the yardstick of the average consumer as defined by Community law"[24]. In this case, ECJ upheld the CFI decision that the survey evidence is not suitable for assessing the inherent distinctiveness of a sign. It is submitted that this finding narrows the circumstances in which survey evidence would be accepted by the court in any event (Davis 2005).

Based on the experience from the trade mark field, the author believes that carefully designed and applied average audience/viewer test should be able to overcome the idiosyncrasy of the researcher and accurately assess the existence of the audience confusion and association in the way that reflects the opinion of the audience. Being aware of the fact that a survey conducted among the audience is the straight forward way of finding out whether an individual case generates audience confusion or association, the author also explored the possibility of applying the empirical methods for the assessment. The experience from the trade mark field has been drawn on and the current popular method in the marketing field has been examined.

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[21] *Koninklijke Philips Electronics NV v Remington Consumer Products Ltd*(Case C-299/99) [2002] 2 C.M.L.R. 52

[22] *Estee Lauder Cosmetics GmbH & Co OHG v Lancaster Group GmbH* [2000] 1 C.M.L.R. 515 (ECJ) [note 47]. In *Sektkellerei Kessler* the Court, citing paras [35] to [37] of its judgment in Gut Springenheide, also expressed reservations as to their utility: "It is only where it has particular difficulty in appraising the misleading nature of the brand name that, in the absence of any Community provision on the matter, the national court must assess whether it is necessary, under the conditions laid down by its national law, to decide upon measures of enquiry such as an expert's report or a consumer research poll as guidance for its judgment …."

[23] *Mag Instrument Inc v Office for Harmonisation in the Internal Market (Trade Marks and Designs)* (C-136/02 P) [2004] E.T.M.R. 71(OHIM) [AG45]

[24] Ibid, [AG 48]

While the European courts recognise that surveys that are impeccably conducted have the probative value, in many cases the survey evidence were not accepted by the courts because they fail to meet the required standard of the quality (Niedermann 2006). Although the difficulty of meeting the required quality standard of survey should not become the reason why survey should not be adopted for making assessment in cases such as the Athens collection of ambush marketing incidents, the amount of the job needed for conducting surveys involving *** incidents the majority of which happened in Greece back in 2004 renders survey and in fact empirical methods in general an impractical choice.

"Recall and recognition", is a test which enjoys wide corporate popularity for testing the effectiveness of sponsorship function and of ambush marketing. This test is conducted through a survey among the audience and investigates the dimensions of recall and recognition. Normally one series of questions simply asked respondents to list the sponsors in various product categories (i.e. recall). Another series of questions listed a few companies in a product category and asked respondents to check those which were official sponsors (i.e. recognition). Among the outlined companies, one is the sponsor, one is an ambusher and the others will be neither (Sandler and Shani 1989).

This method, however, is not suitable here. First it can't measure the existence of audience' association with ambusher. When association arises, it simply means that ambusher intrude upon the consciousness of the audience but audience know the ambusher had nothing to do with the event and just take the chance to win some exposures. Therefore, in the recall section, audience would not put the ambusher's name as sponsor. Second, this method is not designed to measure the effectiveness of some specific ambush marketing incidents in terms of generating association and confusion, which are the purpose of the current research. The method was however designed to measure the effectiveness of sponsorship function and of ambush marketing in general.

Average audience/viewer

Applying the average viewer test is an intuitive process. The same way that judges apply average consumer test in competition law and trade mark law field, the researcher has to rely on her pragmatic experience based on the personal experience as a viewer to the Athens Olympics and insight obtained in researching ambush marketing, in particular, by decisions by the courts, by empirical studies conducted in the marketing field, and by the observation of behaviour of ambush marketers and sponsors.

By applying the average viewer model, the researcher bears in mind Lord Diplock's warning and is "alert to the danger of allowing [her] own idiosyncratic knowledge or temperament to influence [her] decision." After researching ambush marketing for eight years, the researcher is very familiar with the sponsorship structure of the Olympic Games and the strategies that ambush marketers normally adopt. When analysing each individual incident of the Athens collection, the researcher will put such knowledge aside, and assess the existence of the likelihood of confusion and association from the perception of "a substantial number of members of the public who did not share my idiosyncratic knowledge"[25].

Based on the previous case decisions and empirical studies conducted in the marketing field, the researcher has developed some characteristics of average viewer as follows. First, the attention level of the average viewer towards alleged ambushing message is not high. In *New Zealand Olympic and Commonwealth Games Association Inc*,[26] the defendant published a newspaper advertisement, which played on the Olympic symbol. The advertisement consisted of the word RING five times replacing the five circles of the Olympic symbol in the same colour and position respectively. Underneath it said, "with Telecom mobile you can take your own mobile phone to the Olympics". Putting himself in the shoes of the average reader, Justice McGechan observed, "Those who read newspaper advertisements tend to browse. They will not be reading advertisements in a closely focused way, at least in the first instance." Although the average reader will understand the advertisement is a play with the Olympic symbol and be amused, "it is a long way from that brief mental process to an assumption that this play on the Olympic five circles must have been with the authority of the Olympic organisation, or through sponsorship of the Olympics."

Second, average viewer in general lacks sponsorship knowledge. The researcher agree with the argument of Sandler and Shani (1998) that "[a]mbush marketing can be a successful tactic only when consumers are not well informed about who are the official sponsors, what are their rights, and what is the role the sponsors play in staging the Olympic Games." (p.370). Olympic Games' sponsorship is complicated system consisting of several layers at the IOC level, organising committee level and national committee level. At each level there are different types of sponsors.[27] The whole Olympic sponsorship system is like a maze to the public. Therefore average viewer is not supposed to correctly identify sponsors or have knowledge about their specific contribution and rights.

Third, average viewer is supposed to have some amount of the viewship of the Athens Olympics through any major media but not a heavy viewer. Survey conducted by Sandler and Shani (1989) showed the audience's ability to both recognise and recall the sponsors varied directly with their TV viewship of the games. Heavy viewers are more capable to correctly recognize and recall the sponsors than light viewers. Accordingly heavy viewers are less likely to be confused by ambush marketing

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[25] *GE* n19 [236] (Lord Diplock).

[26] n18.

[27] For example, at the IOC level there are two types of sponsors: The Olympic Partnership (TOP) and Official Supplier. The former is operated on the principle of the product-category exclusivity, namely exclusive sponsors in their business sectors worldwide and are granted the rights to the specified Olympic intellectual property and Olympic marketing opportunity in return for their contributions of products, services, technology, expertise and financial resources to the Olympic family. The latter was designed to provide the IOC with key support and products required for operations and received relatively limited marketing rights. Athens Olympic Organising Committee ran the domestic sponsorship programme, which consisted of three tiers of sponsors: Grand National sponsors, Supporters and Suppliers/providers. This programme granted marketing rights within Greece only. It primarily focused on fulfilling the many specific operational needs of the ATHOC during the planning and staging of the Games. In addition, it also supported the Greek Notional Olympic Committee and Greek Olympic team.

message than light viewers. Viewship is thus a factor that affects the assessment of the average viewer's confusion. Today (and also back in 2004 when the Athens Olympics were staged) TV remains one of the main media alongside internet, newspaper and radio for the public to access the Olympic Games. For the purpose of the analysis in the article, all these type of media will be taken as major media for the average viewer.

Forth, there is no assumption of demographics factors of the average viewer such as gender, age, income and education. This is based on the experience of constructing average consumer model in trade mark field. There the courts have discarded the class assumption of the average consumer, which often manifests itself in the assumption of average consumer's income and education. The courts instead pay more attention to the nature of the products concerned (Davis 2005). The study by Sandler and Shani (1989) also confirmed that age, income and education level did not account for differences in ability to correctly identify sponsors.[28]

Based on the common ambush marketing strategies and the possible defence argument that an ambush marketer might have, the guidelines have been set up in the following seven aspects regarding how to assess the effect of ambush marketing on an average viewer in the circumstances as outlined. First, absence of express claims to official sponsorship does not provide the safety net for the ambush marketer by excluding the possibility of the existence of average viewer's confusion. This element, in *New Zealand Olympic and Commonwealth Games Association Inc*, was categorised as not a strong factor in deciding whether audience confusion will be caused. Justice McGechan was not convinced that "whether any average reader who did by chance wonder whether the advertisement was authorised by the Olympic Association would consciously look for a sponsorship claim, notice there was none, and proceed to reason Telecom was therefore not claiming to be a sponsor."[29] In his view, it is not "the causal reality of the newspaper reader" but rather "an analytical process which appeals in hindsight to lawyers".

Second, humorous nature of ambush marketing message does not help to exclude the possibility of confusing average viewer either. In *Irvine v Talksport Ltd*,[30]the claimant, a celebrity Formula One racer, sues the defendant, a radio station, for passing off based on the fact that defendant has used his manipulated image on the cover of its promotion brochure, which according to the claimant suggests his endorsement to the defendant. One of the defendant's arguments was that "The manipulated image was designed to amuse the target audience" [31]. In his judgement, Parker LJ concluded that "The fact that the whole Formula One pack may have been intended as a joke, and may well have been perceived as such by recipients of it, seems to me to be nothing to the point. In particular, the humorous nature (if that it be) of the image on the front of the leaflet does not seem to me to affect the question whether the impression which

[28] However, there are contradictory findings by Sandler and Shani (1989) and Gardner and Shuman (1987) regarding whether gender is a significant variable. The contradiction is also a reason why the researcher does not take gender into account when constructing the average viewer model.
[29] This also implies that the attention level of audience in the view of Justice McGechan is not very high.
[30] [2003] F.S.R. 35 (CA)
[31] Ibid, [26]

the image gives is that Mr Irvine has endorsed Talk Radio." [32] Accordingly, the humorous nature of ambush marketing message will not be taken into account when assessing whether average viewer will be confused or not.

Third, the clear use of the Olympic symbols or words will cause average viewer's confusion. The survey conducted by Sandler and Shani (1998) following the 1996 Atlanta Olympics found out that 86.5% of the respondents knew it was the sponsors' right to the Olympic symbol. Till today, it is still common sense for the public that it is customary practice for the sponsors to use Olympic symbols and words. In *New Zealand Olympic and Commonwealth Games Association*, Justice McGechan commented that the defendant's play of the Olympic symbol will not confuse average reader because "[i]t quite simply and patently is not the use of the five circles as such". This comment implies he would view the use of the exact Olympic symbol as causing confusion to average reader. Indeed, regarding what would cause the confusion, he gave the example of "five actual circles in the advertisement caricatured in some way, as, for example, with little animals swinging from the tops or peering out". Similar to the five circle Olympic symbol, the emblem for Athens Olympics had been widely recognized by the public as an exclusive representation to Athens Olympics through the heavy promotion of ATHOC since its birth and presumably enjoyed the same status as the Olympic symbol in the mind of average viewer. Therefore, the use of the Athens Olympics emblem will be assumed to be likely to confuse average viewer.

However, the way that the Olympic symbol and the Athens Olympics emblem were used will be taken into account when assessing the effect of the use on the average viewer. It is only when the use by ambush marketers was in the same way as by the sponsors, there will be assumption of confusion on the part of the average consumer. Other use, such as producing a promotion brochure for the Games with the Olympic symbol on it and advertising the company inside the brochure as well, would certainly cause association but not necessarily confusion on the part of average consumer.

Forth, the use of other Games related images and words will not be taken as to confuse average consumer. These include words such as "Athens 2004", "Games City", "gold medal", "sponsorship" and images such as torches and laurel wreath. These type of words and images give the public association with the Athens Games especially during the Games time. Indeed, Greece has outlawed the use of Athens 2004 through its special legislation for the Games[33] and UK has outlawed the use of the words such as Games city and gold medals[34]. These words and images on the other hand have the generic nature in that they have been in the public domain for a long time and have not been the exclusive representation of the Games. Therefore the public would not be likely to think it is the sponsors' exclusive right to use such words and images. Likewise, the use of athletes' image would not be likely to confuse

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[32] Ibid, [81] In *New Zealand Olympic and Commonwealth Games Association*, although Justice McGechan concluded that the defendant's manipulation of the Olympic symbol would amuse the average reader without confusing him/her, the judge didn't comment whether the humorous nature of the defendant's advertisement could be a defense. Therefore the judgment in this case is not contradictory to the *Irvine* case.

[33] Article 3 of law 2598/1998 as supplemented and amended by virtue of article 2 of law 2819/2000 and article 16 para.2 and 3 of law 2947/2001

[34] London Olympic Games and Paralympic Games Act 2006

the average viewer. Celebrity athletes would probably remind the audience of the Games especially during the Games time.[35] Thus when ambush marketer run an advertising campaign featuring high-profile athletes, average viewer would naturally understand the ambush marketer were referring to the Games but it is a long way from this stage to an assumption that the use must be authorized by ATHOC or through the sponsorship.

Fifth, companies who win the exposure within the clean zone are viewed to cause association rather than confusion on the part of the average viewer. Olympic games has a conventional clean venue policy, according to which no commercial message especially the message from non sponsors will appear in clean zone, normally referring to the stadium or areas surrounding the stadium. Ambush marketer's exposure is not likely to mislead average viewer into thinking they are supporting the Games somehow although the association on the part of average viewer is inevitable. Therefore, the related ambushing strategies such as dressing some inside venue audience with branded clothing or clothing which represent the company image such as Brava's famous orange mini dress cheering squad at South Africa FIFA world cup 2010, or distributing branded materials such as hats or flag to inside venue audience before they entered the venue, will be taken to cause association but not confusion of the average viewer.

Sixth, the use of the tickets for ambush marketing purpose will be treated to cause association rather than confusion on the part of the average viewer. Tickets have been a popular tool for ambush marketers to promote their company image or products. It is not surprising that both UK and New Zealand have included clauses for ticket control in their anti ambushing special legislation.

Seventh, incidents involving that sub category sponsors exceed their sponsorship rights will not be treated to cause confusion on the part of average viewer although sub category sponsors ambushes the main category sponsors (Meenaghan 1998). This is because the public do not understand the specific rights of each sponsorship category and therefore they are not likely to be confused.

On the whole, the threshold for the existence of confusion is much higher than that of association. Winning the exposure through and making reference to the Games will be taken as causing association on the part of the average viewer. Based on the above guidelines, the total ***[36] incidents have been analysed. Among them, **** were identified as ambush marketing incidents by the IOC. *** do not contain sufficient details and are not usable for the analysis. For the rest, *** are likely to confuse average viewer and **** have generated association on the part of the average viewer.

Part Three

Reflection in special legislation

[35] Quantas's advertisement featuring Cathy Freeman, the famous Australian athlete, round the Sydney Olympics time was an example that proved the effect of this type of ambush marketing strategy.
[36] The disclosure of such numbers is the in the process of waiting for the IOC approval.

The analysis result of the ATHOC data shows that IOC/ATHOC intended to regulate not only ambush marketing by association which gives rise to audience confusion but also ambush marketing by intrusion which gives rise to audience association. This intention is also reflected in special legislation for ambush marketing control, the enactment of which is strongly influenced by the IOC and Organising Committee of the Olympic Games.

Take the example of London Olympic Games and Paralympic Games Act 2006, the British Special legislation for London Olympics in 2012.[37] London Olympic association right is created by Schedule 4 of the Act to prohibit the unauthorised use of any representation (of any kind) in a manner likely to suggest to the public that there is an association between the London Olympics and goods or services or a provider of goods or services (paragraph 1(1) of Schedule 4),. The concept of association has not been defined, but four types of relationship have been stated as examples of association: contractual relationship, commercial relationship, corporate or structural connection, and the provision by a person of financial or other support for or in connection with the London Olympics (paragraph 1(2) of Schedule 4). These examples are all a kind of concrete or materialised connection between the alleged infringer and the London Olympics. Hence the concept of association within Schedule 4 seemingly indicates a concrete link with the London Olympics and accordingly targets at preventing ambush marketing by intrusion. In other words, London Olympic association right covers only ambush marketing which gives rise to audience confusion regarding the relationship between the ambush marketer and the Games.

However Paragraph 3 of Schedule 4 which states the infringement of London Olympic association right indicates the Act also intends to catch ambush marketing by intrusion which gives rise to audience association. Paragraph 3 (1) of Schedule 4 the Act states the courts may take account of the use of specific expressions outlined in Paragraph 3 (2) and (3) when assessing whether London Olympic association right is infringed. The infringement use is the use of combinations of expressions of the first group with expressions of the second group or other expressions of the first group (Paragraph 3 (2)). The first group consists of four expressions, namely, “games”, “Two Thousand and Twelve”, “2012”, and “twenty twelve”. The second group consists of seven expressions, namely, “gold”, “silver”, “bronze”, “London”, “medals”, “sponsor” and “summer” (Paragraph 3 (3)). The combinations such as 2012 summer and games medals are thus all under the protection. As explained in Part Two the use of such generic words will cause audience association but not necessarily confusion.

Although the Act use the word “may” in Paragraph 3 (1) suggests there is only a possibility that use of such words will constitute infringement, the use is actually deemed infringement according to the explanation by London Olympics Organising Committee (LOCOG). In theory LOCOG’s explanation has no authority in courts, but as the driving force for the enactment of this Act, LOCOG’s explanation actually reveals what the Olympic Games owner and organisers expect this Act to cover.

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[37] There are two pieces of statutes which address the issue of ambush marketing in the UK. London Olympic Games and Paralympic Games Act 2006 (UK) was enacted for London 2012 Olympic Games. Section 33 creates London Olympic association right which is explained in Schedule 4.

