Evaluating market power in the telecommunications industry in South Africa

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Contents

List of Figures

List of Tables

1 Introduction

The costs to communicate in South Africa are high, particularly in respect of broadband services (see, for example, Bonakele *et al*, 2014) . There is growing pressure to reduce these costs, both from Parliament[1] and from the sector regulator, the Independent Communications Authority of South Africa (ICASA)[2]. Two recent proposed transactions, the Vodacom/Neotel (ICASA, 2014a) merger and the MTN/Telkom network sharing deal (Lourie, 2014), if approved, will result in significant consolidation of the sector. This might cause costs to communicate to rise even further. In order to reduce the costs of broadband by addressing Telkom's market power, ICASA is currently undertaking a Regulatory Impact Assessment for Local Loop Unbundling (LLU) (ICASA, 2014b).

The central question in this thesis is: to what extent does market power exist in the telecommunications sector in South Africa? This will indicate the extent to which Telkom has market power in respect of fixed lines, and will indicate whether the services provided by Neotel and Vodacom, and Telkom and MTN, overlap. The second question to be addressed in this is: what is the optimal policy response to these level/s of market power, in the context of the political economy of the regulation of the telecommunications sector in South Africa?

An important feature of assessing market power in the telecommunications sector is evaluating the extent of fixed to mobile substitution (FMS). FMS has been analysed by a variety of means, including discrete choice models of demand. These studies usually evaluate the impact of prices and other variables on the choice of service provider. The research proposed here will extend this literature in two ways:

- By measuring the quality of fixed line broadband: while fixed line broadband prices do not vary significantly over time or between different locations, quality, which depends on the physical length of the copper line between households and Telkom exchanges, varies considerably.
- By estimating demand for broadband in South Africa, taking into account the choices faced by South Africans which are fixed lines and mobile broadband. This is unlike previous research, which has focused largely on fixed to mobile voice substitution, and which otherwise examines European countries which have implemented local loop unbundling and often have competing cable and copper fixed line networks, whereas South Africa does not have cable networks.

The first contribution of the research will be evaluating the extent to which Telkom, the fixed line incumbent, has market power. This will include developing a unique quality variable, which involves linking the National Income Dynamics Survey (NIDS) dataset and a dataset on the location and quality of the Telkom network provided by broadbandstats.co.za. The second contribution will be the estimation of demand and assessment of market power by specifying and evaluating a discrete choice model of demand for fixed line and mobile broadband services, using the All Media Products Survey (AMPS) dataset. The third and final contribution will be evaluating optimal approaches to market power in markets for telecommunications services in countries comparable to South Africa.

The rest of this proposal is structured as follows: First, the research question is set out. Next, a review of the existing literature is provided. This is followed by a description of the motivation and methodology for each of the three main contributions. Conclusions are provided in a final section.

2 Research questions

The central question to be addressed is: to what extent does market power exist in the telecommunications sector in South Africa? This will indicate the extent to which fixed line operators, including Telkom and Neotel, have market power and will indicate the extent to which services provided by the mobile operators, including MTN, Vodacom and Cell C have market power. Flowing from this analysis, a second question to be addressed is: how should South Africa go about implementing open access network policies in order to

[1] See, for one example among many, the Parliamentary Portfolio Committee on Communications' hearings on the 'cost to communicate' in South Africa, held in July 2013.

[2] See, for example, ICASA's cost to communicate programme (ICASA, 2013).

address market power in the telecommunications sector in the context of international experience and the political economy of telecommunications regulation in South Africa?

To the extent that mobile broadband is a substitute for fixed line broadband, Telkom would not have market power. However, since Telkom provides the vast majority of fixed lines in South Africa, if mobile broadband were not a substitute for fixed broadband, Telkom would indeed have market market power. The consequences of the results of this analysis are very different in the two cases: in the event that Telkom has market power, there are a range of potential policy interventions that regulators might consider, including local loop unbundling. If Telkom does not have market power, then other policy options are available to reduce the cost to communicate in South Africa, such as more extensive mobile network sharing. The extent of fixed to mobile substitution also has policy implications for the assessment of the MTN/Telkom and Vodacom/Neotel transactions, since this will indicate whether the services offered by these companies compete with one another which in turn will indicate whether the market consolidation will result in a lessening of competition.

The first question (on the extent of market power) will be addressed in two separate contributions:

- Estimating consumer demand for fixed line broadband relative to the outside good (including mobile broadband and not buying broadband) in a discrete choice framework, using National Income Dynamics Survey (NIDS) household data and a unique variable on fixed line broadband quality (distance between household and local exchange).

- Estimating demand for broadband services relative to the outside good (in this case, not buying broadband) in a discrete choice framework using All Media Products Survey (AMPS) data and data on broadband service prices for Telkom, Vodacom, MTN and Cell C.

The third contribution will be to evaluate open access network policy options implemented in other countries that are comparable to South Africa. This will be undertaken by means of a comparative benchmarking approach. A key feature of this analysis will be to examine the political economy of telecommunications regulation in South Africa in order to choose appropriate policies to address market power in the sector.

3 Motivation

Understanding market power in the telecommunications sector in South Africa is an important precursor to evaluating policy options to address high costs to communicate: if there are firms that have market power, then the sources and effects of that market need to be addressed. Understanding market power in respect of broadband services requires, in part, assessing whether fixed line and mobile broadband services are substitutes for one another.

The costs to communicate, in respect of broadband services, are high in South Africa (see, for example, Bonakele *et all*, 2014). South Africa has very high broadband prices relative to its developing/middle income country peers, for services that have relatively slow speeds (see Figure 1).