Section 19 and Section 25 of the Act 2006 grant the Secretary of State the power to make regulations about advertising and trading in the vicinity of London Olympic events. Accordingly Advertising and Street Trading Regulations are expected to come into force in late 2010 or the beginning of 2011. The regulations are also expected to specify clean zone or clean venue, which are the areas around the events venue and are free from any commercial messages of non-sponsors. Section 31 makes the unauthorised sale of an Olympic ticket criminal offence. The regulation of ticket sale aims at stopping any party using tickets as a tool to commit ambush marketing. Again, as discussed in Part Two, ambush marketing involving clean venue and tickets in general just cause audience association rather than confusion.

The IOC's intention to catch ambush marketing by intrusion which gives rise to audience association probably represent that of all mega sporting events owners such as The Fédération Internationale de Football Association (FIFA) and ICC. Indeed, special legislation enacted in New Zealand[38] and South Africa[39] for the staging of mega sporting events other than Olympic Games casts wider net to catch more types of ambush marketing strategies which could give rise to audience association.

Clearly events owners such as the IOC want to regulate both ambush marketing by association and ambush marketing by intrusion. The former as mentioned in the introduction can be dealt with existing laws such as common law tort passing off or unfair competition law. Take the example of passing off. To apply it, three elements need to be proved: goodwill, misrepresentation and damage. The first element, goodwill in mega sporting events is quite obvious. When an ambush marketer creates the impression to the public that the company has sponsored or supported the event, misrepresentation can be proven. The damage is harm that has done to the sponsorship functions and consequently event's sponsorship scheme as analysed in part two. This tort in theory is suitable for dealing with ambush marketing by association. There is no need to look for new regulatory tools. All that needs to be done is to enhance the courts' understanding regarding what type of ambush marketing activities trigger off the public confusion.

What is problematic is how to regulate ambush marketing by intrusion. In effect, a fundamental question is: Is the regulation of ambush marketing by intrusion well justified? if so, can it be regulated? As mentioned in the introduction, the legislation attempts the host countries have made so far has attracted criticism for being the overreach of IP law and even infringing the human rights of commercial freedom of speech (Longdin 2009 and Cobett and Roy 2010). The following will examine first the justification of the protection from ambush marketing by intrusion that is conferred to the events owners.

To discourage the consumer conception is a well accepted purpose of IP law but it is not the case for regulating consumer or the public association. The closest example for such purpose is trade mark dilution law. "Dilution is an evocative umbrella term for a range of non-confusing yet proscribed associations between signs." (Burrell and Gangjee 2010). Dilution deals with the association which is detrimental to the distinctiveness or repute of the trade mark. Association is an essential element in

[38] See, Major Events Management Act 2007 (New Zealand) (MEMA 2007)
[39] See, Merchandise Marks Amendment Act 2002 (South Africa)

dilution. In *Adidas-Salomon AG v Fitnessworld Trading Ltd*[40], ECJ decided to an element required by Art.5(2) of Directive 89/104, the dilution provision in the EU trade mark directive, is that "the relevant section of the public makes a connection between the sign and the mark, that is to say, establishes a link between them even though it does not confuse them" [27]. Such link is understood as association in broad sense as defined in *Sabel* ,"where the public considers the sign to be similar to the mark and perception of the sign calls to mind the memory of the mark, although the two are not confused" [16].

However trade mark dilution law has struggled to find a suitable justification. The dilution law protects the advertising function of the trade mark[41]. Trade mark owner's investment in building up the brand value of the trade mark seems to be a ready justification at the first glance. However, IP law does not protect the investment alone and the public good that will be brought by this protection needs to be proved as well (Longdin 2009). Dilution law fails to provide a satisfactory answer regarding how it contributes to public good. So will be the regulation of ambush marketing by intrusion. Although the investment in building up the Olympic brand is easy to prove, the contribution to the public interest through this regulation is a difficult question for host countries to answer.

A common justification for dilution law is dilution as free riding. This justification, however, is also ill founded. As Burrell and Gangjee (2010) point out, in real markets not all positive externalities are compensated for. They give the example that "the person who invests time and money in developing an attractive garden receives nothing from neighbouring property owners who benefit from owning a house on a 'well kept street'". More importantly, "It is not enough to demonstrate that free riding has occurred; it must also be demonstrated that *legal intervention promotes efficiency taking account of transaction costs, imperfect information, etc*". To demonstrate such efficiency, an empirical question needs to be answered but it is difficult to both calculate the effects of antidilution protection and to make the case "that in the absence of dilution protection there is likely to be an underinvestment in the development of new brands is likely to prove particularly difficult given the benefits that inevitably accrue to the owners of famous marks".

There is similar difficulty to apply the justification of ambush marketing by intrusion as free riding. How can we calculate the benefits of regulating this type of ambush marketing? Also, how can we make the case that in the absence of such regulation (which the mega sporting events have already started either through legislation or practical strategies such as contractual dealings) there is likely to be an underinvestment in sponsorship scheme? Therefore, free riding justification will not suit the regulation either.

Moreover, there is difference between the dilution law and regulation of ambush marketing by intrusion, which poses more challenges for the regulation to find a justification. Dilution protection conferred to the trade mark owner to prevent consumer association has its constraints built in to prevent the over expansion of the protection. In the EU trade mark law, these constraints are revealed as being

[40] [2004] E.T.M.R. 10
[41] To the effect, see Schechter (1927).

detrimental to or taking unfair advantage of the repute or distinctiveness of the mark. These are the requirement that trade mark owners have to meet in order to qualify for the protection to stop the consumer association. In *Intel*,[42] a trade mark dilution case, ECJ endorsed the approach of Jacob L.J. that a powerful mark should not be protected against all use by third parties, especially if such use did not affect its distinctiveness in relation to the goods against which it was used. For the regulation of ambush marketing by intrusion, what damage that event owner can prove in order to prevent the audience association? Without a constraint what the regulation is trying to achieve is the protection from pure audience association. There is no such precedent in IP law. In this sense, the criticism that the regulation is the overreach of IP law is well founded.

Judiciary capability of regulating ambush marketing by intrusion

Besides the problem of justifying the protection conferred to the event owner. The regulation faces another problem of finding a manifestation for the brand for the events. Although IP law protects the intangible assets, each type IP law actually has its tangible manifestation. For trade mark, the manifestation is the mark. For patent it is the invention. For design it is the outlook of the products. For copyright, it is the expression of the ideas. These manifestations are the basis of the protection. Therefore trade mark protection provides the monopoly of the use on the products and so on.

According to the IOC, regulation of ambush marketing in general is to protect the value of Olympic brand. Widely accepted comments are that regulation of ambush marketing, in particular ambush marketing by intrusion, is to protect the goodwill and the publicity value of the event which attracts the sponsorship investment. No matter what it is called: brand value, goodwill or publicity, what remains unclear is what is the manifestation of such valuable thing that the events owners endeavour to protect? Take the example of the Olympic event. Clearly the Olympic symbol alone, the five circles, can't represent the manifestation of the Olympic brand even though it is most valuable logo of the IOC. Lacking a manifestation of the value (brand, goodwill or publicity) makes the protection conferred to the event owners difficult to find its base. This is a technical problem that challenges the regulation of ambush marketing by intrusion. In order to find a manifestation of such value, legislations such as London Olympic Games Act 2006 create proprietary rights in so many words or images which might represent the events. As a consequence, many generic words such as Games 2012 have been taking out of the public domain without compensating the public.[43]

Conclusion

The prerequisite of the legal regulation of ambush marketing should be a sound justification of this regulation. The study of the sponsorship theory shows, in theory ambush marketing can cause either audience confusion or association, which can potentially damage the effectiveness of sponsorship. The analysis of the ATHOC collection shows the incidents that are categorized by the events owner do cause either audience confusion or association. The regulation of ambush marketing by

[42] Intel Corp Inc v CPM United Kingdom Ltd [2008] E.C.R. I-8823(ECJ).
[43] For similar criticism to MEMA 2007, see Cobett and Roy (2010).

association could be achieved through existing law such as passing off because of the existence of audience confusion. However the justification of regulating ambush marketing by intrusion is problematic and presents to be an overreach of the IP law. Lacking a manifestation of the intangible valuable assets that the regulation seeks to protect poses a technical problem which challenges the legislature's capability to regulate. The criticism that such regulation infringes the constitutional right of freedom of commercial speech is, albeit popular, of not discussed in this article. Since the legitimacy of protection to the event owner cannot be justified in the first place there is no need to resort to a constitutional tool for stopping the regulation.

Bibliography

Bently, L. and Sherman, B., 2009. *Intellectual property law*. 3nd ed. Oxford: Oxford University Press.

Burrell, R., and Gangjee, D., 2010. Trade marks and freedom of expression - a call for caution. IIC, 41(5), 544-569.

Corbett, S., and Roy, Y. V., 2010. Events management in New Zealand: one law to rule them all? J.B.L., 4, 338-362.

Eichmann, H., 2000. The present and future of public opinion polls in litigation in Germany: Part 1. IIC, 31(4), 408-420.

Eichmann, H., 2000. The present and future of public opinion polls in litigation in Germany: Part 2. IIC, 31(5), 530-559.

Kendall, C. and Metz, T., 2003. Ambush marketing and the Beijing Olympics: lessons from the Australian experience. *Intellectual property forum*, 55, 30-44.

Longdin, L., 2009, Public law solutions to private law problems: major event regulation subverts IP's internal balance. J.I.P.L.P., 4(10), 726-742.

Meenaghan, T., 1991. Sponsorship-legitimising the medium. *European journal of marketing,* 25 (11), 5-10.

Meenaghan, T., 1994, Ambush Marketing: Immoral or Imaginative practice. *Journal of advertising research*, September/October, 77-88.

Meenaghan, T., 1996. Ambush Marketing- A Threat to Corporate Sponsorship. *Sloan management review*, 38(1), 103-113.

Meenaghan, T., 1998. Ambush marketing: corporate strategy and consumer reaction. *Psychology & marketing,* 15(4), 305-322.

Meenaghan, T., 1998. Current Development & Future Directions in Sponsorship, *International journal of advertising*, 17(1), 20-21.

Mintel, 2004, the measure of the success http://www.marketingcollege.com/upload/Measure%20Success-Brand%20paper.PDF

Payne, M., 1998. Ambush Marketing: the undeserved advantage. *Psychology and marketing*, 15, 323-331.

Pfluger, A., 2008. Legal research in practice - empirical legal research and research into legal facts. IIC, 39(2), 198-210.

Sandler, D.M. and Shani, D., 1993. Sponsorship and the Olympic Games: the consumer perspective. Sport Marketing Quarterly 2(3), 38–43.

Schechter, F., 1927. The rational basis of trademark protection. *Harvard law review*, 40, 813-833.

Sleight, S., 1989. *Sponsorship: what it is and how to use it*. London: McGraw-Hill.

Sandler, D. and Shani, D., 1989. Olympic Sponsorship vs "ambush" marketing: who gets the gold? *Journal of advertising research, 29*, 9-14.

Sandler, D. and Shani, D., 1998. Ambush marketing: is the confusion to blame for the flickering of the flame? *Psychology and marketing*, 15, 367-383.

Townley, S., Harrington, D. and Couchman N., 1998. The legal and practical prevention of ambush marketing in sports. *Psychology and marketing*, 15, 333-348.

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Comparative Advantage and Intellectual Property Rights: Some Evidences from Creative Industries in Bhutan, China and Egypt[1]

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Views expressed in this paper are those of the authors and do not represent that of the organizations we work. Errors if exist are the responsibility of the authors. Comments and feedbacks are welcome and can be addressed to Zhen Ye via email to drzhenye@gmail.com

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1. Background to Creative Industries

Creative industries (CI) "are the cycles of creation, production and distribution of goods and services that use creativity and intellectual capital as primary inputs" (UNCTAD 2010). The notion that intellectual capital can be organized as a primary factor of production whereby various industries can be deemed 'creative' does not go without inviting academic scrutiny (Oakley 2004; Elliot 2007). In the UK where the idea conceived, as Labour government was voted out of the office and general business environment changed, 'creative industries' have lost much of its currency as an industrial policy tool. With the onset of the worst recession in decades, many cultural organizations and creative businesses which have only recently gone through a period of boom are found to be facing large budget cut and the withdrawal of supports by the government.

Elsewhere in the world, the contrast could not be more different. In the dynamic industries such as new media, game and performing arts, Germany is rising fast to challenge the traditional US leadership. In the developing world the concept is now increasingly taken up by the government to encourage creativity, entrepreneurship and innovation. China, for example, instituted first official Cultural and Creative Industries Development Plan to 'kick start' a nation-wide campaign, and began strategic reorganization of state owned enterprises (SOEs) in publishing and media, to be followed by capital market listing, Chinese firm such as Crystal CG has quietly entered the world stage of creative business after its debut in the grand opening of the Beijing Olympics. In India, increasing level of specialization has made India the world's largest exporter of handmade paper with 23 % of the world's export market share[4]. In spite of major instability, Afghanistan has become the 11th largest carpet exporter in the world with a 2 % of global share in export[5].

While creativity is and has always been a key force behind human progress, it can be argued that the concept of creative 'industries' offers a new lens through which one can examine and capture 'kaleidoscopic' combination and recombination of human ingenuity and organization. In the context of development, trade in creative goods such as handicrafts provides the least developed countries (LDC) with income generation and diversification opportunities from traditional agriculture. Trading a country's authentic material culture embodied in the form of traditional handicraft also gives voice to the nations (Barrowclough and Kozul-Wright 2007; Schultz and Van Gelder 2008) and has a great potential to transform skills into opportunity driven entrepreneurship and self empowerments (UNIDO 2011).

Based on recently released international trade data provided by UNCTAD's creative economy

[4] Computed by the authors from trade flow matrix based on UNCTAD Creative Economy Database.

[5] Ibid.

programme, this paper presents some preliminary findings of an ongoing study which aims to empirically assess, though at this stage very partially and limited, the relationships between revealed comparative advantage (RCA) and intellectual property rights (IPRs). While there is no shortage of academic literatures which pointed out the importance of IPRs to creative industries (Schultz and Van Gelder 2008), there remains few sector based, large scale, cross national study which investigates the relationship between RCA and IPR. While the research is ongoing to explore wider implication of IPRs for development, the focus of this paper is to present the result of empirical assessment on creative economy hence the focus is leaned towards understanding the overall performance of creative industries in the world and related comparative advantage of CI and its sub-groupings. Specifically, the paper looks at (1) trade dependency ratio in relation to CI, (2) revealed comparative advantage across 24 CI sub-groups and top performer, (3) local development issues pertaining to CI based interventions aiming at enhancing competitiveness.

The analysis is drawn from a 206 x 206 country to country trade flow matrix organized by 24 creative industries sub-groups to assess sectoral pattern of trade. The dataset for trade dependency ratio uses a smaller sample of 103 countries which reported on both trade in goods and services. The research has not been able to provided evidences on the linkage between RCA and IPR which would only be available with more time and efforts finding a suitable concordance between WIPO based statistics measure and UNCTAD's ISTC/HS systems. Future directions are discussed as to how to develop from this paper for the ongoing research and the difficulty to integrate WIPO based IPR statistics with UNCTAD's classification on creative industries[6]. The structure of this paper is as follows. The first part of the paper presents an overview of creative economy in terms of trade dependency and RCA. The second part of this paper looks at the RCA and sectoral pattern of CI trade in the cases of Bhutan, Egypt and China. The third part of this paper reflects on the findings from the field missions and discusses the potential of CI for development. The final part of this paper outlines further steps for the future research.

2. Creative Economy and Trade Dependency

UNCTAD's creative industries' classification is divided into three categories: (1) Trade in Creative Goods (CG), (2) Trade in Creative Services (CS) and (3) Related Industries (RI). Both (1) and (2) constitute 'core' creative industries in UNCTAD's classification which is different from UNESCO's systems of cultural statistics in terms of classifying 'core' vs. 'periphery'. CG data was sourced from UN COMETRADE whereas CS data was obtained from IMF's Extended Balance of Payment in Services (EBOPS). HS2002 is the relevant standard applied to trade in goods. Significant amount

[6] One key issue encountered on IPR statistics for creative industries points to the difficulty to obtain HS or ISTC corresponding/concordance tables with IPR classification systems such as IPC and Lucanno.

of data gathering have been presented using UNCTAD's statistical framework. Due to aggregation, UNCTAD did not disclose HS2002 code name or codes used to aggregate 24 sub-groups of CG or the quantity of goods traded as a result of aggregation. There are no separate CI based IPR statistics and IPR statistics are presented on the whole as related industries. A future 'wish list' is proposed by UNCTAD based on Central Product Classification (CPC) classification. The classification is shown in the table below. Appendix 1 provides more detail descriptions.

Table 1: Categories of CG and Number of Codes

Category & No. of Code Included	Sub-group	Sub-Code	Category & No. of Code Included	Sub-group	Sub-Code
Art Crafts (60)	Carpets	17	Design (continue)	Toys	17
	Celebration	2	New Media (8)	Recorded Media	6
	Other	6		Video Games	2
	Paperware	1	Performing Arts (7)	Music (CD, Tapes)	6
	Wickerware	4		Printed Music	1
	Yarn	30	Publishing (15)	Books	4
Audio Visuals (2)	Film	2		Newspaper	3
Design (102)	Architecture	1		Other Printed Matter	8
	Fashion	37	Visual Arts (17)	Antiques	3
	Glassware	5		Paintings	3
	Interior	32		Photography	4
	Jewellery	10		Sculpture	7

Source: author's compilation from UNCTAD 2010

UNCTAD data on CI provide an international base for assessing comparative advantage across the world. When triangulated with national account, it can help to examine the impact of CI based policy interventions on income and expenditure, investment and consumption, and can offer useful utility for trade policy analysis and modeling, for example, finding out whether export oriented promotional strategies targeting specific CI improves income. Trade policy analysis can also provide opportunities to align domestic interest for CI development with subsequent effort for nation branding/territorial marketing, and helping to spread a country's material culture abroad. Further potential exists for developing a CI based global input output table for trade policy modeling, and the identification of key linkage sector in the input output table as new growth engine (Ye and Yin 2011).

To assess the overall importance of CI, trade dependency (TD) ratio[7] is used to estimate a country's degree of reliance on CI (both CG and CS). Related industries (RI) are not included to avoid over-estimation[8]. The dataset contains 103 countries which reported on both goods and services categories. The table below shows countries with above average (2.8%) TD ratio. As revealed, it includes many European and developing as well as developed island economies. There is also higher level of concentration in top 10 for European countries from the central and eastern European (CEE) (Hungary, Czech, Slovenia and Moldova). Of top 10 countries include 7 European states (4 CEE plus Malta, Ireland, Netherland and Belgium) and 4 island economies (HK, Ireland, Singapore and Malta). Hong Kong's top position reflects a known phenomenon that it tends to channel a large part of trade in and out of China. More than half (23 out of 36 countries) presented below are European (12 from CEE). The list also contains many small developing island economies (French Polynesia, Netherland Antilles, Barbados, Jamaica etc). To what extent and in what specific CI grouping these countries have greater dependency is the focus of further studies.

Table 2: Trade Dependency (TD) Ratio (Above Average 0.028)

		TD CGS	TD CG	TD S			TD CGS	TD CG	TD S
1	Hong Kong	0.293	0.291	0.002	19	Fr. Polynesia	0.038	0.025	0.012
2	Malta	0.252	0.036	0.216	20	Macedonia	0.038	0.013	0.025
3	Netherlands	0.087	0.026	0.062	21	Latvia	0.037	0.022	0.016
4	Ireland	0.083	0.018	0.066	22	Austria	0.036	0.032	0.003
5	Belgium	0.069	0.035	0.034	23	Germany	0.036	0.017	0.019
6	Hungary	0.059	0.017	0.042	24	Serbia	0.034	0.013	0.020
7	Singapore	0.057	0.054	0.002	25	Lithuania	0.031	0.026	0.004
8	Czech	0.056	0.040	0.016	26	Canada	0.030	0.016	0.015
9	Slovenia	0.052	0.031	0.021	27	N. Antilles	0.030	0.026	0.004
10	Moldova	0.051	0.047	0.005	28	Barbados	0.030	0.030	0.000
11	Estonia	0.050	0.033	0.017	29	Mauritius	0.030	0.024	0.006
12	Luxembourg	0.048	0.018	0.030	30	Jamaica	0.030	0.022	0.008
13	Switzerland	0.047	0.047	0.000	31	New Caledonia	0.028	0.011	0.017
14	Croatia	0.044	0.020	0.024	32	Portugal	0.028	0.014	0.015
15	Bulgaria	0.042	0.022	0.020	33	Poland	0.028	0.017	0.011
16	Slovakia	0.040	0.027	0.013	34	Guyana	0.028	0.021	0.007
17	Cyprus	0.039	0.021	0.018	35	Portugal	0.028	0.014	0.015
18	Malaysia	0.039	0.020	0.019	36	Average	0.028	-	-

Source: UNCTAD 2010, based on 103 countries.

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[7] $TDR_i^c = \frac{X_i^c + M_i^c}{GDP^c}$, GDP, export and import are based on current prices and current exchange rates

[8] RI will be included to understand its potential for supporting CI.

Table 3 below further reports on TD ration for trade in CG. The world average is lower than total TD ratio (1.35%) for creative goods. Compares with the last table, many more developing economies from Asia, Africa, Middle East, Central and South America have joined.

Table 3 Creative Goods (CG) Trade Dependency Ratio

Rank	Country/Region	%	Rank	Country/Region	%	Rank	Country/Region	%
1	Hong Kong SAR	29.13%	23	Thailand	2.59%	45	Namibia	1.81%
2	Afghanistan	6.23%	24	French Polynesia	2.52%	46	EU	1.81%
3	U.A.E.	5.58%	25	Denmark	2.48%	47	Luxembourg	1.80%
4	Singapore	5.45%	26	Bosnia & Herzegovina	2.47%	48	Ireland	1.80%
5	Switzerland	4.69%	27	Mauritius	2.41%	49	Italy	1.76%
6	Moldova	4.65%	28	Tunisia	2.27%	50	Hungary	1.75%
7	Viet Nam	4.42%	29	Paraguay	2.25%	51	Poland	1.72%
8	Czech	4.02%	30	Lebanon	2.23%	52	Germany	1.69%
9	Macao SAR	3.91%	31	Zimbabwe	2.22%	53	Madagascar	1.65%
10	Malta	3.61%	32	Jamaica	2.20%	54	El Salvador	1.64%
11	Belgium	3.53%	33	Bulgaria	2.19%	55	Canada	1.60%
12	Maldives	3.35%	34	Latvia	2.16%	56	Romania	1.60%
13	Estonia	3.26%	35	Dominican Rep.	2.12%	57	Panama	1.56%
14	Austria	3.24%	36	Cyprus	2.08%	58	Bahamas	1.54%
15	Seychelles	3.17%	37	Guyana	2.06%	59	Dominica	1.45%
16	Slovenia	3.09%	38	China	2.06%	60	Taiwan	1.44%
17	Barbados	2.99%	39	Malaysia	2.04%	61	France	1.40%
18	Jordan	2.89%	40	Cambodia	2.04%	61	Belarus	1.38%
19	Slovakia	2.70%	41	Croatia	1.98%	62	Nicaragua	1.37%
20	Lithuania	2.64%	42	Sweden	1.92%	63	Portugal	1.35%
21	Net. Antilles	2.59%	43	United Kingdom	1.91%	64	The World	1.35%
22	Netherlands	2.59%	44	Montserrat	1.90%	65	Costa Rica	1.34%

Source: Calculated from 2008 trade flow matrix based on 2008 data from 2010 UNCTAD Stats Creative Economy Report; GDP measure is calculated from UNCTAD Stats Economic Trends; Using World Average 1.35% as a benchmark, the table shows those countries with Trade Dependency Ratio ＞or ≅ 1.35%.

Two most notable inclusions on the table above are Afghanistan and U.A.E. (6.23% and 5.58%) amongst two five. For Afghanistan, high TD in goods seems to suggest great potential for CI to play a leading role in the post-war reconstruction of the war torn Afghan economy. In the case of U.A.E., the country has become a key driving force for demand and supply in CI and a global creative hub for trading[9]. The rise of U.A.E. has important implication for the gulf region and demonstrates a successful case of diversification from the traditional petrol sector. Other MENA based countries on the list include Jordan, Tunisia and Lebanon. Amongst top 10 also includes Moldova and Vietnam. Full results for 103 countries are reported in Appendix 3 and 4. Given the importance of trade in creative goods for developing economies, further works are needed to assess the size of the sector and finding out key sector as well as specific sub-groups, and if they can be enhanced further for specialization and comparative advantage.

3. Revealed Comparative Advantage of Creative Economy

Since its first use by Balassa (Balassa 1965; Yeats 1985), Revealed comparative advantage (RCA) or Balassa index have undergone different revisions by successive authors (Aquino 1978; Bowen 1983; Yeats 1985; Vollrath 1991; Hausmann, Hwang et al. 2007; Amador, Cabral et al. 2011). The authors are not unaware of the limitation of applying the traditional Balassa index such as in dealing with unbalanced trade. At this stage, we calculate the traditional Balassa index[10] to assess the performance of RCA in 24 sub-groups of creative goods presented on 206 x 206 country to country flow matrixes. Further works will use other measures of CI to enhance empirical rigor and in consideration of unbalanced trade and other technical factors reported (Bowen 1983; Vollrath 1991; Amador, Cabral et al. 2011). Grubel-Lloyd (GL) index will also be used to detect the presence of intra-industry trade.

The table below reports top ten countries in 24 sub-grouping. Due to time constraints and the limit of space for presenting, RCA for 24 CI sub-groups is not presented but will be examined. As revealed by Table 4, art crafts, design and publishing are three product areas where developing economies have strong RCA, both in terms of numbers of countries represented and the strength of RCA measure. Afghanistan and Pakistan which have strong sub-grouping in carpet (art crafts) and fashion (design) also have higher level of bilateral trade in carpet and antique sub-groups. Afghanistan and Zimbabwe which reported high RCA value in visual arts show even higher RCA in the sub-grouping of antique. Top ten in performing arts still include mostly advanced economies. Both new media and audio-visual sub-groupings have more limited number of countries which have greater than one value for RCA but include large Asian emerging economies like China and India and some developing economies such as Thailand and Lebanon. Further research into sub-groupings are needed in order to find out reasons behind strong RCA in the countries shown under these seven categories

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[9] Abu Dhabi, for example, is building its own Louvre.

[10] $\mathrm{RCA1}_i^c = \frac{X_i^c / XT^c}{\sum_{c=1}^m X_i^c / \sum_{c=1}^m XT^c}$ Revealed Comparative Advantage or Balassa Index. X denotes exports in a sector, XT is total exports in a country, c (= 1…m) refers to countries and i (=1…n) refers to sectors. If RCA > 1, sector i in country c is said to have a comparative advantage in commodity or industry i, and vice versa.

Table 4	Art Crafts			Audio Visual			Design			New Media			Performing Arts			Publishing			Visual Arts	
1	Afghanistan	45.62	1	Canada	15.49	1	Pakistan	3.76	1	Hong Kong	4.95	1	Ireland	5.07	1	Canada	3.81	1	Zimbabwe	15.53
2	Moldova	9.46	2	Bulgaria	13.95	2	Hong Kong	3.59	2	China	3.82	2	Austria	4.94	2	Czech Rep.	3.16	2	Afghanistan	9.92
3	Tanzania	7.43	3	Italy	8.24	3	Viet Nam	3.37	3	Mexico	3.11	3	Sweden	3.18	3	Slovenia	2.93	3	Dominica R.	4.58
4	Turkey	6.72	4	Romania	3.66	4	Italy	3.10	4	Austria	2.64	4	Czech	3.16	4	Lebanon	2.86	4	U.K.	4.35
5	Pakistan	6.72	5	Argentina	2.58	5	China	3.08	5	Netherland	2.10	5	Netherlands	2.52	5	Sweden	2.40	5	Switzerland	3.83
6	China	4.20	6	Thailand	2.34	6	Dominican R.	2.49	6	Slovenia	2.04	6	Germany	2.36	6	Colombia	2.26	6	U.S.	2.66
7	Egypt	3.71	7	India	1.93	7	F. Polynesia	2.32	7	Czech	1.45	7	Singapore	1.80	7	Estonia	2.11	7	Rwanda	2.37
8	Viet Nam	3.27	8	U. K.	1.35	8	Lebanon	2.24	8	Germany	1.43	8	Luxembourg	1.61	8	U.K.	2.09	8	Palestine	2.01
9	Colombia	3.16	9	Tanzania	1.29	9	Lithuania	2.09	9	Latvia	1.42	9	Denmark	1.51	9	Serbia	2.00	9	China	1.58
10	Belgium	3.01	10	Greece	1.28	10	India	2.03	10	U.S.	1.26	10	U.K.	1.42	10	Belgium	1.81	10	France	1.55
11	El Salvador	2.51	11	Australia	1.16	11	Moldova	2.01	11	Macao	1.23	11	U. S.	1.29	11	Slovakia	1.76	11	Korea R.	1.06
12	Hong Kong	2.49	12	Lebanon	1.14	12	Romania	1.97		Bulgaria	0.75	12	Poland	1.22	12	Finland	1.66		Hong Kong	0.94
13	Latvia	2.05	13	Mauritius	1.06	13	Switzerland	1.95		Denmark	0.71	13	Lithuania	1.02	13	Poland	1.55		Pakistan	0.92
14	Madagascar	2.04		Spain	0.91	14	Palestinian	1.92		Bosnia & He.	0.61		France	0.93	14	Kenya	1.54		Viet Nam	0.82
15	India	1.99		Croatia	0.87	15	Turkey	1.85		Australia	0.59		Serbia	0.93	15	Hong Kong	1.50		Portugal	0.75
16	Palestinian	1.73		Armenia	0.83	16	Thailand	1.80		U.K.	0.59		Hong Kong	0.88	16	Spain	1.44		India	0.73
17	Korea	1.58		Mexico	0.82	17	U. A. E.	1.66		Slovakia	0.59		Bulgaria	0.84	17	France	1.44		Namibia	0.72
18	Sri Lanka	1.37		Portugal	0.66	18	Jordan	1.66		Singapore	0.58		Paraguay	0.82	18	Germany	1.43		Senegal	0.70
19	Taiwan, Cn.	1.35		Georgia	0.57	19	Poland	1.65		Sweden	0.42		Mexico	0.80	19	Italy	1.35		Bahamas	0.67
20	Philippines	1.23		France	0.55	20	Malta	1.45		Taiwan, Cn	0.39		Belgium	0.79	20	Peru	1.27		Canada	0.64
21	Thailand	1.20		Russia	0.55	21	Madagascar	1.42		Serbia	0.38		Tanzania	0.73	21	Austria	1.24		S. Africa	0.62
22	Estonia	1.17		U.S.	0.46	22	Armenia	1.42		Spain	0.34		Japan	0.71	22	Russia	1.17		Israel	0.59
23	Italy	1.13		Morocco	0.37	23	Denmark	1.42		Canada	0.29		Estonia	0.71	23	Switzerland	1.14		Singapore	0.58
24	Austria	1.12		N. Zealand	0.29	24	Bolivia	1.40		Lithuania	0.28		Hungary	0.71	24	Jordan	1.08		Belgium	0.57
25	Romania	1.11		Hong Kong	0.18	25	Estonia	1.39		Japan	0.25		Croatia	0.61	25	Lithuania	1.07		Zambia	0.57
26	Ecuador	1.03		Germany	0.17	26	Czech Rep.	1.26		Croatia	0.24		Macao SAR	0.61	26	Latvia	1.05		Italy	0.56
27	Bulgaria	1.01		Denmark	0.16	27	Bosnia & Hez.	1.25		Romania	0.22		Switzerland	0.58	27	Chile	1.05		Sri Lanka	0.52
	Mauritius	0.93		Belgium	0.16	28	Slovenia	1.23		Greece	0.21		Latvia	0.50	28	El Salvador	1.04		Germany	0.52
	Guatemala	0.91		U.A.E.	0.16	29	France	1.17		Barbados	0.20		Slovakia	0.47	29	U.S.	1.01		Philippines	0.50
	Portugal	0.90		Korea, Rep.	0.13	30	Malaysia	1.13		Ireland	0.19		Russia	0.45	30	Nigeria	1.00		Austria	0.49

Source: Computed from UNCTAD STATS Creative Economy Database

4. The Case of Bhutan, China and Egypt

The exclusive focus on the export of original RCA index (RCA1) has a serious limitation in the contemporary context where a significant and rising part of international trade takes the form of intra-industry trade. RCA2[11] the within-country RCA presents a measure which reveals a country or a sector's comparative advantage in generating net exports. In the context of Bhutan, Egypt and China[12], this section further applies the above approach (RCA1) but with more emphasis on intra-industry trade (G-L index), sectoral composition and trade partners. RCA2 is introduced here and further triangulation with G-L index. This is then followed by a discussion on relevant methodology and insights gained from related UNIDO missions to these countries and an outline for the ongoing research.

Table 5 Creative Goods (CG) Trade Dependency Ratio

Unit Million USD or Percentage	Bhutan	Egypt	China	Developing Economies	World
Total Export (X)	676	42,536	1,237,079	5,626,637	15,644,866
Total Import (M)	941	63,699	1,774,218	7,039,999	19,923,480
CG Export (X)	0.7	703	84,807	176,211	406,992
CG Import (M)	5.7	522	6,078	93,721	420,783
CG (X+M) Current Price (P)	6.4	1,225	90,885	269,933	827,775
GDP Current P & Exchange	1,245	164,844	4,416,104	17,289,154	61,146,661
Trade Dependency Ratio %	0.51	0.74	2.06	1.56	1.36
RCA1/Balassa Index[13]	0.04	0.64	2.64	1.20	1.00
RCA2/Within Country RCA2	0.17	2.02	20.01	2.35	1.32
Grubel-Lloyd (G-L) Index	22	85	13	69	98

Source: Calculated from 2008 trade flow matrix based on 2008 data from 2010 UNCTAD Stats Creative Economy database; GDP, export and import are based on UNCTAD Stats Economic Trends– current prices & exchange rates.