Moreover, South Africa is falling behind its developing and middle income country peers in respect of broadband speeds: While India was the slowest of the above group of countries historically, India has now caught up to South Africa (see Figure 2). South Africa has significantly slower speeds than the Russian Federation, Brazil, China and Turkey.

There are important policy consequences that flow from the analysis of demand for broadband services, which will include an evaluation of fixed to mobile substitution. If mobile and fixed services largely do not overlap, the Neotel/Vodacom merger may not give rise to significant concerns in markets for retail voice and data services since Vodacom largely offers mobile services while Neotel largely offers fixed line services. Similarly, to the extent that mobile services do not compete with fixed services to any significant extent, the MTN/Telkom transaction raises greater competition concerns since it consolidates spectrum among three large mobile players instead of four, and this number reduces to two large mobile players if Cell C is excluded from the market due to the skewed spectrum and infrastructure holdings arising from the transactions. If fixed services (excluded from the MTN/Telkom transactions) were a substitute for mobile services, there would be greater competition in the market and the MTN/Telkom transaction would be of less concern.

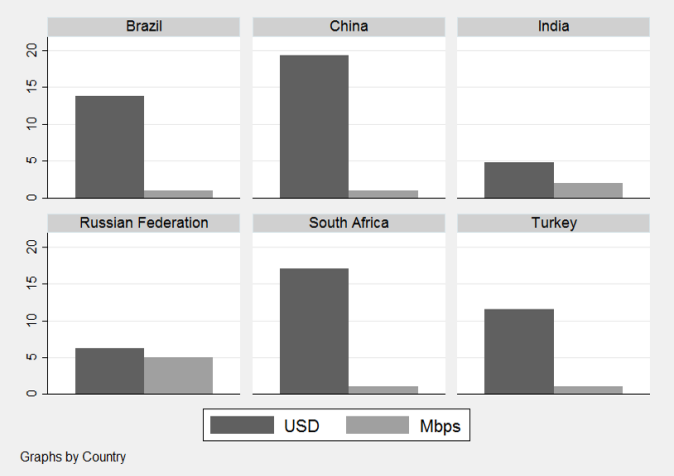


Figure 1: Broadband speeds (Kbps) and prices (USD) in South Africa and in Brazil, China, India, Russia and Turkey (2013)

Source: Analysis of International Telecommunications Union (2014).

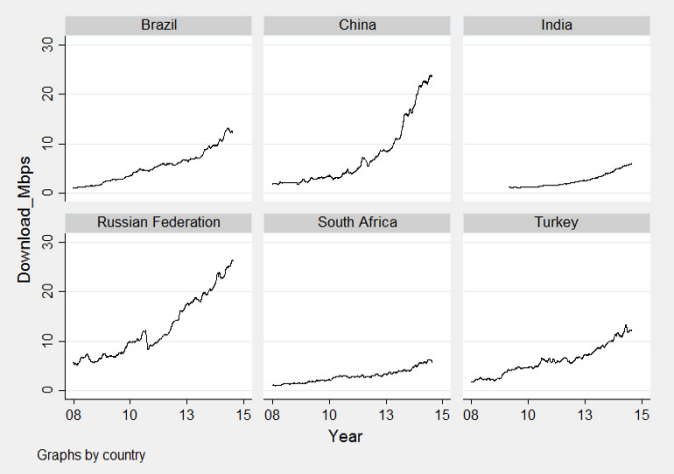


Figure 2: South Africa's broadband speeds compared to those in Brazil, China, India, Russia and Turkey (2008-2015)

Source: Analysis of: Ookla (2015).

Furthermore, if mobile networks constrain fixed line networks sufficiently, local loop unbundling may not be necessary. LLU is a remedy imposed on fixed line networks which gives new entrants access to incumbent fixed lines between customer premises and points of aggregation in the fixed line network (including local exchanges). LLU is imposed on fixed incumbents in the EU and elsewhere to reduce barriers to entry and increase competition for fixed broadband services. To the extent that fixed and mobile services are substitutes, there may be no need to impose LLU since markets for services provided over these different network technologies may be sufficiently competitive.

Finally, evaluating the optimal approach to address market power in the telecommunications sector is a complex question, which requires striking a balance between incentivising new investment and ensuring that consumers and businesses are charged sufficiently low prices. Open access network policies have been implemented in different ways in a significant number of countries. Alternative policy choices implemented in relevant countries comparable to South Africa will be benchmarked in order to address this question.

4 Literature review

4.1 Review of fixed to mobile substitution in developed countries for broadband services

A number of papers have been written on fixed to mobile substitution for voice services, several of which find some degree of fixed to mobile substitution (see, for example, Vogelsang, 2010). There are fewer papers that examine fixed to mobile substitution for broadband. While there are a number of papers that examine the effectiveness of open access policies on broadband outcomes, these largely consider fixed line broadband technologies (including copper and co-axial cable networks).

Nardotto, Valletti and Verboven (2012) analysed broadband penetration and broadband quality across more than 4,265 UK local exchanges, assessing the effect of where new entrants use LLU lines at those exchanges and where the incumbent, BT, provides services directly to customers or provides services indirectly to customers via third parties using a service called Bitstream access. The data was evaluated over 17 periods. The authors further examined the impact of inter-modal competition from cable broadband providers. Their main findings were that LLU does not have an impact on broadband penetration but it does have an impact on broadband quality, as new entrants try to differentiate themselves from their incumbent through broadband speed offerings. Inter-modal competition between cable and DSL has a positive impact on both broadband penetration and on innovation. While the authors do not assess the extent to which mobile broadband is a substitute for fixed line broadband, to the extent that LLU has improved quality, this suggests that competition between fixed line operators plays an important role on quality adjusted prices in the sector. This indicates that mobile broadband may not sufficiently discipline incumbent fixed line broadband providers.

Grzybowski and Verboven (2014) assess fixed and mobile substitutability for broadband and voice services among 160,363 households in 27 EU countries between 2005 and 2011 using a discrete choice model of demand. The authors find that the services are perceived as substitutes over time on average but that there is significant heterogeneity between countries, and the extent of substitutability is a relatively recent phenomenon. For example, they find that while fixed and mobile services may be substitutes in Central and Eastern European countries including Romania, Lithuania and the Czech Republic, these services are weak complements in Sweden, the Netherlands and Malta. At the same time, the demand for each type of service is independent in the UK, Luxembourg and Slovenia. Including fixed line broadband in their analysis introduces greater complementarity between fixed and mobile services. The authors find that the introduction of fixed line broadband has slowed FMS. The authors used household survey data (the Eurobarometer) and price data from Teligen. Prices used were composite price bundles for services, including usage and access charges. Instead of assessing whether mobile voice and fixed voice services are substitutes by themselves, their model allows households to choose bundles of fixed voice and mobile voice services, as well as choose different providers including incumbent and competitor fixed or mobile providers. The model is further extended for households to choose between different types of internet, including DSL, dial-up, mobile broadband, cable, other (including satellite, wifi, etc.) and no internet. The authors find that having a mobile broadband connection makes fixed and mobile services greater substitutes while having

a fixed line broadband connection makes fixed lines and mobiles strong complements. They further find that fixed and mobile services offered by the incumbent are viewed as complements rather than substitutes. This is because consumers generally see fixed and mobile voice services as substitutes but once fixed line broadband is taken into account, fixed and mobile services become complements.

In general, the quality of fixed line and mobile services have not featured strongly in the literature, whether for voice or for broadband services. Vogelsang (2010) finds overall that prices for mobile network services have declined significantly over time while quality improved, and this has fostered greater fixed to mobile substitution. Nonetheless, this has not been tested empirically: while Nardotto *et al* (2013) examine the quality of fixed line broadband, they do not test this against the quality of mobile broadband.

4.2 Measurement of fixed and mobile substitution in developing countries

The analysis of fixed to mobile substitution in developing countries largely concerns voice services. There are important differences between assessing fixed to mobile substitution in developed and developing countries. One of these differences relates to supply-side differences. Vogelsang (2010) finds that relatively little work in this area has been undertaken. FMS might be taking place due to falling costs for mobile networks, which means that mobile operators can reduce their prices and cause customers to switch away from fixed line networks. Relative price declines for mobile services might arise from cost reductions arising from technical progress and/or economies of scale and scope andor greater competition. Mobile networks are significantly cheaper to build than the replacement cost of fixed line networks. The fixed costs of fixed line networks in developed countries have largely been recovered already, and they are therefore regulated at incremental cost, which makes them relatively cheap. Fixed line networks are still being built in developing countries, however, and their costs may be higher. Therefore, while mobile networks might not be significantly cheaper than fixed networks in developed countries, there may be significant differences in costs between fixed and mobile networks in developing countries.

Hamilton (2003) evaluates fixed and mobile substitution across 23 African countries between 1985 and 1997. The study measured the impact of mobile penetration (subscriptions / population * 1000), GDP per capita, institutional factors (using the International Country Risk Guide), economic freedom, democracy, extent of urbanisation and trade on fixed line penetration (measure in two ways: fixed telephone lines supplied / population, and demand for fixed telephone lines / population). She finds that mobile penetration is positively associated with fixed line penetration for most specifications of her model, which supports the hypothesis that mobile networks and fixed line networks are complements. This might be because greater competition from mobile operators induces fixed operators to invest in their networks and improve the quality of their services, which in turn causes fixed line networks to expand. She finds however considerable variability in her results over time (she finds much stronger complementarity in 1987 than she does in 1997) and between countries. She also finds some evidence of substitutability between fixed lines and mobile phones as penetration of mobile phones grows.

Narayana (2008) estimates fixed and mobile substitutability in India using a logit model of demand, and estimates the impact of relative prices for mobile services on the demand for fixed lines in addition to estimating the impact of relative prices for fixed line services on the demand for mobile services. In addition to access and usage prices, Narayana (2008) used income, family size, age, education, caste and occupation as explanatory variables. For usage charges, Narayana finds very high and positive levels of cross-price elasticities between mobile and fixed line services in both directions, which suggests that the two services are substitutes. However, access charges for each type of service do not appear to explain demand for the other service.

Ward & Zheng (2012) evaluate own-price and cross-price elasticities of demand for fixed and mobile telephony in 31 provinces in China between 1998 and 2007. They find that the two services are substitutes. For access charges, the authors use Average Revenue Per User (ARPU) while for usage they use Average Revenue Per Minute (ARPM). The authors use changes in state ownership and concentration in neighbouring provinces as instrumental variables for prices to deal with the endogeneity problem between quantity and prices and estimate own price and cross-price elasticities using Generalised Method of Moments (GMM).

4.3 Evaluations of open access policies

One of the key potential interventions to achieve competitive outcomes in markets for broadband services is local loop unbundling (LLU) and open access network policies more generally. Unbundling of the local loop is a regulatory process which allows several internet service providers to use the copper lines between the fixed line operator's nearest point of network aggregation (usually a local exchange) and the end-customer's premises. This notion is applied to mobile networks in the form of facilities leasing rules (such as mast sharing and radio access network sharing), roaming regulations and mobile virtual network operator (MVNO) regulations. Unbundling of the local loop is intended to facilitate services-based competition, innovation, lower prices and offer consumers and businesses a variety of access options for ICT services.