In terms of the structure of trade in creative goods reported in Table 5, both China and Egypt have achieved trade surplus (China: 78,728 million; Egypt: 181 million) whereas Bhutan shows trade deficit of 4.9 million. Geographically, Bhutan's land-locked geographical position tends to increase both transportation cost and transaction cost. For example, it is relatively expensive to send creative goods outside due to limited availability of flight and in the capital of Bhutan – Thimphu, retail terminal of two well known credit card providers were serviced from Nepal and have introduced a higher charge on using the terminal. Prevalence of cash economy, limited currency convertibility and high transaction cost posed

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[11] $\mathrm{RCA2_i} = \frac{X_i/XT}{M_i/MT} = \frac{X_i/M_i}{XT/MT}$

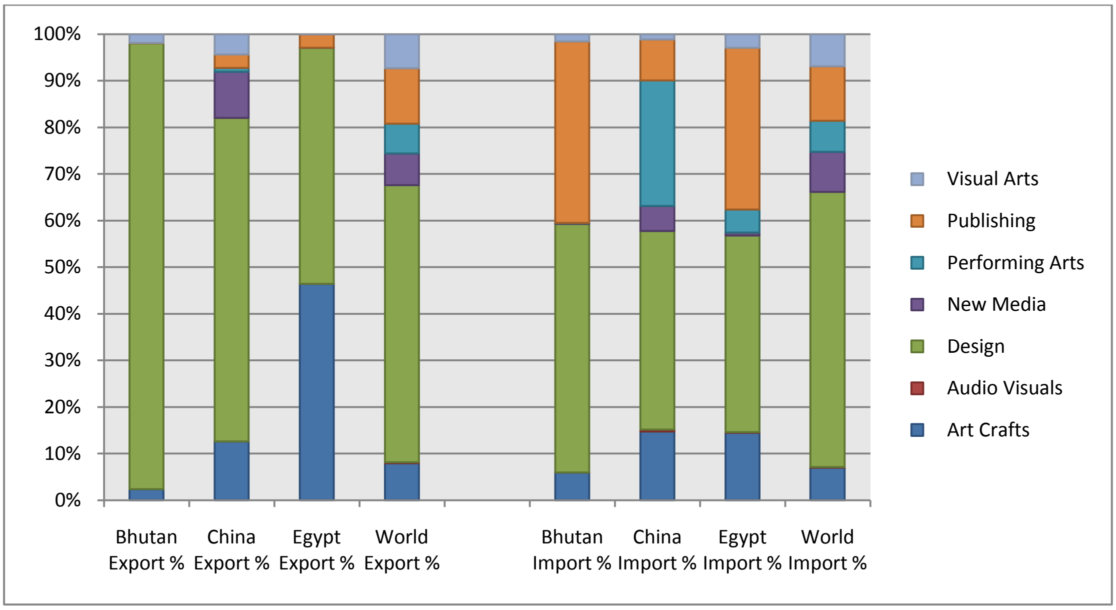
[12] For statistical purpose and following the convention of usage by UNCTAD stats, Chinese statistics only shows Chinese mainland with Hong Kong and Taiwan listed separately. All are measured in USD with unit in millions.

[13] X denotes exports in a sector, XT is total exports in a country, c (= 1…m) refers to countries and i (=1…n) refers to sectors. If RCA > 1, sector i in country c is said to have a comparative advantage in commodity or industry i, and vice versa. Where M_i and MT denote sectoral and total imports respectively. Theoretically, this index can vary between 0 and ∞. A value above unity indicates the sector's above-average ability to generate net exports and thus a comparative advantage over the other sectors in the external market.

by credit card companies and international courier services present supply side constraints which limit the growth potential of Bhutan in spite of huge potential of this country's unique tradition and culture strongly embodied in *Zorig Chusum* (thirteen traditional art crafts). The extent to which export and import statistics are reported by Bhutanese micro and small handicraft business is also likely to understate the size of CG export.

The table below depicts structural composition of seven main categories of CI trade in three countries and compares with the world average[14]. Close to half (46%) of Egypt's export in CG is based in art crafts.

Table 6 The Structure of Creative Goods Trade by Seven Main Category of CG (2008)



Source: computed from UNCTAD STATS Creative Economy

In all three countries, design constitutes the largest category of CG export and import. In terms of export, the share is, respectively, Bhutan (95.65%[15]), China (69.39%) and Egypt (50.64%). Internationally, China ranks first in terms of design export with a value of 58.84 billion in 2008. In Egypt, the share of design export is lower than the world average (59.45%). However, Egypt's art crafts export constitutes 46.42% of all CG export and is well above the world average for art crafts (7.94%) revealing its overall importance to Egypt's CG export. Egypt's RCA1 value for art crafts is 3.71 (rank 7th) suggesting enjoys strong comparative advantage in the presence of higher level of intra-industry trade revealed by G-L index (85, higher than

[14] UNCTAD (2011) stated that the data on creative economy tend to underestimate the size of creative economy. Triangulation is sought from demand side figure, i.e. the world's import from a given country when no data are present or when significant differences exist. However, caution is needed as import figure tends to be estimated CNF (Cost Freight and Insurance) whereas export figure is generally stated on a lower FOB (Free on Board) basis.

[15] There is no data on new media, performing arts and audio visual export reported by Bhutan in UNCTAD Stats. However, documentation and field insight revealed that Bhutan has an up and coming audio visual sector. Triangulated with the world's import suggests the world imported 779 thousand USD worth of film from Bhutan. The share of design export is over-estimated.

developing economies' average of 69. In contrast, Bhutan has lower than average share of export (2.37%) in art crafts due to the constraints mentioned above.

China's design export of which fashion, interiors and toys are three top performing product clusters (a share of 65.04% of all CI export and 93.74% of design export) have relatively high market shares in the world's export (fashion: 34.04%, interiors 25.42%, toys: 33.94%). However, top market shares of the world in China point to wickerware (78.67%) and celebration (54.29%) within art crafts. Egypt's carpet export is ranked highest to the world amongst all its CI export. Of Bhutan's 708 thousand USD export of all CI, jewellery which is valued at 660 thousand USD represents 93.22% of total CI export.

New media export from China (9.88%) is higher than the world average (6.82%). This is an area where China has made inroad into relatively concentrated market place given the already strong domestic demand which provide some degrees of industrial capability for global expansion. In terms of import, all three countries show net trade deficit in publishing and performing arts. In the case of Bhutan and Egypt, the gap in publishing is particularly large (Bhutan: -2.2 million; Egypt: -160 million) for trade deficit. China, on the other hand, has achieved a trade surplus of 1,884 million. Table 7 below summarizes three countries' key trading partners and concentration. Although does not shown as an entity, E.U. would have become top partners with both three countries. In all three countries, U.A.E. has entered into top ten trading partners.

Table 6 Trading Partner of Bhutan, China and Eygpt

Bhutan			China			Egypt		
X	M	X+M	X	M	X+M	X	M	X+M
U.A.E.	India	India	U. S.	Japan	U.S.	U.S.	China	China
Australia	Thailand	Thailand	H. K.SAR	U.S.	H. K. SAR	Saudi Arabia	U.S.	Saudi Arab.
U. S.	China	China	Japan	H.K. SAR	Japan	Italy	France	Italy
Nepal	Singapore	Singapore	Germany	Singapore	Germany	Libya	Turkey	U.K.
Viet Nam	H. K. SAR	U.A.E.	U. K.	Italy	U.K.	U.K.	Russia Fed.	France
Japan	Switzerland	H. K. SAR	Netherland	Taiwan	Netherland	U.A.E.	Italy	U.A.E.
Switzerland	Nepal	Switzerland	Russia Fed.	S. Korea	Italy	Netherland	Germany	Libya
Netherland	Malaysia	Nepal	Italy	Germany	Russia Fed.	France	U.K.	Germany
Canada	Viet Nam	Malaysia	Canada	France	Canada	Germany	Canada	Turkey
France	Japan	Viet Nam	U.A.E.	U.K.	France	Morocco	U.A.E.	Netherland
Bhutan's Trading Partner Concentration			**China's Trading Partner Concentration**			**Egypt's Trading Partner Concentration**		
X	M	X+M	X	M	X+M	X	M	X+M
Top 1 Country Partner Concentration			Top 1 Country Partner Concentration			Top 1 Country Partner Concentration		
56%	60%	56%	30%	13%	30%	16%	27%	16%
Top 5 Countries Partner Concentration			Top 5 Countries Partner Concentration			Top 5 Countries Partner Concentration		

62%	92%	62%	58%	43%	58%	46%	54%	46%
Top 10 Countries Partner Concentration			Top 10 Countries Partner Concentration			Top 10 Countries Partner Concentration		
64%	98%	64%	70%	66%	70%	62%	74%	62%

Source: computed from UNCTAD STATS Creative Economy

5. Reflections on UNIDO missions to Bhutan, Egypt and China

While the motivation of this study is to reflect on the structure of creative economy and comparative advantage, it is hoped that current study might pave the way for future study in which more systematic modeling of the linkage between trade and IPR could become possible. There is a shortage of data on IPR for creative industries. UNCTAD STATS database group intellectual property as related industries and the data on IPR cannot be disaggregated into UNCTAD's classification of creative industries. Hence the research has not been able to provided evidences on the linkage between RCA and IPR which would only be available with more time and efforts finding a suitable concordance between WIPO based statistics measure and UNCTAD's ISTC/HS systems. One key issue encountered on IPR statistics for creative industries points to the difficulty to obtain HS or ISTC corresponding/concordance tables with IPR classification systems such as IPC and Lucanno. However, important as UNCTAD data as a tool for the analysis of international trade in creative industries, further insights are needed from the field to triangulate in the absence of data. This section, therefore, looks at issues which were identified during the missions to Bhutan, China and Egypt between 2009 and 2010.

Firstly, traditional knowledge are under appreciated and not utilized for business advantage. The protection mechanism for recording traditional knowledge remain weak; in certain cases such weakness give rise to infringement and exploitation by established business outside the community. There is also a sense of urgency as gradual substitution of traditional practices which are in general sustainable are replaced by industrial techniques, displacement of local production by outside forces leave little or no benefits to the indigenous communities.

Secondly, intellectual property rights in the form of trade mark and registered design rights are not recognized in local business practice due to the absence and equally high cost of obtaining services such as IPR registration agency and the absence of governmental supports in these areas - IPRs are considered as private benefits by the government, hence an absence of owner in the case of indigenous knowledge. In the case of China, the government did provide some supports though not linked to creative industries in the registration of geographical indicators (in agri-food) but such cases are limited.

In regards to both issues, one possible solution is to design a regional system of intellectual property rights to reflect culture and diversity with IPR as a public good for community ownership and development. For example, using collective marks and group registration to differentiate regional and ethnic characteristics, hence creating unique selling points (USP) through differentiation for ethnic art crafts. This requires both advocacy and policy action on the part of the government and careful institutional redesign of existing support processes. More effective mechanism would depend on the building of a sustainable bottom up ownership structure which allows communities ownership and business active participation, with limited but important regional and central government supports in the provision of business development services such as IPR registration agencies which are largely absent in underdeveloped regions.

In terms of business aspects, although there is no clear evidence that IPR can increase sales. The absence of IPR might be a reason for under-performance. Where B2B is the predominant mode in the supply chain for creative goods, trade margin for B2B (Business to Business) transaction remains low because of downward pressure and restrictive business practices exercised by the intermediary - making both individual pricing and branding difficult and resulting in difficulty to move up the value chain. This is due to strong bargaining power of the buyer (middle men and women) and weak bargaining power of the suppliers (in negotiating selling price, or economising on bulk purchase) but can be ameliorated by creating new forward linkages (B2C) directed to the final consumers, and creating group procurement in the form of trade association. If however capacity for forward linkages are lacking, the intermediary business model will continue to dominate and not much marketing can be developed which IPR relies on.

B2C (Business to Consumer) demand varies by product. However, overall potential for e-commerce remains weak, which might otherwise create more direct 'trickle down' effects to the producers (bypassing middle men and women). Detailed studies are needed to design transaction platforms, common standards and capacity to enhance B2C transactions, as well as local and international delivery mechanism and overall logistics. Generally, there is only a small volume of B2G (Business to Government) transaction where the government action can make a visible difference. This should be advocated by buying gifts and supplies from local business hence improving local capacity. New product design is needed to look into this as well as possible change of procurement practices by local government to increase accessibility.

6. Towards a Holistic Interpretation of Creativity and Development

For the future work, a more rigorous assessment of the competitiveness and sustainability of a country's creative sector require a careful examination of the sector's own productive characteristics, factor contents and intensity as well as its dynamic interactions with the rest of the economy in addition to the historical comparative advantages that the country enjoys over its main international competitors. However, due to the relatively short history of economic analysis of this sector and thus the general paucity of data at the firm and industry level, a comprehensive assessment is beyond the remit of this study. The focus of future research should seek to further quantify the link and impact between IPR penetration and revealed comparative advantage which this paper has partially developed.

Other challenges remain, for example, the lack of sector specific data on factor inputs into the creative sector precludes the traditional international trade approach to the sources of industrial competitiveness and trade specialization. International occupational matrixes for creative industries are needed from leading organization such as ILO. In terms of theories, the distinct characteristics of the creative sector can often render the traditional theories of comparative advantage less applicable than in the manufacturing industries where the theories are usually applied and tested. Therefore, the direction of future study can focus on how such comparative advantages are related to the industrial organisation of the creative sector in comparison with the other domestic industries, how much value are created by IPR in the value chain for different creative products.

Internationally, the study of the link between IPR penetration and RCA should help the government to decide what sector specific strategy should be pursued where there are already strong comparative advantage but weak IPR penetration to the partner. In terms of development benefits, a more holistic approach needs to be developed not to construe creative industries too narrowly. Indeed, the linkage with other sectors of the economies, for example, tourism and agro-food sectors should be allowed to be included flexibly to address local development needs depending on the communities concerned. Returning to the statement in the beginning that the concept of creative 'industries' offers a new lens through which one can examine and capture 'kaleidoscopic' combination and recombination of human ingenuity and organization. In as far as the concept of creative industries is concerned, definitional and classification differences should not over-write more important development goals such poverty alleviation and sustainable livelihood creation.

REFERENCES

Amador, J., S. Cabral, et al. (2011). "A Simple Cross-Country Index of Trade Specialization." Open Economies Review **22**(3): 447-461.

Aquino, A. (1978). "Intra-industry trade and inter-industry specialization as concurrent sources of international trade in manufactures." Review of World Economics **114**(2): 275-296.

Balassa, B. (1965). "Trade Liberalisation and "Revealed" Comparative Advantage1." The Manchester School **33**(2): 99-123.

Barrowclough, D. and Z. Kozul-Wright (2007). Creative industries and developing countries: voice, choice and economic growth, Routledge.

Bowen, H. P. (1983). "On the theoretical interpretation of indices of trade intensity and revealed comparative advantage." Review of World Economics **119**(3): 464-472.

Elliot, L. (2007). Fantasy island. London, Constable & Robinson.

Hausmann, R., J. Hwang, et al. (2007). "What you export matters." Journal of Economic Growth **12**(1): 1-25.

Oakley, K. (2004). "Not so cool Britannia." International Journal of Cultural Studies **7**(1): 67.

Schultz, M. F. and A. Van Gelder (2008). "Creative Development: Helping Poor Countries by Building Creative Industries." Kentucky Law Journal.

UNCTAD (2010). Creative Economy Report 2010. UNCTAD/DITC/TAB/2010/3. Geneva, UNCTAD.

UNIDO (2011). Report of Peer Review Workshop on Creative Industries. Vienna, Austria, UNIDO HQ.

Vollrath, T. L. (1991). "A theoretical evaluation of alternative trade intensity measures of revealed comparative advantage." Review of World Economics **127**(2): 265-280.

Ye, Z. and Y. P. Yin (2011). "Economic Linkages and Comparative Advantage of the UK Creative Sector." International Review of Applied Economics **Forthcoming**.

Yeats, A. J. (1985). "On the appropriate interpretation of the revealed comparative advantage index: implications of a methodology based on industry sector analysis." Review of World Economics **121**(1): 61-73.

Appendix 1: UNCTAD CG Classification and Data Reporting Structure in Bhutan China and Egypt

Category	Sub-group	Sub-Code	Description	Bhutan		China		Egypt	
				X	M	X	M	X	M
Art Crafts 60 codes	Carpets	17	Carpets of wool or other fine animal hair, cotton, coconut fibres and other plant fibre, knotted or woven	x	x	x	x	x	x
	Celebration	2	Articles for Christmas, festivities, carnivals, etc.	x	x	x	x	x	x
	Other	6	Candles, tanned or dressed fur skins, artificial flowers, wood marquetry, etc.	o	x	x	x	x	x
	Paperware	1	Handmade paper.	x	x	x	x	x	x
	Wickerware	4	Plaits, mats, basketwork, wickerwork, etc.	x	x	x	x	x	x
	Yarn	30	Handmade lace, hand-woven and needlework rugs, embroidery, bed linen, man-made or printed, knitted or crocheted materials, etc.	x	x	x	x	x	x
Audio Visuals 2 codes	Film	2	This subgroup has 2 codes; only 2 types of exposed cinematographic film are included in this subgroup.	o	x	x	x	x	x
Design 102 codes	Architecture	1	Original drawings for architectural plans.	o	x	x	x	x	x
	Fashion	37	Handbags, belts, accessories (ties, shawls, scarves, gloves, hats, hairpins, etc), sunglasses, headgear, leather goods, etc. Clothing and shoes are not included.	x	x	x	x	x	x
	Glassware	5	Table/kitchenware, drinking glass made with crystals.	o	x	x	x	x	x
	Interior	32	Furniture (living room, bedroom, kitchen, bathroom), tableware, table linen, wallpaper, porcelain, lighting sets, etc.	x	x	x	x	x	x
	Jewellery	10	Articles of jewellery made from gold, silver, pearls and other precious metals as well as imitation jewellery.	x	x	x	x	x	x
	Toys	17	Dolls, wheeled toys, electric trains, puzzles, games, etc.	o	x	x	x	x	x
New Media 8 codes	Recorded Media	6	This subgroup has 8 codes: 6 code for recorded media for sound and image, and 2 codes for video games.	o	o	o	o	o	o
	Video Games	2	This subgroup has 8 codes: 6 code for recorded media for sound and image, and 2 codes for video games.	o	x	x	x	x	x
Performing Arts 7 codes	Music (CD, Tapes)	6	Has 7 codes. It covers 6 types of recorded laser discs and recorded magnetic tapes as well as printed or manuscript music.	o	x	x	x	x	x
	Printed Music	1	Has 7 codes. It covers 6 types of recorded laser discs and recorded magnetic tapes as well as printed or manuscript music.	o	x	x	x	o	x
Publishing 15 codes	Books	4	Books, dictionaries, encyclopedias, brochures, leaflets, children's drawing and colouring books and other printed matter.	x	x	x	x	x	x
	Newspaper	3	Newspapers, journals and periodicals.	o	x	x	x	x	x
	Other Printed Matter	8	Maps, brochures, postcards, calendars, advertising materials, etc.	o	x	x	x	x	x
Visual Arts 17 codes	Antiques	3	Antiques more than 100 years of age.	o	x	x	x	x	o
	Paintings	3	Paintings, pastels executed by hand, wooden frames for paintings.	x	x	x	x	x	x
	Photography	4	Photographic plates for offset reproduction; photographic film and microfilms, exposed and developed.	o	x	x	x	x	x
	Sculpture	7	Statuettes and other ornamental articles of wood, porcelain, ceramics, ivory or other metals, worked carving materials.	x	x	x	x	x	x

Source: Author's calculation based on UNCTAD Stats Creative Economy database; o means data not available and x means data available.