While the impact of LLU interventions has been assessed by a range of academics and institutions, including Hausman & Sidak (2005) , the Berkman Centre (2010) , and Nardoto, Valletti, Verboven (2013) , there is relatively little research as to which of these policies ought to be implemented in developing countries like South Africa. Research on the political economy of open access network policies is even less well researched.

There is a range of possible open access interventions that need to be considered, including:

- No intervention;
- Limited intervention allowing network sharing but not regulating access prices;
- Regulating access prices with a generous allowance for fixed costs; and
- Regulating access prices at incremental cost (taking into account no or limited fixed costs).

For example, The Federal Communications Commission (FCC) implemented mandatory unbundling using the Total Element Long Run Incremental Cost (TELRIC) methodology (Hausman & Sidak, 2005). LLU was partly rolled back after a US court decision in 2002 removed line sharing as a means of unbundling (which was offered at very low rates), citing a failure by the FCC to consider competing alternatives, including cable (Hausman & Sidak, 2005). The FCC subsequently considerably reduced the scope of open access policies in the US (Berkman Centre, 2010).

New Zealand presented an example of a country that did not mandate local loop unbundling (other than one, light form of LLU, Bitstream access) before 2005 (when the Hausman & Sidak, 2005 paper was published). Since then, New Zealand has implemented LLU (see, for example, Comcom (2013)).

Hausman & Sidak (2005) find that LLU implemented using incremental costs (such as TELRIC or TSLRIC) was less successful than where joint and common costs were taken into account. For example in Canada and Germany, where joint and common costs were taken into account when setting prices for unbundled network elements, there was greater investment by new entrants into their own networks (see also Cave, 2006) .

The Berkman Centre (2010) report, published 5 years after the Hausman & Sidak (2005) report, came to different conclusions regarding open access policies in analysing outcomes in the US against outcomes in other countries. The report concluded that (Berkman Centre, 2010): *'Our most surprising and significant finding is that "open access" policies - unbundling, bitstream access, collocation requirements, wholesaling and/or functional separation - are almost universally understood as having played a core role in the first generation transition to broadband in most of the high performing countries; that they now play a core role in planning for the next generation transition; and that the positive impact of such policies is strongly supported by the evidence of the first generation broadband transition.'*

The Berkman Centre (2010) report further found that countries with the slowest broadband speeds and highest prices, such as the US and Canada, relied on inter-modal competition between cable and DSL to deliver broadband. Countries that had the fastest speeds and lowest prices had DSL and cable broadband providers and additionally had new entrants that relied on the use of facilities owned by incumbents through open access policies. Countries between these positions usually had ineffectively enforced open access regimes or had only recently implemented open access policies.

The key lessons learned in respect of open access policies assessed in the Berkman Centre (2010) report are reproduced on Table 1.

Core lesson	Case study or section
Open access policies, unbundling in particular, played an important role in facilitating competitive entry; where facilities based entrants were present, access based entrants played an important role in catalysing competition; In some cases, access based competition resulted in increased competition, technological progress, lower prices and service innovation	Japan, Denmark, the Netherlands, Norway, Sweden, France, UK, New Zealand
Having an actively engaged regulator enforcing open access policies is more important than formally adopting open access policies; incumbents resist open access policies whether they are formerly government owned or not.	Japan, South Korea, France, UK, Canada
Broadband providers are regulated as carriers, and their carrier function is regulated separately to their services function	All surveyed countries
Open access rules are being applied to next generation access networks, particularly to fibre based broadband networks.	Japan, South Korea, Sweden, Netherlands, France, UK, European Regulators GroupEU, New Zealand
Vertical integration between fixed and mobile is increasingly allowed, with open access principles being applied to mobile networks	Japan, South Korea apply access; France and Germany experience integration but do not apply access
In the two earliest instances in which functional separation was implemented, it had rapid effects on competitive entry, penetration, prices and or speeds	UK, New Zealand
Where functional separation was introduced, it had a significant impact on competitive entry, prices and / or speeds	UK, New Zealand, Sweden, Netherlands, Italy, Australia
Functional separation is increasingly being adopted to support open access, particularly for next generation access networks	Japan, South Korea, Denmark, Norway, Sweden, the Netherlands, UK, France, Germany, Italy, New Zealand
Entrepreneurial competitors have tended to enter through bitstream or unbundled access	Japan, South Korea, Denmark, Norway, Sweden, the Netherlands, France, UK
Unbundled access is often used by incumbents from neighbouring regions or countries; entry often takes place by acquiring entrepreneurial new entrants	Denmark, Norway, Sweden, Finland, Germany
Where open access policies are weakly implemented countries rely on facilities based competition with weaker results	Germany, Canada
The high costs of next generation access are causing countries to work out ways to share costs, risks and facilities rather than the duplication of facilities for facilities based competition; they aim to mitigate the loss of facilities based competition with new models of open access and shared facilities, tailored to fibre	European Regulators Group, the Netherlands, France, Germany, Switzerland, UK

Table 1: Policy lessons from international experience with the development of broadband (Berkman Centre, 2010)

The Berkman Centre report (2010) found, in general, that open access policies, particularly LLU, led to more competition, lower prices, higher broadband speeds and more innovation in a number of countries. Open access policies are being extended to next generation optical fibre networks.