Appendix 2: Regional Arrangement for Creative Goods Trade

Bhutan		Egypt		China	
X	M	X	M	X	M
GCC	APTA	APEC	APEC	EU	APEC
APEC	SAARC	FTAA	EU	APEC	APTA
FTAA	APEC	NAFTA	APTA	GCC	EU
EU	ASEAN	EU	FTAA	FTAA	FTAA

Source: Asia-Pacific Trade Agreement (APTA) (Former Bangkok Agreement), South Asian Association for Regional Cooperation (SAARC), Asia-Pacific Economic Cooperation (APEC), Association of South-East Asian Nations (ASEAN), Gulf Cooperation Council (GCC), Free Trade Area of the Americas (FTAA), North American Free Trade Agreement (NAFTA).

Appendix 3: Trade Dependency Ratio for 103 Countries (2008)

	TD-CGS	TD-CG	TD-S		TD-CGS	TD-CG	TD-S
Hong Kong SAR	0.293	0.291	0.002	Nether. Antilles	0.030	0.026	0.004
Malta	0.252	0.036	0.216	Barbados	0.030	0.030	0.000
Netherlands	0.087	0.026	0.062	Mauritius	0.030	0.024	0.006
Ireland	0.083	0.018	0.066	Jamaica	0.030	0.022	0.008
Belgium	0.069	0.035	0.034	New Caledonia	0.028	0.011	0.017
Hungary	0.059	0.017	0.042	Portugal	0.028	0.014	0.015
Singapore	0.057	0.054	0.002	Poland	0.028	0.017	0.011
Czech Republic	0.056	0.040	0.016	Guyana	0.028	0.021	0.007
Slovenia	0.052	0.031	0.021	Romania	0.027	0.016	0.011
Moldova	0.051	0.047	0.005	Albania	0.027	0.013	0.015
Estonia	0.050	0.033	0.017	Norway	0.026	0.009	0.017
Luxembourg	0.048	0.018	0.030	Italy	0.025	0.018	0.007
Switzerland	0.047	0.047	0.000	Bosnia & Herzegovina	0.025	0.025	0.001
Croatia	0.044	0.020	0.024	Spain	0.024	0.011	0.013
Bulgaria	0.042	0.022	0.020	Tunisia	0.024	0.023	0.001
Slovakia	0.040	0.027	0.013	Papua New Guinea	0.024	0.023	0.001
Cyprus	0.039	0.021	0.018	United Kingdom	0.023	0.019	0.004
Malaysia	0.039	0.020	0.019	Dominica	0.023	0.021	0.002
Fr. Polynesia	0.038	0.025	0.012	Algeria	0.023	0.002	0.022
Macedonia	0.038	0.013	0.025	Namibia	0.023	0.018	0.005
Latvia	0.037	0.022	0.016	Occupied Palestinian	0.023	0.011	0.012
Austria	0.036	0.032	0.003	Ukraine	0.022	0.010	0.013
Germany	0.036	0.017	0.019	China	0.022	0.021	0.001
Serbia	0.034	0.013	0.020	Kazakhstan	0.021	0.005	0.016
Lithuania	0.031	0.026	0.004	Cambodia	0.021	0.020	0.001
Canada	0.030	0.016	0.015	Sweden	0.020	0.019	0.001

N.B. CGS (Creative Goods and Services), CG (Creative Goods), S (Services). Computed from UNCTAD Stats Creative Economy Database. Highlighted in blue are those with above average share.

Appendix 4 (Continue from the above): Trade Dependency Ratio in 103 Countries (2008)

	TD-CGS	TD-CG	TD-S		TD-CGS	TD-CG	TD-S
Korea, Repub.	0.020	0.010	0.010	Mexico	0.011	0.011	0.001
Bahamas	0.019	0.015	0.004	Colombia	0.011	0.006	0.005
Belarus	0.019	0.014	0.005	Bolivia	0.011	0.010	0.001
India	0.018	0.009	0.009	Chile	0.009	0.008	0.001
Ghana	0.018	0.013	0.005	Brazil	0.009	0.002	0.007
France	0.017	0.014	0.003	Egypt	0.009	0.007	0.002
New Zealand	0.017	0.012	0.005	Venezuela	0.008	0.005	0.003
El Salvador	0.017	0.016	0.000	United Rep. Tanzania	0.008	0.007	0.001
Georgia	0.017	0.011	0.006	Guinea	0.008	0.005	0.003
Turkey	0.016	0.012	0.004	South Africa	0.007	0.007	0.000
Costa Rica	0.016	0.013	0.002	Philippines	0.007	0.006	0.001
Australia	0.015	0.008	0.007	Senegal	0.007	0.006	0.001
Dominican Repu	0.015	0.009	0.007	Kenya	0.007	0.006	0.000
Cape Verde	0.015	0.010	0.006	Rwanda	0.007	0.006	0.001
Mozambique	0.015	0.006	0.010	Japan	0.006	0.005	0.001
Belize	0.014	0.010	0.005	Uruguay	0.006	0.006	0.001
Morocco	0.014	0.011	0.003	Mali	0.006	0.005	0.001
Iceland	0.013	0.012	0.001	Ethiopia	0.005	0.003	0.002
Russian Federation	0.013	0.004	0.009	Côte d'Ivoire	0.004	0.003	0.001
Armenia	0.013	0.010	0.004	Nigeria	0.003	0.003	0.000
Guatemala	0.013	0.012	0.000	Niger	0.003	0.003	0.000
Pakistan	0.013	0.011	0.001	Azerbaijan	0.002	0.001	0.000
Finland	0.012	0.011	0.000	Peru	0.002	0.002	0.000
Argentina	0.012	0.004	0.008	Sudan	0.002	0.002	0.000
United States	0.011	0.009	0.002	Yemen	0.002	0.002	0.000

N.B. CGS (Creative Goods and Services), CG (Creative Goods), S (Services). Computed from UNCTAD Stats Creative Economy Database.

The Market Value of Patenting: New Findings from Japanese Firm Level Data

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Abstract

This paper focuses on how competition in innovation markets affects the market value of publicly traded companies in Japan. We develop a strategy using patent citation patterns across and within areas of scientific knowledge as identified by the patent classification system. This allows for measures of both patent importance and the emergence of potentially competing technologies. Our estimator of market value incorporates correlated dynamic effects and addresses the potential endogeneity of R&D to firm value.

Our findings indicate that self-citations have a strong effect on Tobin's q in Japanese firms. However, this effect is mainly associated with self-citations to patents, and patent portfolios, in the same technology fields of the citing patent. At the same time, firms' market values tend to decrease when its patents are cited in the same technology fields by competitors. In addition, our empirical results suggest that the number of joint inventors per patent play important role on the firm's market values.

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1 Introduction

In this paper, we focus on how competition in innovation markets affects the market value of publicly traded companies in Japan. We follow the strategy for building citation patterns across firms and across firm's research expertise as revealed by their patent portfolios. The patent classification system provides detailed information on the areas of science implicit in both the citing and cited firms. We exploit this information to distinguish between citations that may signal patent importance versus citations that may signal the development of a potentially competing technology.

Our contributions are threefold. First, we discriminate the citation patterns between self-citation and external citations to identify the role of competing patenting by outside inventors on the market value of a firm. In addition to citation information, we also utilize the number of joint inventors and joint applicants listed on patents to investigate the effects of innovation organization with the firm. Second, we use a large unbalanced panel data that covers approximately 1,500 Japanese publicly traded companies for the period of 1990-2005. We expect that estimated results based such extensive data may provide a comprehensive view of the market performance for patented innovations in Japan during this period. Lastly, we attempt to the inherently complex and dynamic process of the relationship between the market value and patented innovations with an estimator with similar properties. The likely feedback mechanism linking increased market value from previous R&D performance with investment in R&D and subsequent new patenting implies an endogenous system. In addition, market performance generally has an auto-correlated structure. To address the endogeneity issue and the correlated dynamic effects, we apply the dynamic panel GMM estimation techniques developed by Arellano and Bover (1995) and Blundell and Bond (1998).

Our findings show that self-citations have a dominant effect on Tobin's q in Japanese firms. However, this dominant effect is mainly associated with self-citations to the same technology fields of the firm's cited patent and or the firm's patent portfolio. At the same time, a firm's market value tends to decrease when its patents are cited by inventors affiliated with competitors in the same technology fields. Our empirical results also suggest that the number of inventors in patent applications for play important role on the firm's market values.

The remainder of the paper is organized as follows. Section 2 provides some background on measuring market value of inventive activity using patents information. Section 3 describes the data employed in this paper and explains variables used in our analysis. Section 4 provides empirical results and discusses implications arising from those results. Section 5 concludes.

2 Background

The empirical literature on the value of patents to firms has been surveyed in Reitzig (2004), van Zeebroeck and van Pottelsberghe (2007), Greenhalg and Rogers (2007) and van Zeebroeck and van Pottelsberghe (2011). As pointed out in these surveys, because patents are often not traded, it is difficult to directly determine even their private value. As a consequence, a popular approach to determining the value of intellectual property is to infer the value of patents from their effects on the prices of shares in publicly traded companies.

The maintained assumption in the literature on the relationship between patents and market value is that market participants have "rational expectations" (Hall et al. 2005). For the purposes of patent valuation, financial markets are assumed to price shares "correctly". Investors' estimates of the future dividend payments will be a function of the stock of both tangible and intangible assets owned by the company. Since patents are one component of the intangible assets, the measures of intangible assets, say, the knowledge stock such as patent statistics may be correlated with market values of the company.

The specification of the market value function goes back to Griliches (1981). The model can be given by

$$V_{it} = q_t \left(A_{it} + \gamma K_{it}\right)^{\sigma}$$

where V_{it} is the market value of firm i at time t, A_{it} is the book value of total tangible assets of the firm, K_{it} is the stock of intangible assets not included in the balance sheet, σ allows for the possibility of non-constant returns to scale, and γ is the ratio of shadow values of intangible assets. Taking logarithms and rearranging the log equation, we obtain

$$\log Q_{it} = \log\left(\frac{V_{it}}{A_{it}}\right) = \log q_{it} + \log\left(1 + \gamma\frac{K_{it}}{A_{it}}\right) \qquad (1)$$

where Q_{it} is the conventional Tobin's q, and the intercept of the equation (1) can be interpreted as an estimate of logarithmic average Tobin's q.

Patents have long been used as a good proxy for the intangible assets, and recognized as a rich data source for the study of innovation. However, there are serious limitations for using the patents. One of limitations in these studies is related to the fact that not all innovations are patented. Not all inventions meet the patentability criteria and that the inventors have the options such as relying on secrecy or using other means of appropriability rather than patenting (Cohen et al. (2000), Cohen et al. (2002)).

Hall et al. (2005) argued that, the major limitation of many studies was that they relied exclusively on patent counts as indicators of innovative output. However, because the distribution of the values of innovative output are extremely skewed in their technological and economic "importance", simple patent counts are inherently limited in the extent to which they can capture such heterogeneity. For this reason, Trajtenberg (1990), and Albert et al. (1991) suggested using patent citations as a means to tackle such heterogeneity.

Patent citations serve an important legal function since they serve to delimit the scope of the property rights awarded by the patent holder. Thus, they convey information about two major aspects of innovations we exploit here: the linkages between inventions, inventors, and assignees along time and space and the economic and technological "importance " of individual patents. These aspects provide ways of gauging the enormous heterogeneity in the "value" of patents (Trajtenberg et al. (1997), Hall et al. (2000) and Hall et al. (2005))

Bloom and van Reenen (2002) examined the role that patents play in determining the market value of large UK firms. In their empirical analysis on 236 UK firms who had taken out at least one patent in the US Patent and Trademark Office (USPTO) between 1968 and 1996, they reported three different specifications for the knowledge stock variable: patent stocks measured by simple patent counts, citation-weighted patent stocks using an imputation of all future patent citations, and citation-weighted patent stocks over the next five years. Their results show that patents have had an economically and statistically significant impact on firm-level market value and that patent citations are more informative than the simple patent counts that had been previously used in the literature.

Hall et al. (2005) directly explored the usefulness of patent citations as a measure of the "importance" of a firm's patents or innovations. Using an unbalanced panel of 4,864 publicly traded US firms that have patents granted by the USPTO between 1976 and 1995, they also show that, in addition to R&D, and simple patent counts, patent citations contain significant information on the market value of firms. In their recent paper, Hall et al. (2007) provided novel empirical evidence on the market value of patents in European firms which held patents issued by both the European Patent Office (EPO) and the USPTO. They showed that, although citation–weighted patent is significant, using either forward citations or an index based on forward citations is only modestly informative for market value. By using Japanese firm-level data, Nakanishi and Yamada (2007) investigated the effect of quality of patents on the market value for Japanese firms where they consider as the proxy of quality of patents, the number of citations as well as the number of objections. Their findings suggested that in some cases the objections play more important role than that for patent citations on the firm's market values.

In the equation (1), Hall et al. (2005) and Hall et al. (2007) measured the value of R&D, the number of patents, and the number of citations assuming that the market incorporates these into the price when they are observed and are assumed to be determined exogenously. However, the relationship between Tobin's q and R&D investments, as well as patenting activities, cannot be treated as exogenous since R&D investment and patenting activities are chosen on the basis of economic incentives.

Much of the empirical literature has shown that R&D investments depend on firm's expected economic performance and in particular on Tobin's q (Blundell et al. 1992; Bond and Cummins, 2001). This issue raises concern on the direction of causality between Tobin's q and R&D investments and patenting. In fact, previous empirical work has already recognized this potential issue and has treated R&D investments as an endogeneous (e.g., Jaffe 1986, Munari et al. 2002).

McGahan and Silverman (2006) find evidence that the market value of firms depends on patented innovation by competitors. By using a large panel of the US publicly traded firms during the 1981-1999 period, their empirical results suggested that the market value of an incumbent is negatively associated with "importance" of patenting by outside inventors. In industries characterized by a strong reliance on complementary assets, however, the relationship could be reversed.

Findings by Patel and Ward (2011) strengthen the idea of competition in innovation markets. Using US pharmaceutical industry firm-level data they distinguished the effect on market value of patent citations to a patent in the same narrow area of science from those across areas as represented by the patent classification system. Their findings showed that firms' market value increases when its patent portfolio is cited, but controlling for this "importance" effect, citations from the same area of science tend to reduce market value. They interpret that as consistent with citations indicating more valuable intellectual property but citations from potentially competing technologies decreasing its market value. Their study also differs from most of earlier literature in that they used daily abnormal stock returns rather than annual measures of Tobin's q.

3 Data and Variables

3.1 Tobin's q

For the purpose of the estimation of the market value function for Japanese firms, we link the patent data with financial data drawn from the NEEDS's Corporate Financial Report, including the stock price, the number of shares issued, and the amounts of debts, assets, and R&D expenditure.

Tobin's q is measured as the ratio of the firm's market value to the book value of its tangible assets. Corporate finance scholars have developed complex methodologies for the measurement of Tobin's q which rely on estimated market value of the firm (Abel and Blanchard, 1986; Perfect and Wiles, 1994). As indicated by DaDalt, Donaldson, and Garner (2003), these approaches to Tobin's q produce more precise estimates but are computationally costly. Moreover, these approaches may be subject to a larger selection bias as some of the required information may be unavailable for a nonrandom subset of firms. They suggest that a simple approach is preferable unless extreme precision of the q estimate is paramount and sample selection bias is unlikely to be significant. We use a simpler approximation version as discussed in Chung and Pruitt (1994) and DaDalt, Donaldson, and Garner (2003), who propose the following simple approximation of Tobin's q:

$$\text{Tobin's } q = \frac{MVE + PS + LTDEBT + CL + BVINV - NCA}{TA},$$

where MVE is the year-end value of common stock and PS is the liquidation value of preferred stock. $LTDEBT$, CL, $BVINV$, NCA, and TA denote the book values of long-term debt, current liabilities, inventory, net current assets, and total assets respectively. We exclude PS in our measure for Tobin's q because the data are unavailable.

The mean and media values of Tobin's q for our sample companies are 1.19 and 1.09 respectively, which are close to those reported in Hall, Jaffe, and Trajtenberg (2005) for the US firms, but slightly below those in Fukuda et al. (1999) for Japanese firms in the period 1985–1996, perhaps reflecting the fact that the "lost decade" began after the collapse of the bubble economy undermined to the extent the market performance of Japanese companies, especially in the 1990s.

3.2 Patents and Citation Data

We collect data on patent application filing date, patent citations, and index of technology classification (ITC) for patents applied for in the Japan Patent Office (JPO) from the database released by Japanese Institute of Intellectual Property (IIP)[1]. The ITC is created by the IIP based on the international patent classification (IPC). Since the IIP database did not provided whole information of ITC assigned to the JPO patents, we use the Patstat database (Patstat April 2011 version) released by European Patent Office (EPO) to obtain all of the information for the IPC for the JPO patents. We then link the IPC code with the ITC code by using the concordance between the ITC and IPC summarized in Appendix Table 1.

The patent classification has as its primary purpose the establishment of an effective search tool for the retrieval of patent documents by patent examiners in order to evaluate the inventive step of technical disclosures in patent applications [2]. Depending on the content of a patent document, the information disclosed therein, more than one classification may apply. This is the case when the invention information is associated with different categories of subject matter, i.e., processes, products, apparatus or materials, or the case that the technical characteristics of the subject of the invention are concerned both with function-oriented places and application places.

Figure (1) presents the histogram of the number of the ITCs to which our sample patents are assigned by the JPO. Although the ITC classification used in our analysis does not provide as detailed a classification as did in the IPC, more than 70% of patents are assigned to two or more ITC classes. This suggests that ITCs are useful tools to identify the technical characteristics of patented innovation and citation patterns the patents received.

Bloom and van Reenen (2002), Hall et al. (2005) and Hall et al. (2007) employed

[1]See Goto and Motohashi (2007) for details of the IIP dataset.

[2]See the details for patent classification in the Guide of International Patent Classification (IPC) in WIPO website.

two kinds of citations to a firm's patents, i.e., forward citations and backward citations, in their analyses for the USPTO and EPO patents. The former refers to the sum of all future citations to a specific firm's current patent, while the latter are the sum of all current citations to all patents previously applied for or granted. The key distinction between the two types of citations is the timing when this information is revealed to market participants. Because one purpose of the paper is to examine the dynamic effects of patent citation on the market value, a major interest is the timing of when the information regarding a patented innovation is revealed to the market participants. We focus our empirical analysis on backward citations that are known to current market participants. Furthermore, according to Japanese Patent Law, a Japanese patent application will be published no later than 18 months after filing of application. Thus, instead of grant, we consider the timing of the publication for constructing backward citations for Japanese firms. Here we suppose that "news" about the importance of a new technology is fully appreciated by market participants upon the date of publishing of the patent application (see Patel and Ward, 2011).

As a result, we collect the data that covers 1,492 Japanese publicly traded companies between 1990 and 2005. These companies received a total of 4,211,067 citations during the sample period with about 77% being external citations. Appendix Table 2 presents the share of citations across industries, where the industry code is assigned to Japanese publicly traded companies by Nikkei co. ltd. Surprisingly, more than half of all citations are concentrated in electric machinery industry.

We calculate the values for citation patterns as did in Patel and Ward (2011). For each patent, we identify each ITC to which a patent is assigned. We use the ITC group of patents to represent research areas which we assume to be closer to each other if two patents share a common ITC group. We measure a citation pattern by counting how many times the citing patent shares same ITC group with cited patent. More same ITC groups the citing patent shares with the cited patent may convey information of the "importance" or may represent a potentially competing technology to the cited patent than citations that share no common ITC groups. We label this citation pattern as $SlCitSame$ and $ExCitSame$, where the former refers to self-citation and the letter refers to external citation.

We also build another kind of citation measure as the follows.

For each patent applied for by firm i, ITC group j and year t, we define the sum $Area_{ijt}$ as the number of patents in the ITC groups that were classified in technology field j for the patents applied for by firm i in year t. Then the share of the ITC for the patents in the group that were applied for by the firm over the past five years can be measured as,

$$AreaSh_{ijt} = \frac{\sum_{q=1}^{5} Area_{ijt-q}}{\sum_j \sum_{q=1}^{5} Area_{ijt-q}}$$

The higher relative shares in a specific ITC group demonstrate more expertise in that area of technology. Thus, the vector $AreaSh_{it}$ can be described as measuring the IP portfolio for firm i in year t. We then define $CitArea_{kjr}$ as a citation from firm k at time r to patent in area j. The sum of the interaction can be obtained as the follows,

$$\begin{aligned} & SlCitGrp_{is}(\text{or}ExCitGrp_{is}) \\ &= \sum_k \sum_j SlCitArea_{kjs}(\text{or}ExCitArea_{kjs}) \times AreaSh_{ijs} \end{aligned}$$

where $SlCitArea$ and $ExCitArea$ refer to self and external $CitArea$. Rather than measuring citations to firm i's specific patents, this measures citations to areas where i has expertise. This measure can be thought of as "near miss" citations when citations come from other firms.

A related alternative measure focuses on patents rather than citations. To explore the effect of competing innovation by competitors, we also employ the same method to build a patenting pattern that can be measured as,

$$\begin{aligned} & ExPGrp_{is} \\ &= \sum_k \sum_j ExPArea_{kjs} \times AreaSh_{ijs} \end{aligned}$$

where $ExPArea_{kjs}$ refers to the number of ITC for the patent applications published by firm k at time s in area j. Thus, we can use $ExPGrp$ to show competitive filing pressure on the IP portfolio of firm i in year s.

In our empirical analysis, rather than flow values, we use stock values for all variables we discussed above and all other variables such as R&D stock Rd, patent application stock Pat, self-citation stock $SlCit$, external citation stock $ExCit$. The stock values at publication year t are measured by using the perpetual inventory method as follows:

$$K_t = I_t + (1 - \delta)K_{t-1}$$

where K is the stock of the variables at the end of period t, I_t is the flow values of the variables during period t, and δ is the depreciation rate. Following convention in the literature, we resort to the traditional 15% depreciation rate (see Hall, Jaffe, and Trajtenberg (2005)). We use the flow values in 1975, fifteen years before our sample begins, as the benchmark value for K.

The IIP database also provides the detailed list of joint inventors and joint applications for the patents applied for to the JPO. This allows us to observe the changes of innovation organization across firms. We use $INVT_{it}$ and $APPT_{it}$ to denote the average number of joint inventors and joint applicants in patents published by firm i in year t. Figures (2) and (3) present histograms of the number of joint inventors and joint applicants in our sample of patents. The histogram of $INVT$ shows that the most of patents published by Japanese companies have two or more joint inventors.

Table 1 shows the descriptive statistics, and Appendix Table 2 presents the correlations of variables used in our empirical analysis.

3.3 Econometric Methodology

We present estimates from two separate econometric estimators. The first is the commonly used fixed-effect panel estimator. The second is more recently developed dynamic panel GMM estimator that relaxes assumptions on the nature of data generating process.

3.3.1 Fixed-Effect Panel Estimator

We utilize a linear panel approximation of specification to the firm–level market value function such as done in Hall et al. (2005) and Hall et al. (2007). The estimating equation can be given as,

$$\log(Q_{it}) = \sum_{i=1}^{k} \beta_i X_{itk} + \gamma_t + \eta_i + \epsilon_{it} \tag{2}$$

where Q refers to Tobin's q, X^j is the regressor of interest: Rd/Ta, Pat/Rd, $SlCit/Pat$, $ExCit/Pat$, $SlCitGrp/Cit$, $ExCitGrp/Cit$, $ExPGrp/Pat$, $SlCitSame/Cit$, $ExCitSame/Cit$, $INVT/APPT$, and $APPT$. Ta and Cit denote total assets and total backward citation stock respectively.

We also add year-specific intercepts, γ_t, and firm-specific effect, η_i, to account for unmeasured firm-invariant or time-invariant effects. If firm-specific effects are uncorrelated with all inputs in all periods (strict exogeneity), then a standard fixed effects model, or the first difference representation, is appropriate. If industry-specific effects are correlated with some inputs, however, the generalized method of moments (GMM) techniques proposed by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) are useful to address this simultaneity problem.

3.3.2 Dynamic Panel GMM Estimation

We consider the following autoregressive panel data specification for (2),

$$\begin{aligned} y_{it} &= \sum_{k=1}^{p} \alpha_k y_{i(t-k)} + \sum_{l=0}^{q} \beta_l x_{i(t-l)} + \gamma_t + \eta_i + \epsilon_{it} \\ & \quad t = p+1, \cdots, T; \;\; i = 1, \cdots, N \end{aligned} \tag{3}$$

where γ_t and η_i are respectively time and individual specific effects, and ϵ_{it}'s are assumed to be independently distributed across individuals (or firms in (2)) with zero mean. y_{it} and x_{it} are a dependent variable and a vector of explanatory variables respectively referring to $\log(Q_{it})$, and X_{it} as defined in (2). The ϵ is assumed to be independently distributed across individuals with zero mean, but arbitrary forms of heteroskedasticity across units and time are possible. The x_{it} is allowed to be correlated with individual effects η_i and a part of x_{it} is allowed to be endogenous variables with respect to ϵ_{it} as we discussed for R&D term in equation (2).

Based on the work of Arellano and Bond (1991), Arellano and Bover (1995) and others, Blundell and Bond (1998) presented a linear GMM estimator (GMM-SYS) that provides efficiency gains relative to the basic first difference estimator. GMM-SYS can be defined with individual i's differenced and level equations stacked together. The lagged dependent and endogenous variables in the levels and differenced may then be used as instruments for the former and latter equations respectively. In GMM–SYS, the one-step estimators are asymptotically inefficient relative to the two-step estimators, even if the ϵ_{it} in (3) are homoskedastic.

4 Results

4.1 Preliminary Findings

Table 2 reports fixed-effect panel regression coefficients for various specifications of the regressions. The magnitude of the average elasticities of Rd/Ta, R&D expenditures to total assets, varies between 0.15 and 0.26, which coincides closely with those reported in Hall et al. (2005) for the European firms, but are much below those reported in Hall et al. (2005) for US firms. The estimates for Pat/Rd, the ratio of patent stock to R&D stock, failed to reject the null hypothesis at the usual significant levels in all cases. The coefficients of $INVT/APPT$, the ratio of number of joint inventors to number of joint applicants, shows an interesting way that the number of joint inventors affect the market performance of the firms. In the most cases, the estimates of $INVT/APPT$ is negatively significant against the null, while it turns to be positive significant for $(INVT/APPT)^2$, suggesting a diminishing effect. This is consistent with our recent findings in a survey for Japanese engineers that, in Japanese companies, the names of managers in different levels of the hierarchy are usually included in the list of joint inventors due to the recognition of team work, although they may not actually be involved in R&D activities [3]. However, in the case that managers are real inventors, or play a dominant role in the R&D activities, the list of joint inventors may only include the managers themselves. On the other hand, large size of joint inventors may be related to an important R&D project. Therefore, the estimates for the number of joint inventors reveals an effect varying along with an inverse squared function change[4].

Table 2 also presents estimated results for different specifications uncovering patterns of the effects of patent citations. Column (2) indicated that $SlCit/Pat$, self-citations, shows a strong positively significant effect on the $\log(Q)$, while this is not

[3]The findings are based on our recent survey undertaken with Japanese Electrical and Electronic Information Union (JEIU) on the career development of Japanese high-value-added engineers. See JEIU (2008).

[4]We also added $(APPT)^2$ in the regressions. Unlike the results of $INVT/APPT$, however, the coefficients of $APPT$ and $(APPT)^2$ were not stable across the different specifications for the regression of $\log(Q)$. The estimates of $(APPT)^2$ are available for the request.

the case for $ExCit/Pat$. These results are consistent with the estimated coefficients for $SlCitSame$, self-citations in the same technology fields, which are also positively significant in Column (3), (4), (5) and (9) while $ExCitSame$, the external-citations in the same technology fields, fails to reject the null of zero effect in Column (3), (6), (7) and (10). Both of $SlCitGrp$ and $ExCitGrp$ between Column (8) and (12) indicate positive effects on $\log(Q)$, and the same results are obtained for $ExPGrp$ in Column (13), (14), (15) and (16).

Our preliminary results imply that, for Japanese companies, strong effect of self-citations on the market value may be resulted both from self-citations to the same technology fields and the patent portfolio the firms built. However, it is not clear how matter on external ciations affect the firms' market value when the ciations occured in the same technology filed. We then turn our attention to the dynamic panel estimation results to see what will be happened for external citations if we control the problems such as the endogeneity issue and the correlated dynamic effects.

4.2 Dynamic Panel Estimates

Table 3 reports the estimated coefficients based on the GMM-SYS estimator proposed by Blundell and Bond (1998). This estimator is efficient in the sense that it exploits the maximum number of moment conditions under certain conditions, where $\log(Q)$, Rd/Ta and Pat/Rd are instrumented with their lagged levels and first differences[5]. The Sargan test statistics are distributed in χ^2 distribution under the null. Our test results indicate that the extended set of instrument is appropriate and not rejected by the test of over-identifying restrictions. The rows labeled "arm1" and "arm2" represent the tests for first-order and second-order serial correlation in the first-differenced residuals which are asymptotically distributed as N(0,1) under the null of no serial correlation[6].

[5]In practice, the number of orthogonality conditions may have to be limited due to computational problem. For this reason, we added $SlCit/Pat$, $ExCit/Pat$, $INVT/APPT$, and $APPT$ in instrument set.

[6]These tests report the absence of first-order and second-order serial correlation in the first-differenced residuals. If the disturbances ϵ are not serial correlated, there should be evidence of significant negative first order serial correlation in differenced residuals (i.e., $\hat{\epsilon}_{it} - \hat{\epsilon}_{it-1}$), and no evi-

In most of the cases of Table 3, these statistics are consistent with the assumption of no serial correlation in ϵ in equation (4).

Table 3 is generally consistent with our preliminary findings in Table 2. For example, the coefficients of $SlCit/Pat$ show strong positive effects on the market value while the $ExCit/Pat$ coefficients do not. The coefficients for $INVT/APPT$ and $(INVT/APPT)^2$ have negative and positive signs respectively as they did in Table 2. However, when the correlated dynamic effects and the endogeneity problems for $\log(Q)$, Rd/Ta and Pat/Rd controlled for, the dynamic panel estimators evidently indicate different effects for the patterns of citations related to the technology fields. The estimated coefficients for *SlCitSame* and *SlCitGrp* remain both significant and positive in Column (3), (4), (6), (7) and (8), suggesting that self-citations convey "importance" information to market not only in the citations to the firm's same technology fields, but also to the firm's patent portfolio. In contrast, the effects of external-citations are quite mixed. The estimates of *ExCitSame* in Column (3), (5) and (9) become significant and negative, whereas those of *ExCitGrp* in Column (6) and (8) retain their positive signs from Table 2. This difference in the signs of coefficients between *ExCitSame* and *ExCitGrp* may arise because the two types of external citations convey different information to the market. Patel and Ward (2011) discussed the differing influence between the citations from competitors to the same technology field of patents held by a firm and those to this firm's patent portfolio. They argue that the former indicates to future competition in the technology field and reduces the firm's market value. The latter confers a message of "importance" to an area of technology in which the firm has already built their patent portfolio or intellectual property. Our results confirm with their findings for the US pharmaceutical industry. Thus, weak effects of $ExCit/Pat$ on market performance may reflect this contradictory relationship between the two types of external citations.

Lastly, the coefficients of *ExPGrp* in Column (8), (9) and (11) show significantly negative effects, suggesting that patenting by competitors to the firm's patent portfolio reduces its market value consistent with competition in innovation markets.

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dence of second order serial correlation in the differenced residuals.

4.3 Sensitivity Analysis across Industries

In order to test if the estimated results are sensitive across industries, we repeat the analysis separately for several most cited industries: chemicals, machinery and automotive, and precision and electric machinery. These industries represent 80% of all citations in the sample period. Table 4 reports the GMM-SYS estimates for these industries.

Sargan test suggest that the null hypothesis of over-identifying restrictions is not rejected and tests of "arm1" and "arm2" indicate that the estimator's assumption for ϵ in equation (4) is not rejected. Column (6) to Column (16) report estimated results from investigating the effects of citation patterns in electric machinery, automotive and precision instruments industries. The coefficients of $INVT/APPT$ and $(INVT/APPT)^2$ have the negative and positive signs respectively that we expected. The estimated results for *SlCitSame*, *ExCitSame*, *SlCitGrp* and *ExCitGrp* are also consistent with those we found in Table 3, although the coefficient of $ExGrp/Cit$ is not significant in the Machinery and Precision Instruments industries. On the other hand, the results for Chemicals in columns between Column (2) and (6) contradict our main findings in full sample not only for the signs of $INVT/APPT$ and $(INVT/APPT)^2$, but also for those of *SlCitSame* and *SlCitGrp*. Especially, they turns to significantly negative for both of the coefficients of *SlCitSame* and *SlCitGrp* in columns (3) and (4). However, $ExPGrp/Pat$ takes on the result found in Table 3.

Cohen et al. (2000) distinguishes between "complex" versus "discrete" product industries on the basis whether a new, commercializable product or process is comprised of numerous separately patentable elements versus relatively few. In the US, for example, new drugs or chemicals typically are characterized as "discrete" as they are comprised of a relatively small number of patentable elements. In contrast, electronic products, such as semiconductors, are characterized as "complex" as they tend to be comprised of a larger number of patentable elements. These "complex" product industries are industries where a single product can contain intellectual property covered by thousands of patents held by hundreds of patent holders. In such industries, patent portfolios often serve the defensive function of facilitating cross-licensing negotiations.

Our results may reflect the fact that effects of portfolio strategy for Japanese companies may be different on their market value. For "discrete" industries, i.e., Chemicals, continually exploring a new technology field may be critical and important in the firm's innovation strategy. More self-citations to the same technology field or portfolio may mean less innovation in the new product, which may undermine its market value. However, these citations may raise its Tobin's q for "complex" because a larger scale of portfolios or intellectual property can strengthen a firm's position in cross-licensing negotiations.