There are therefore contrasting approaches to the implementation of open access network policies around the world. While much research on open access network policies has been undertaken on developed countries, relatively little research has been undertaken on how to implement such policies in developing countries, with more complex political economy contexts.

4.4 Methodological problems with empirical studies on FMS and open access policy interventions

The first methodological problem encountered with fixed and mobile substitution models is that, as with all demand estimations, price and quantity are determined simultaneously (see, for example, Ward and Zheng, 2012). Furthermore, a significant amount of data is required to estimate diffusion models over time (Vogelsang, 2010). In addition to this, pricing data for network services are complex, with connection (installation charges), access charges and usage charges all playing an important role. Technological improvements also impact on prices over time. For example cameras, navigation and music all improve the experience of owning a mobile phone (see, for example, Ward & Zheng, 2012). Furthermore, the call termination rate regime matters: different call termination rates mean different usage prices, subsidies for handsets, and access charges and therefore failure to capture all of the relevant prices may result in seriously biased results (Vogelsang, 2010).

Some of these methodological issues have been solved using fixed-effects. For example, within-country idiosyncrasies can be controlled for to some extent by using country dummy variables (such as in Hamilton, 2003) and technological progress can be captured through the use of a dummy variable for each year (such as in Ward & Zheng, 2012).

While price data for individual countries may work better than for cross-country studies, there may not be sufficient variability in the data to make sensible inferences from it (Vogelsang, 2010). For example, access charges within country do not vary significantly over time and therefore the impact of access charges on fixed and mobile substitutability are difficult to assess. The number of subscribers on broadband networks also appear to be inflated in many countries (and therefore studies) due to the inclusion of inactive prepaid subscribers (Vogelsang, 2010). The inflated subscription numbers might also be due to the advent of machine to machine communications that use mobile SIM cards.

A further problem that arises in cross-country studies in developing countries is endogeneity between the uptake of fixed lines and mobile broadband where the government owns the incumbent fixed line operator and also makes policy for the mobile sector (Hamilton, 2003). In many developing countries in Africa for example, the fixed line operators tend to be state owned and report to the Minister responsible for telecommunications. The fixed line operator might therefore be in a position to influence the number of mobile subscriptions. This means that the number of mobile subscriptions and the number of fixed lines might be jointly determined. Ordinary least squares would attribute changes in fixed line subscriptions to mobile subscriptions when in fact the two are jointly set by a third party, the government. Accordingly, mobile penetration would be correlated with the error terms in the regression model. An instrumental variable approach presents one possible solution to this problem, and involves finding an alternative variable that is correlated with the mobile phone penetration variable but is not correlated with the error terms in the regression model. The author used this approach, using the percentage share of private participation in the economy (private credit extension as a percentage of GDP) as a proxy for the extent of mobile penetration.

A further drawback of the Hamilton (2003) study is that it pools a large group of heterogenous countries, from Arabic speaking North African countries to French speaking West African and English speaking Southern African countries. There are significant differences between these countries. For example, French speaking West Africa has a very different administrative law system to the common law system employed in English-speaking Southern African countries. While Hamilton (2003) controls for these problems using fixed effects for each country, and then separately using fixed effects for different regions, it is not clear that pooling very different countries in the first place makes any more sense than, for example, pooling a group of sub-Saharan African countries with Western European countries does.

In addition to this, it is difficult to control for the regulatory and policy specificities applicable in different

countries which might lead to different outcomes for fixed and mobile substitutability. For example, the UK has seen tremendous uptake in LLU lines at least in part due the functional separation imposed on BT, the fixed line incumbent there (see Cave, 2006). This has led to highly competitive outcomes resulting in high quality for fixed line broadband in the UK (see, for example, Nardotto *et al*, 2013) which may have the effect of limiting fixed to mobile substitution. This is in contrast to countries that are in transition in Eastern Europe that are more likely to have weaker institutions and therefore less competitive fixed line sectors.

A problem that arose in the assessment of the impact of LLU in terms of broadband penetration and quality was that there was endogeneity between explanatory variables. Nardoto, Valletti & Verboven (2013) used average income levels and new entrants using LLU at Local Exchanges (LEs) as explanatory variables to assess the impact of LLU on broadband penetration and broadband quality. However in 2005, for example, LEs that were served by an LLU new entrant had higher broadband penetration. LLU new entrants were likely to target high income consumers and businesses that were more likely to take up broadband in the first place. The authors solved this endogeneity problem by using a system GMM approach, and using lagged differences of the explanatory variables as instruments for the endogenous variables, following Blundell and Bond (1998) and Blundell *et al* (2000).

A further problem is that there is likely to be considerable heterogeneity among different categories of customers using fixed and mobile services. There are groups of customers that use fixed and mobile services as complements (such as business customers and perhaps high usage residential customers) and groups that substitute between fixed and mobile services (see, for example, Hamilton, 2003 and Grzybowski & Verboven, 2013). This means that differing levels of substitutability need to be considered for different groups of customers.

Finally, in respect of the literature on open access network policies, relatively little research has been undertaken on how such policies have been implemented in developing countries, taking into account the complex political economy features of those economies. While there have been reasonable attempts to assess the impact of LLU, for example, in developed countries, there are very few examples of the implementation of LLU in developing countries. Telecommunications regulators (such as ICASA in South Africa) are constrained by the nature of the holding power of powerfully politically networked incumbent operators (Khan, 2010) in the sector which limits ICASA's ability to transition the electronic communications sector to be an enabler of growth. The Competition Commission has been similarly constrained, particularly in respect of transitioning towards an open access fixed line network, in that TelkomâĂŹs holding power delayed the final settlement by 8 years (discussed in more detail in section 7 below).

4.5 Gaps in the literature to be addressed

Many of the studies cited above attempt to assess fixed and mobile substitution across a number of different countries (including Hamilton (2003) and Grzybowski & Verboven (2014)).These studies inevitably run the risk of pooling observations from countries with widely divergent regulatory systems and consumer tastes. Furthermore, many of the studies discussed above tend to focus on voice services rather than broadband services. The assessment of fixed to mobile substitution in respect of broadband services is limited to Grzybowski & Verboven (2014), which suffers the limitation that it pools data from a number of diverse countries, which have widely differing institutional frameworks that are likely to result in different levels of FMS, depending on how well the fixed line incumbent is regulated. Assessing fixed to mobile substitution for broadband services in one country therefore will contribute to this gap in the literature.

An additional feature of the literature is that supply side considerations are not taken into account: developed countries have existing fixed line networks that are largely depreciated, while developing countries do not (Vogelsang, 2010). Fixed lines may be more expensive in developing countries as a result of this, which might lead to greater FMS. The lack of any research on broadband fixed to mobile substitution in developing countries leaves this question open to be tested.

Furthermore, the quality of broadband service is not taken into account in any of the papers cited, other than Nardoto, Valetti & Verboven (2014). The latter does not address fixed to mobile substitution however: it addresses the effectiveness of LLU using data on fixed lines (cable and copper). Furthermore, it uses broadband speeds as a measure of quality. The quality variable to be developed will take advantage of the physical properties of copper based broadband: the broadband speed achievable over copper is inversely proportional to the distance between the local exchange and the customer's premises.

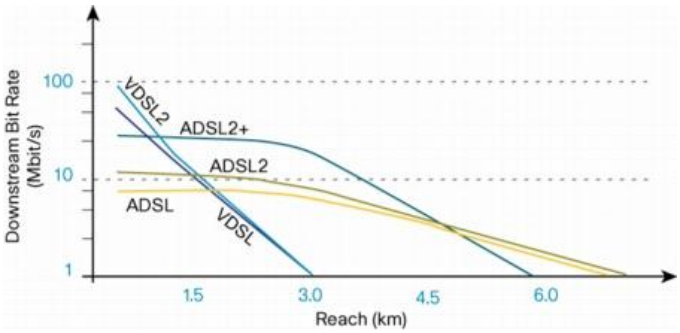


Figure 3: ADSL maximum speeds and distances

Cisco, 2009

Finally, the local loop unbundling policy reviews have not taken into account the nature of developing countries which tend to have limited coverage fixed line networks, and near universal mobile network coverage. The policy options to be researched in the context of the nature and extent of FMS in South Africa will therefore make a contribution to this area of the literature.

4.6 Approach to addressing gaps in the literature

The first problem addressed is that the research will focus on one country: South Africa, exploiting regional variations in broadband quality (in the first contribution) and survey respondent choice of broadband operator (in the second contribution).

The first contribution will also address a second gap in the literature: the paucity of any research on the impact of broadband quality on consumer choices. This will be addressed by developing a unique quality variable, measuring the quality of fixed lines as the geodetic distance between the local exchange and survey respondent households.

The third contribution will review open access policy implementation in reference countries, taking into account the political economy features of South Africa, a developing country. Khan's (2010) framework on political settlements will be used to evaluate optimal network open access policies in South Africa.

5 Contribution 1: Do any of the network operators in South Africa have market power? (using NIDS)

5.1 Motivation and contribution

Market power in markets for telecommunications has not been measured formally in South Africa. This analysis requires detailed data on consumer choices. To this end, a dataset on consumer choices on fixed and mobile services using the National Income Dynamics Study (NIDS) and broadbandstats.co.za will be developed. This involves developing a variable for the quality of fixed line broadband in South Africa by calculating the distance from Telkom exchanges to customer premises in order to assess whether consumers that have replaced fixed with mobile tend to be further away from local exchanges (which gives rise to poorer quality broadband). The key principle that this analysis rests on is the attenuation (weakening) of signal as the length of the copper line grows. [3]. This reduces the signal to noise ratio. This is illustrated, for example, on Figure 3.

[3]The quality of the broadband connection is also affected by interference from other signals travelling across the same medium (crosstalk). These factors can be assessed in terms of the Shannon Limit, which provides a theoretical maximum data rate possible over a communications channel, calculated using the signal to noise ratio on that communications channel.

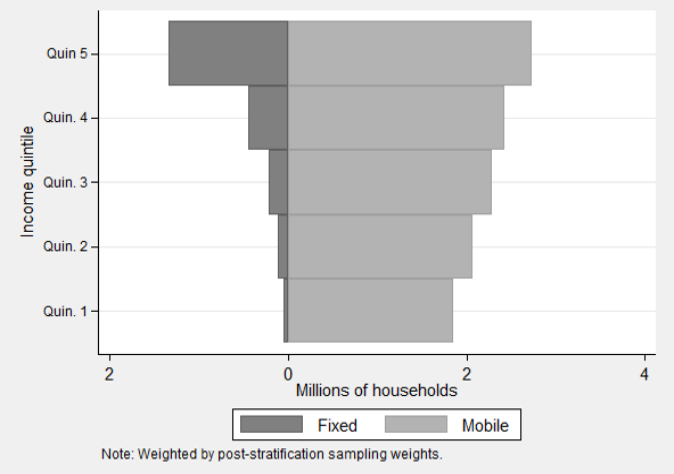


Figure 4: Income distribution of fixed and mobile access, (NIDS Wave 1, 2008)

The locations of Telkom's exchanges have been collated from Broadbandstats.co.za. The latter dataset also contains the maximum speeds available at each of Telkom's exchanges, an additional measure of quality. This dataset will then be used to develop descriptive statistics on consumers that substitute between fixed and mobile networks as a first contribution towards answering whether mobile networks are substitutes for fixed line networks.