5 Conclusions

In this paper, we investigate how competition in innovation markets affects the market value of publicly traded companies in Japan. We utilize a strategy of building measures based on citation patterns based on patent classification system that are related to competition in narrow areas of science. Our preferred estimator considers the correlated dynamic effects and the endogeneity issues inherent in the market-value function.

Our findings revealed that self-citations have the dominant effect on Tobin's q in Japanese firms. However, this dominant effect is mainly associated with self-citations to the same technology fields as measured by either citations to individual patents or to areas in its patent portfolio where it has developed expertise. At the same time, a firm's market value tends to decrease when its patent portfolio is cited by competitive inventors.

Our empirical results also suggested that the number of inventors listed in patents applied for play important role on the firm's market values. This effect varies along with an inverse squared function change.

Lastly, we also examined the effects of competition patenting on the firm's market value. Our results indicated that patenting by competitors to the firm's patent portfolio increases competition and destroys its performance in the market.

References

[1] Abel, Andrew B. and Oliver J. Blanchard (1986), "The present value of profits and cyclical movements in investment," *Econometrica* Vol. 54, pp. 249–273

[2] Albert, M., D. Avery, F. Narin and P. McAllister (1991), "Direct validation of citation counts as indicators of industrially important patents," *Research Policy*, Vol. 20, pp. 251–259

[3] Arellano, Manuel and Stephen Bond (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations," *Review of Economic Studies*, 58, pp. 277–297

[4] Arellano, Manuel and O. Bover (1995), "Another look at the instrumental-variable estimation of error-components models," *Journal of Econometrics*, 68, pp. 29–52

[5] Blundell, R. W. and Stephen Bond (1998), "Initial conditions and moment restrictions in dynamic panel data models," *Journal of Econometrics*, 87, pp. 115–143

[6] Blundell, R., S. Bond, M. Devereux, and F. Schiantarelli (1992), "Investment and Tobin's Q: Evidence from company panel data," *Journal of Econometrics*, Vol. 51, pp. 233-257

[7] Bond S. and J. Cummins (2001), "Noisy share prices and the Q model of investment," IFS Working Paper 01/22

[8] Branstetter, Lee G., Raymond Fisman and C. Fritz Foley (2004), "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data," *The Quarterly Journal of Economics*, Vol. 121, Issue 1, pp. 321–349

[9] Bloom, M. and J. van Reenen (2002), "Patents, real options and firm performance," *Economic Journal*, Vol. 112, pp. 97–116

[10] Ceccagnoli, Marco (2006), "Appropriability and Firm Performance," mimeo

[11] Chung, Kee H. and Stephen W. Pruitt (1994), "A simple approximation of Tobin's q," *Financial Management*, Vol. 23, pp. 70-74

[12] Cohen, Wesley M., R. Nelson and J. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent or not," NBER Working Paper 7552

[13] Cohen,Wesley M., A. Goto, A. Nagata, R. Nelson and J. Walsh (2002), "R&D spillovers, patents and the incentives to innovate in Japan and the United States," *Research Policy*, vol. 31, pp.1349-1367

[14] DaDalt, Peter J., Jeffrey R. Donaldson, and Jacqueline L. Garner (2003), "Will any q do?" *Journal of Financial Research* Vol. 26), pp. 535–551

[15] Goto, Z. and K. Motohashi (2007), "Development and Innovation of a patent database," The Web Side of *The Institute of Intellectual Property (IIP)*

[16] Greenhalgh, C. and M. Rogers (2007), "The value of intellectual property rights to firms," Oxford Intellectual Property Research Centre Working Paper

[17] Griliches, Z. (1981), "Market value, R&D, and patents," *Economic Letters*, Vol. 7, pp. 183–187

[18] Hall, B. (2000), "Innovation and market value" in R. Barrel, G.Mason and M. O'Mahoney ed., *Productivity, innovation and economic performance*, Cambridge UK, Cambridge University Press

[19] Hall, B., A. Jaffe and M. Trajtenberg (2000), "Market value and patent citations: A first look," NBER Working Paper 7741

[20] Hall, B., A. Jaffe and M. Trajtenberg (2005), "Market value and patent citations," *RAND Journal of Economics*, Vol. 36, pp. 16–38

[21] Hall, B., G. Thoma and S. Torrisi (2007), "The market value of patents and R&D: Evidence from European firms," NBER Working Paper 13426

[22] Jaffe, A. B. (1986), "Technological opportunity and spillovers of R&D: evidence from firms' patents, profits, and market values," *American Economic Review*, Vol. 76, pp: 984–1001

[23] Japanese Electrical and Electronic Informantion Union, (2008), "Survey on career development of high value-added engineers," *Chousa Jihao* No. 374, pp: 1–403. (in Japanese)

[24] MaGahan, Anite M. and Brian S. Silverman (2006), "Profiting from technological innovation by others: The effect of competitor patenting on firm value," *Research Policy*, Vol. 35, pp. 1222–1242

[25] Munari, F., E. Roberts and M. Sobrero (2002), "Privatization processes and the redefinition of corporate R&D boundaries," *Research Policy*, vol. 33, pp. 33–55

[26] Nakanishi, Y. and S. Yamada (2007), "Market value and patent quality in Japanese manufacturing firms," MPRA Paper No. 10790

[27] Patel, Darshak and Michael R. Ward (2011), "Using patent citation patterns to infer innovation market competition," *Research Policy*, Vol. 40, pp. 886–894

[28] Perfect, Steven B. and Kenneth W. Wiles (1994), "Alternative construction of Tobin's q: An empirical comparison." *Journal of Empirical Finance* Vol. 1, pp. 313–341

[29] Reitzig, M. (2004), "Improving patent valuations for management purpose–validating new indicators by analyzing application rationales," *Research Policy*, 33, pp. 939–957

[30] Trajtenberg, M. (1990), "A penny for your quotes: Patent citations and the value of innovations," *RAND Journal of Economics*, 21, pp. 172–187

[31] Trajtenberg, M., R. Henderson and A. Jaffe (1997), "University versus corporate patents: A window on the basicness of invention," *Economics of Innovation and New Technology*, 5, pp. 19–50

[32] van Zeebroeck, Nicolas, and Bruno Van Pottelsberghe (2011), "The vulnerability of patent value determinants," *Economics of Innovation and New technology*, Vol. 20, pp. 283–308

Figure 1: Histogram of ITC Groups

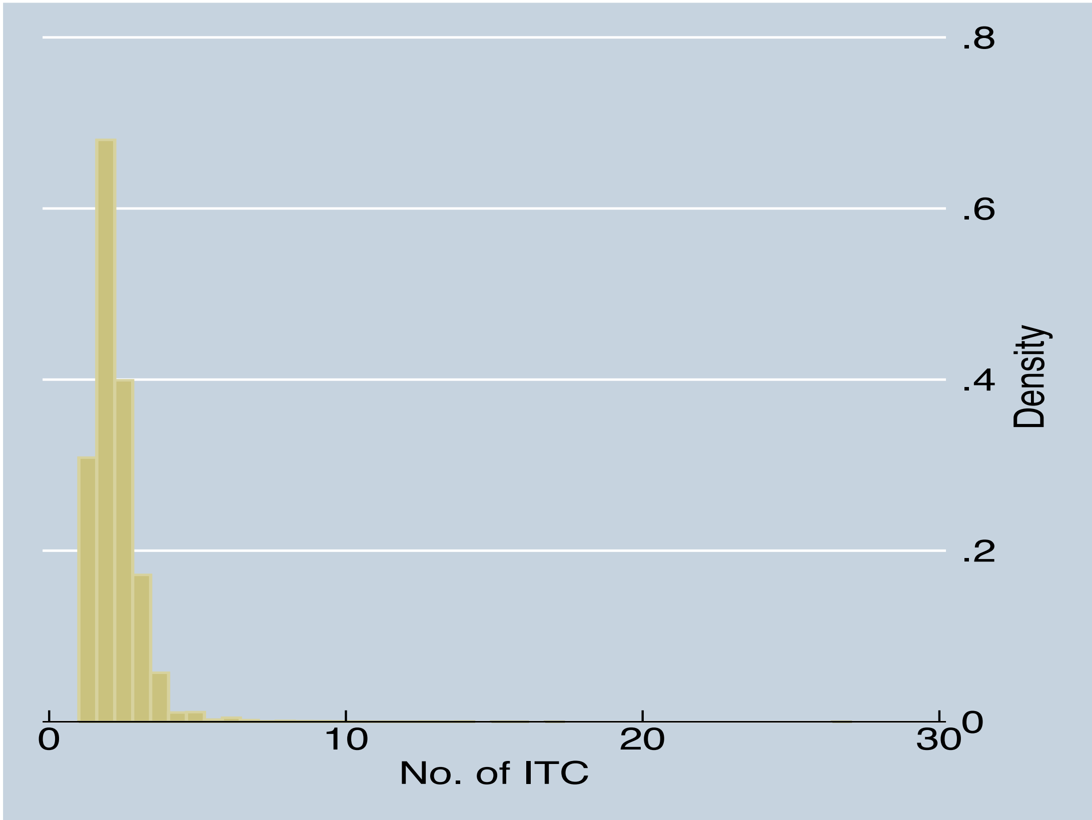

Figure 2: Histogram of Inventors

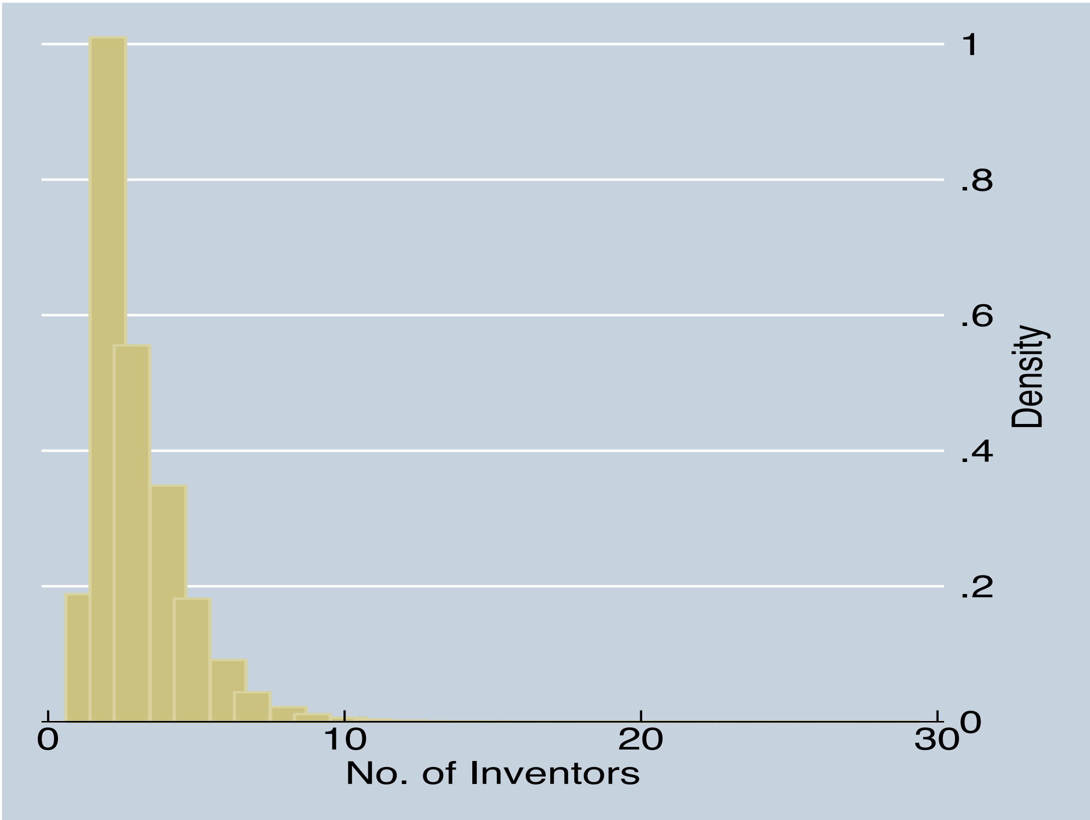

Figure 3: Histogram of Applicants

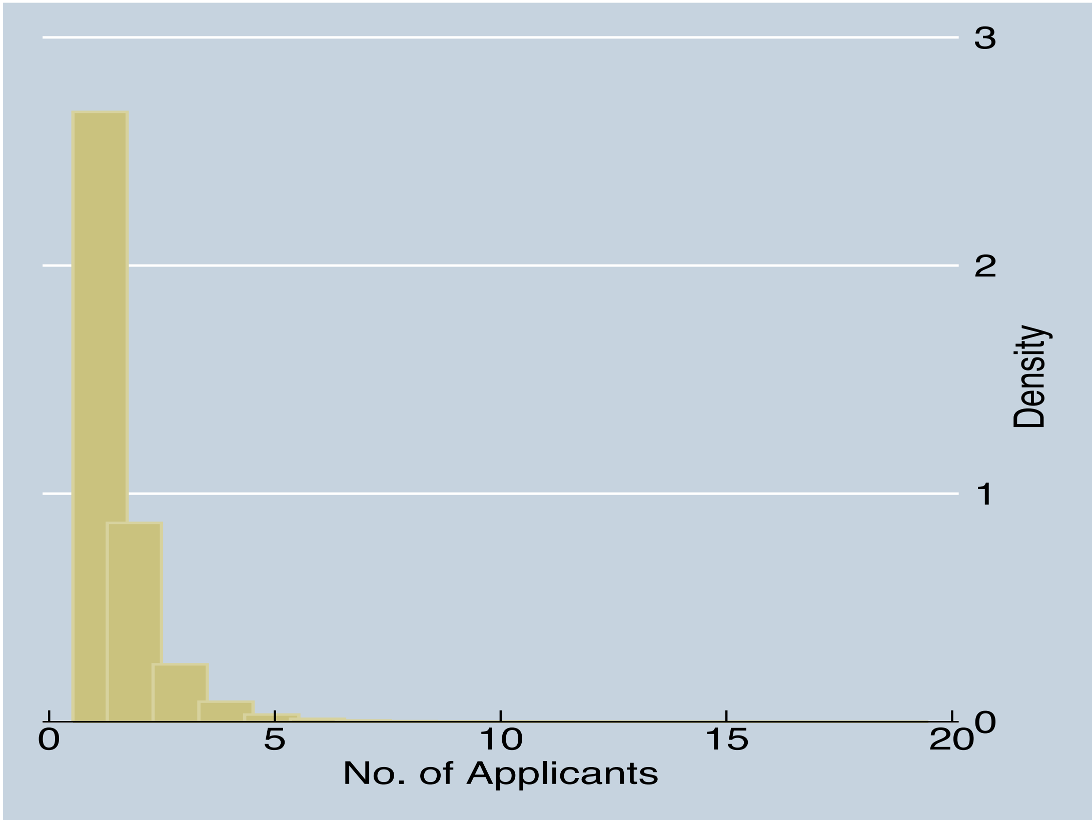

Table 1 Descriptive Statistics

Variable	No. of Obs.	Mean	Std. Dev	Min	Max
$\log(Q)$	17285	0.04	0.51	-7.84	3.51
Ta	17284	211117.70	574106.80	271.00	10700000.00
Rd	17285	26613.17	143369.90	0.10	3417769.00
Pat	17285	750.26	3375.08	0.00	78791.16
$SlCit$	17285	255.48	1192.28	0.00	22475.90
$ExCit$	17285	897.81	4530.49	0.00	86073.15
$SlCit$	17285	235.89	1272.59	0.00	34058.72
$ExPGrp$	17285	1090.18	4796.58	0.00	104780.90
$SlGrp$	17285	8.00	87.38	0.00	3289.55
$ExGrp$	17285	32.77	339.95	0.00	8656.10
$INVT$	17285	3.70	1.52	1.00	35.00
$APPT$	17285	1.24	0.55	1.00	18.00

Table 2 Fixed Effect Estimates of Market Value of JPO Patents

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Rd/Ta	0.2276	0.2053	0.2262	0.2050	0.2334	0.2286	0.1478	0.1769	0.2012	0.1491	0.1429	0.2305	0.2548	0.2574	0.2530
	(2.4)	(2.2)	(2.4)	(2.2)	(2.5)	(2.4)	(1.6)	(1.9)	(2.1)	(1.6)	(1.5)	(2.9)	(3.2)	(2.7)	(2.7)
Pat/Rd	0.0002	0.0001	0.0000	0.0001	0.0002	0.0002	-0.0002	-0.0002	0.0000	-0.0002	-0.0001	0.0000	0.0000	0.0000	0.0000
	(0.2)	(0.1)	(0.0)	(0.1)	(0.1)	(0.2)	(-0.1)	(-0.1)	(0.0)	(-0.2)	(-0.1)	(0.0)	(0.0)	(0.0)	(0.0)
$INVT/APPT$	-0.0242	-0.0236	-0.0230	-0.0236	-0.0252	-0.0242	-0.0255	-0.0252	-0.0252	-0.0255	-0.0253	-0.0241	-0.0247	-0.0251	-0.0246
	(-2.0)	(-2.0)	(-1.9)	(-2.0)	(-2.1)	(-2.0)	(-2.2)	(-2.1)	(-2.1)	(-2.2)	(-2.1)	(-2.2)	(-2.2)	(-2.1)	(-2.1)
$(INVT/APPT)^2$	0.0024	0.0024	0.0023	0.0024	0.0025	0.0024	0.0026	0.0026	0.0025	0.0026	0.0025	0.0024	0.0025	0.0025	0.0025
	(1.8)	(1.7)	(1.7)	(1.7)	(1.8)	(1.7)	(1.9)	(1.9)	(1.8)	(1.8)	(1.8)	(1.9)	(1.9)	(1.8)	(1.8)
$APPT$	-0.0040	-0.0037	-0.0033	-0.0038	-0.0039	-0.0038	-0.0043	-0.0042	-0.0042	-0.0044	-0.0043	-0.0047	-0.0047	-0.0052	-0.0048
	(-0.7)	(-0.7)	(-0.6)	(-0.7)	(-0.7)	(-0.7)	(-0.8)	(-0.8)	(-0.8)	(-0.8)	(-0.8)	(-0.8)	(-0.8)	(-0.9)	(-0.9)
$SlCit/Pat$	0.0000														
	(3.0)														
$ExCit/Pat$	0.0000														
	(-1.4)														
$SlCitSame/Cit$		0.1064	0.2746	0.1068								0.1027			
		(3.9)	(8.0)	(3.9)								(4.8)			
$ExCitSame/Cit$		-0.0026			0.0543	-0.0106							-0.0183		
		(-0.2)			(1.3)	(-0.7)							(-1.3)		
$(SlCitSame/Cit)^2$			-0.1200												
			(-6.8)												
$(ExCitSame/Cit)^2$					-0.0399										
					(-1.7)										
$SlGrp/Cit$							6.1594	32.005	14.949						
							(3.4)	(10.8)	(8.7)						
$ExGrp/Cit$							8.0210			15.244	9.8666				
							(9.5)			(10.8)	(14.4)				
$(SlGrp/Cit)^2$								-650.0							
								(-6.2)							
$(ExGrp/Cit)^2$										-110.0					
										(-4.4)					
$ExPGrp/Pat$												0.0185	0.0192	0.0285	0.0189
												(6.5)	(6.7)	(6.9)	(6.6)
$(ExPGrp/Pat)^2$														-0.0011	
														(-4.8)	
No. of Obs.	16098	16098	16098	16098	16098	16098	16098	16098	16098	16098	16098	16098	16098	16098	16098

(1). Student–t statistics in the parenthesis.