5.2 Research question

The main research question addressed in this contribution is: Does Telkom have market power in respect of the market for fixed line broadband internet access?

5.3 Research objectives

The objective of this contribution is to build a measure of quality of fixed lines from NIDS and Broadbandstats.co.za data and to estimate market power in markets for fixed line broadband, using the variability in fixed line broadband quality to estimate this.

5.4 Data

5.4.1 NIDS

NIDS is a national panel data study on households that has collated more than 20,000 individual observations in each of four waves (the fourth wave is forthcoming this year, 2015). The broadbandstats.co.za dataset covers the period 2011-2013, corresponding to NIDS waves 2,3 and 4.

The NIDS dataset reveals that approximately 12.3% of the households sampled (15%, using the weighted sample) had a working landline, while 74% of households sampled (79%, using the weighted sample) owned a cell-phone, in 2008 (wave 1). While cellphone ownership was reasonably balanced across income quintiles, having a working landline was strongly influenced by income (see figure 4). While more than half of the households in the top income quintile had a working landline, only a small fraction of poorer households owned one.

The panel dimension of the NIDS and Broadbandstats.co.za data will be exploited since the Broadbandstats.co.za data captures upgrades to local exchanges between 2011 and 2013. While there are only 3 usable waves of NIDS, these upgrades will allow us to explore substitution between fixed and mobile, holding household idiosyncracies fixed.

NIDS reveals that, for wave 2 (2010/2011), fixed line penetration among households sampled decreased from 12.3% (15%, using weighted results) of households in 2008 to 10.8% (17%, using weighted results) in 2010/2011 and cellphone ownership had increased from 74% (79%, using the weighted sample) to 77% (82% using the weighted sample) over the same period. Wave 3 (2012) results showed that fixed line penetration

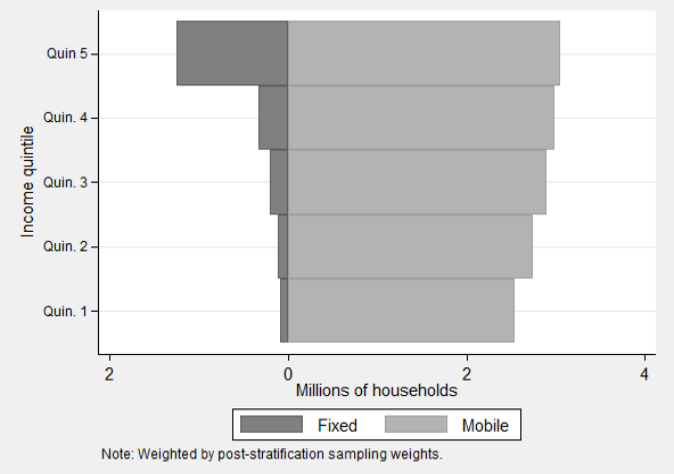


Figure 5: Income distribution of fixed and mobile access, (NIDS Wave 3, 2012)

	Wave 3			
Wave 2	**Yes-W**	**Yes-NW**	**No**	**Total**
Yes-W	388.0	29.0	402.0	819.0
Yes-NW	28.0	19.0	165.0	212.0
No	191.0	94.0	8,106.0	8,391.0
Total	607.0	142.0	8,673.0	9,422.0

Table 2: Households with landlines between NIDS waves 2 and 3

among households sampled decreased from 12.3% of households sampled (15% of the weighted sample) to 7.5% (12% using the weighted sample) between 2008 and 2012. At the same time, cellphone ownership had increased to 90% (88.7% using the weighted sample). Access to fixed lines had become even more skewed relative to access to cellphones by 2012 (see Figure 5). This suggests considerable substitution from fixed lines to mobile services among South Africans, particularly by lower income South Africans.

To be more precise, of the approximately 819 households sampled in Wave 2 (2010/2011) of the NIDS survey that had a fixed line telephone, only 388 (47% of the sample) had a fixed line telephone in Wave 3 (2012) (see Table 2). A further 219 households that did not have a landline in working order in Wave 2 had a working landline in Wave 3.

This suggests that a considerable proportion of households are switching away from fixed lines. In order to determine the causes of this, it is important to understand whether those households disconnected their landlines for reasons unrelated to changes in consumer preferences, including income, geographic location (moving to a location where landlines are not available) and changes in household size (larger households may have a preference for landlines). The NIDS dataset allows for the control of all of these variables.