(2). Year dummies are included in the regressions.

Table 3 Dynamic Panel Estimates of Market Value of JPO Patents

Variable	I	II	II	IV	V	VI	VII	VIII	IX	X
log(Q)										
L1.	0.6728	0.6777	0.6781	0.6775	0.6563	0.6706	0.6762	0.6762	0.6560	0.6765
	(634.1)	(564.5)	(566.9)	(651.1)	(583.8)	(594.9)	(563.9)	(676.1)	(591.8)	(672.8)
L2.	0.0137	0.0113	0.0115	0.0140	-0.0046	0.0026	0.0104	0.0143	-0.0039	0.0143
	(18.9)	(13.1)	(13.9)	(21.3)	(-6.8)	(4.2)	(12.2)	(20.2)	(-6.1)	(20.2)
Rd/Ta										
–.	0.0827	0.0845	0.0882	0.0763	0.1662	0.1426	0.0507	0.0622	0.1630	0.0624
	(6.3)	(6.2)	(6.4)	(5.9)	(15.8)	(12.5)	(3.6)	(4.8)	(15.3)	(4.7)
L1.	0.2866	0.2574	0.2439	0.3134	0.0960	0.1871	0.2309	0.2939	0.0924	0.2819
	(18.1)	(16.4)	(15.7)	(20.2)	(6.2)	(12.2)	(14.7)	(18.9)	(5.8)	(18.0)
L2.	0.3169	0.3491	0.3570	0.3379	0.1007	0.2518	0.3358	0.3325	0.1006	0.3426
	(29.8)	(30.8)	(31.1)	(30.4)	(9.3)	(21.5)	(28.4)	(29.5)	(9.4)	(30.1)
Pat/Rd										
–.	-0.0140	-0.0149	-0.0144	-0.0155	-0.0139	-0.0143	-0.0148	-0.0155	-0.0140	-0.0152
	(-92.2)	(-94.8)	(-91.2)	(-102.8)	(-87.9)	(-93.3)	(-93.0)	(-100.9)	(-94.2)	(-101.3)
L1.	0.0025	0.0026	0.0022	0.0033	0.0015	0.0020	0.0027	0.0036	0.0016	0.0034
	(21.5)	(22.1)	(19.2)	(28.1)	(13.1)	(17.4)	(23.5)	(30.6)	(13.9)	(30.0)
L2.	0.0059	0.0060	0.0060	0.0060	0.0061	0.0061	0.0060	0.0060	0.0061	0.0059
	(163.2)	(165.4)	(164.0)	(170.0)	(187.7)	(175.0)	(157.1)	(164.1)	(220.0)	(163.4)
$INVT/APPT$	-0.0056	-0.0101	-0.0093	-0.0056	-0.0159	-0.0132	-0.0089	-0.0031	-0.0145	-0.0024
	(-3.0)	(-5.4)	(-5.0)	(-3.1)	(-9.4)	(-7.8)	(-4.9)	(-1.7)	(-8.3)	(-1.3)
$(INVT/APPT)^2$	0.0008	0.0015	0.0014	0.0009	0.0022	0.0018	0.0015	0.0007	0.0020	0.0006
	(3.4)	(6.4)	(5.9)	(3.8)	(9.4)	(8.0)	(6.3)	(2.8)	(8.5)	(2.5)
$APPT$	-0.0061	-0.0067	-0.0065	-0.0058	-0.0054	-0.0061	-0.0048	-0.0046	-0.0054	-0.0046
	(-10.7)	(-10.8)	(-10.4)	(-10.4)	(-10.0)	(-11.0)	(-7.7)	(-7.9)	(-9.9)	(-8.0)
$SlCit/Pat$	0.0669									
	(27.8)									
$ExCit/Pat$	0.0000									
	(0.0)									
$SlCitSame/Cit$		0.1071	0.1069				0.1581			
		(49.7)	(49.2)				(62.8)			
$ExCitSame/Cit$		-0.0124		-0.0446				-0.0310		
		(-4.0)		(-15.8)				(-10.6)		
$SlGrp/Cit$					1.4946	6.4584				
					(14.6)	(63.7)				
$ExGrp/Cit$					5.0043				5.5869	
					(62.5)				(81.3)	
$ExPGrp/Pat$							-0.0147	-0.0099		-0.0097
							(-30.4)	(-21.5)		(-21.2)
No. of Obs.	12261	12261	12261	12261	12261	12261	12261	12261	12261	12261
arm1	-11.76	-11.77	-11.77	-11.78	-11.78	-11.79	-11.77	-11.77	-11.77	-11.77
arm2	1.41	1.46	1.46	1.39	2.00	1.78	1.48	1.39	1.97	1.39
Sargan test	1068.1	1062.7	1062.7	1072.4	1054.2	1060.8	1066.8	1063.3	1053.1	1061.9
(Degrees of freedom)	(1054)	(1054)	(1055)	(1055)	(1054)	(1055)	(1054)	(1054)	(1055)	(1055)

Note (1). Linear dynamic panel-data estimation based on Arellano and Bover(1995), Blundell and Bond (1998) where Rd/Ta and Pat are treated as endogenously.

(2). Student–t statistics in the parenthesis.

(3). Year dummies are included in the regressions.

Table 4 Dynamic Panel Estimates of Market Value of JPO Patents for Selected Industries

	Chemicals					Machinery and Automotive					Precision Instruments and Electric Machinery				
Variable	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
log(Q)															
L..	0.5912	0.6019	0.5997	0.5913	0.5935	0.6320	0.6339	0.6343	0.6314	0.6233	0.6733	0.6737	0.6759	0.6652	0.6733
	(108.7)	(115.9)	(97.0)	(116.1)	(129.7)	(266.5)	(250.9)	(239.0)	(310.2)	(227.5)	(329.6)	(303.0)	(303.1)	(242.2)	(287.9)
L2.	0.0552	0.0514	0.0551	0.0517	0.0575	0.0056	0.0062	0.0044	0.0077	0.0132	-0.0123	-0.0026	-0.0080	-0.0153	-0.0065
	(14.2)	(13.0)	(12.3)	(13.1)	(16.1)	(2.5)	(3.0)	(2.2)	(4.5)	(5.7)	(-6.8)	(-1.5)	(-3.7)	(-9.7)	(-3.6)
Rd/Ta	-1.0319	-0.5095	-0.9748	-0.8229	-1.1649	0.6960	0.6796	0.7621	0.7065	0.5922	0.6692	0.7483	0.7294	0.8761	0.7968
	(-4.1)	(-2.0)	(-4.2)	(-3.2)	(-4.6)	(9.5)	(8.6)	(8.1)	(9.6)	(6.8)	(14.8)	(15.2)	(15.6)	(16.5)	(18.6)
L..	0.6488	0.4265	1.2089	0.8470	1.2422	0.1758	0.2486	0.1154	0.1816	0.2132	-0.4502	-0.4796	-0.5202	-0.7281	-0.5170
	(2.0)	(1.1)	(4.6)	(2.6)	(4.4)	(1.7)	(2.3)	(1.0)	(2.2)	(2.0)	(-10.8)	(-9.6)	(-10.0)	(-17.0)	(-11.7)
L2.	0.8944	0.6550	0.2840	0.4768	0.4838	-0.2822	-0.3149	-0.2855	-0.2586	-0.1919	0.1947	0.1377	0.1744	0.1159	0.1483
	(3.3)	(2.4)	(1.4)	(3.5)	(2.3)	(-5.6)	(-5.2)	(-6.9)	(-5.6)	(-4.7)	(5.4)	(3.9)	(3.9)	(3.1)	(3.7)
Pat/Rd	0.0940	0.0534	0.0760	0.0562	0.0550	-0.0517	-0.0482	-0.0480	-0.0488	-0.0512	-0.0149	-0.0165	-0.0157	-0.0155	-0.0158
	(3.1)	(1.7)	(2.4)	(1.8)	(1.4)	(-30.9)	(-27.0)	(-26.5)	(-28.4)	(-30.2)	(-57.2)	(-56.9)	(-60.2)	(-52.4)	(-59.3)
L..	-0.1114	-0.0788	-0.0830	-0.0665	-0.0860	0.0289	0.0274	0.0269	0.0274	0.0315	0.0064	0.0079	0.0074	0.0071	0.0075
	(-6.7)	(-3.5)	(-4.5)	(-3.4)	(-4.8)	(31.2)	(32.8)	(26.9)	(31.3)	(26.9)	(32.5)	(29.5)	(28.5)	(27.7)	(33.9)
L2.	0.0560	0.0532	0.0522	0.0492	0.0535	-0.0046	-0.0039	-0.0040	-0.0044	-0.0003	0.0042	0.0041	0.0041	0.0042	0.0041
	(8.9)	(6.2)	(7.5)	(6.9)	(6.4)	(-16.6)	(-13.1)	(-13.6)	(-16.2)	(-0.9)	(71.0)	(92.4)	(90.1)	(103.9)	(93.5)
$INVT/APPT$	0.0997	0.0487	0.0565	0.0531	0.0765	-0.0874	-0.0918	-0.0946	-0.0941	-0.0923	-0.0249	-0.0107	-0.0179	-0.0133	-0.0142
	(8.4)	(3.7)	(3.2)	(3.4)	(4.9)	(-18.5)	(-17.5)	(-20.5)	(-21.3)	(-18.8)	(-4.9)	(-2.4)	(-4.1)	(-3.3)	(-3.1)
$(INVT/APPT)^2$	-0.0120	-0.0056	-0.0068	-0.0063	-0.0089	0.0114	0.0120	0.0124	0.0122	0.0124	0.0056	0.0043	0.0051	0.0045	0.0044
	(-7.9)	(-3.4)	(-3.2)	(-3.3)	(-4.5)	(16.0)	(16.1)	(17.8)	(19.4)	(19.1)	(12.8)	(7.8)	(8.5)	(8.7)	(8.1)
$APPT$	0.0316	0.0315	0.0287	0.0284	0.0288	-0.0276	-0.0251	-0.0248	-0.0283	-0.0226	0.0702	0.0658	0.0708	0.0655	0.0656
	(6.2)	(7.0)	(5.9)	(5.1)	(5.6)	(-8.9)	(-8.1)	(-8.0)	(-8.3)	(-7.1)	(12.2)	(11.9)	(13.3)	(9.5)	(11.0)
$SlCitSame/Cit$	-0.1879					0.1036					0.3598				
	(-9.4)					(15.9)					(20.7)				
$ExCitSame/Cit$		-0.0185					-0.0542					-0.0735			
		(-0.9)					(-4.2)					(-6.2)			
$SlGrp/Cit$			-3.9854					2.2808					3.8655		
			(-2.2)					(1.7)					(3.9)		
$ExGrp/Cit$				4.1469					0.1000					5.4641	
				(3.2)					(0.1)					(12.9)	
$ExPGrp/Pat$					-0.0109					-0.0236					0.0039
					(-4.3)					(-13.8)					(3.0)
No. of Obs.	1715	1715	1715	1715	1715	2321	2321	2321	2321	2321	2483	2483	2483	2483	2483
arm1	-2.46	-2.48	-2.48	-2.47	-2.47	-4.87	-4.88	-4.89	-4.87	-4.84	-8.09	-8.15	-8.17	-8.16	-8.16
arm2	-0.45	-0.31	-0.25	-0.27	-0.33	-0.30	-0.33	-0.29	-0.35	-0.45	2.47	2.31	2.39	2.49	2.37
Sargan test	130(349)	115(349)	124(349)	117(349)	125(349)	201(349)	203(349)	202(349)	201(349)	201(349)	213(349)	213(349)	208(349)	209(349)	209(349)

Note (1). Linear dynamic panel-data estimation based on Arellano and Bover(1995), Blundell and Bond (1998) where Rd/A and Pat/Rd are treated as endogenously.

(2). Student–t statistics in the parenthesis.

(3). Year dummies are included in the regressions.

(4). Values in the parenthesis are degrees of freedom under the null hypothesis.

Appendix Table 1 Concordance between the ITC and IPC

ITC	Cat. Code (Hall et al. (2001))	IPC
1	6	A01(excl. A01N)
2	6	A21-A24
3	6	A41-A47
4	3	A61-A63(excl. A61K)
5	3	A61K
6	1	B01-B09
7	5	B21-B23
8	5	B24-B32(excl. B31)
9	6	B41-B44
10	5	B60-B64
11	5	B65-B68
12	1	C01-C05
13	1	C07, A01N
14	1	C08
15	1	C09-C11
16	3	C12-C14
17	3	C12N15
18	5	C21-C30
19	6	D01-D07
20	6	D21, B31
21	6	E01-E06
22	6	E21
23	5	F01-F04, F15
24	5	F16-F17
25	6	F21-F28
26	6	F41-F42, C06
27	4	G01-G03
28	2	G04-G08
29	2	G09-G12
30	4	G21
31	4	H01-H02, H05
32	2	H03-H04
33	6	B81, B82

Appendix Table 2 Citation Shares across Industies

Nikkei Industy Code	Self Citations	External Citations	Specification of Industry
1	0.414	0.375	Food
3	2.519	1.699	Textiles & Apparel
5	0.732	0.727	Pulp & Paper
7	11.442	8.091	Chimicals
9	0.264	0.222	Pharmaceuticals
11	0.048	0.074	Oil & Coal Products
13	2.115	1.284	Rubber Products
15	1.653	1.434	Glass & Ceramics
17	2.585	2.039	Steel Products
19	2.606	2.788	Nonferrous Metals
21	7.877	6.330	Machinery
23	43.837	53.131	Electric Machinery
25	0.191	0.250	Shipbuilding
27	7.878	8.266	Automotive
29	0.378	0.169	Other Transport Equipment
31	8.335	5.780	Precision Instruments
33	3.817	2.653	Other Manufacturing
35	0.005	0.008	Fishery
37	0.030	0.019	Mining
41	0.822	1.362	Construction
43	0.347	0.274	Trading Companies
45	0.006	0.011	Retails
52	0.000	0.007	Financial Services
53	0.001	0.008	Real Estate
55	0.031	0.058	Railway/Bus
57	0.004	0.010	Other Land Transport
59	0.000	0.001	Marine Transport
61	0.003	0.010	air Transport
63	0.000	0.002	Warehousing
65	1.480	1.911	Communications
67	0.082	0.259	Electric Power
69	0.392	0.478	Gas
71	0.106	0.270	Services
Sum	100.000	100.000	All Industries

Appendix Table 3 Correlations of the Variables

	log(Q)	Rd/Ta	Pat/Rd	$SlCit/Pat$	$ExCit/Pat$	$SlCitSame/Cit$	$ExCitSame/Cit$	$SlCitGrp/Cit$	$ExCitGrp/Cit$	$ExPGrp/Pat$	$INVT/APPT$	$APPT$
log(Q)	1.000											
Rd/Ta	0.096	1.000										
Pat/Rd	-0.008	-0.056	1.000									
$SlCit/Pat$	-0.006	-0.005	-0.001	1.000								
$ExCit/Pat$	-0.018	-0.009	-0.001	0.679	1.000							
$SlCitSame/Cit$	0.019	0.178	0.002	-0.007	-0.012	1.000						
$ExCitSame/Cit$	0.033	0.108	-0.008	-0.011	-0.023	-0.130	1.000					
$SlCitGrp/Cit$	0.120	0.219	-0.002	-0.003	-0.005	0.395	-0.065	1.000				
$ExCitGrp/Cit$	0.140	0.311	-0.005	-0.004	-0.006	0.113	0.034	0.656	1.000			
$ExPGrp/Pat$	-0.020	0.035	0.014	-0.011	-0.019	0.121	0.180	0.037	0.070	1.000		
$INVT/APPT$	0.053	0.092	-0.037	-0.008	-0.011	0.111	0.103	0.049	0.030	0.090	1.000	
$APPT$	-0.007	-0.121	-0.012	0.043	0.033	-0.099	0.047	-0.072	-0.067	0.023	-0.137	1.000