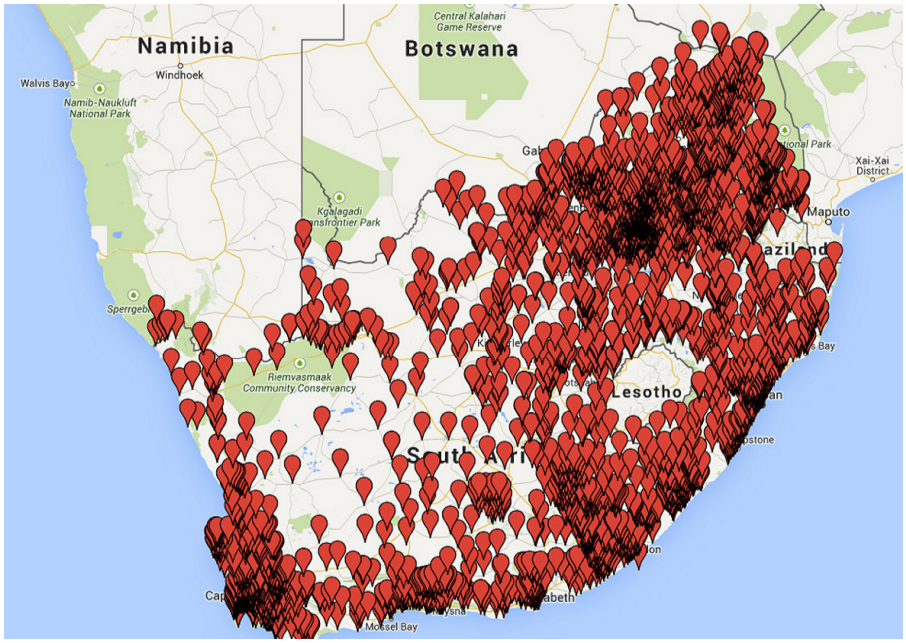
A further variable that should be controlled for is variability in broadband quality. In order to use fixed line broadband in South Africa, a landline in working order is required. While consumers may cease to use their landline to make voice calls due to ownership of a mobile phone, broadband may be slowing fixed to mobile substitution.

NIDS does not directly ask whether the household's fixed line is being used for broadband services. Nonetheless, there are a number of proxies for this including household expenditure on landlines (spend over a certain voice usage average might indicate broadband use) and NIDS contains questions about internet expenditure separately to expenditure on 'mobile experiences' and separately to expenditure on telephone expenses. While the questionnaire allows for internet to be included in telephone expenses, the questionnaire implies that internet expenditure on mobile phones would be captured separately.

5.4.2 Data on locations of and maximum speeds at local exchanges

Broadband quality depends on distance between local exchanges and households: the greater the distance, the lower quality. Households are also only able to achieve the maximum speed available at their local

Figure 6: Telkom exchanges



exchange. The locations and maximum speeds of local exchanges are available for 2011 and 2012 from the broadbandstats.co.za dataset, which is a website that collates maximum speeds and the locations of Telkom exchanges throughout South Africa (see Figure 6). There are 8 available broadband speeds in the dataset: 384kbps, 512kbps, 1Mbps, 2Mbps, 4Mbps, 8Mbps, 10Mbps, 20Mbps. There are approximately 2,000 exchanges located throughout South Africa. The location data will be used to determine distances between each household where a landline is available, and the local exchange (mapped on Figure 6).

5.5 Methodology

5.5.1 Approach I: Multinomial logit

Demand for fixed lines will be estimated using a discrete choice framework. There are several behavioural modelling approaches to estimating discrete choice models of demand for consumer level data (Davis & Garces, 2010). These include multinomial logit, generalised extreme values (including nested logit), mixed logit and probit.

Some of these models have closed form solutions, including multinomial logit and nested logit, while other models, including mixed logit and probit, require simulation (Train, 2009).

An important part of this contribution will be to evaluate these alternative methods and select the best option for the questions being asked and the data available. Two possible approaches are presented above in relation to the first contribution: the multinomial logit and mixed logit models of demand.

The most widely used model for estimating discrete choice models of demand is the conditional logit model, an extension of the multinomial logit (MNL) model (Mcfadden, 1973). A MNL model will be estimated as follows:

Consumer i's utility derived from product j is given by:

$$U_{ij}(p_j, r_j, z_i; \theta) = V_{ij}(p_j, r_j, z_i; \theta) + \epsilon_{ij} \tag{1}$$

where p_j and r_j are the price and intrinsic value, respectively, of product j and z_{ik} is a vector of characteristics of consumer i and z_{ij} is a generic element. There is a vector of parameters to be estimated, θ, and a stochastic error term ϵ_{ij}.

All estimates are relative to the outside option, which is choosing no service at all.

We further assume that:

$$V_{ij}(p_j, r_j, z_i; \theta) = r_j - \alpha p_j + \Sigma \gamma_{jn} z_{in} \tag{2}$$

where α is the price co-efficient and γ is the vector of co-efficients for consumer characteristics.

Consumer i will choose product j if $U_{ij} \geq max_{j \neq k, k \in C_i} U_{ik}$ where C_i is the choice set. This occurs with the following probability:

$$P_{ij} = Pr[V_{ij} + \epsilon_{ij} \geq max_{j \neq k, k \in C_i} V_{ik} + \epsilon_{ik}] \tag{3}$$

We assume that ϵ_{ij} are independently and identically distributed (IID) across individuals and alternatives and follow a type I extreme value distribution and have a scale parameter σ_ϵ. This means that the choice probability can be solved using the logit formula, given by:

$$P_{ijt} = Pr[j|p_i t] = \frac{exp(V_{ijt})}{\sum_{k \in C_i} exp(V_{ikt})} \tag{4}$$

where p_j is the vector of prices for each product j that consumer i may choose from.

In order to estimate Equation 4, log-likelihood will be used. The probability that consumer selected the choice observed is: $\Pi_j P^{y_{ij}}$, where $y_{ij} = 1$ if consumer i chose product j and $_{ij} = 0$ otherwise.

The log likelihood function can be written as :

$$\mathcal{L}(\alpha, r, \gamma) = y_{ij} \sum_{i}^{N} \sum_{j} log(P_{ij}) \tag{5}$$

where the values α, r and γ maximise the estimator $\mathcal{L}$.

The main problem with the multinomial logit (MNL) model is the unreasonable Independence of Irrelevant Alternatives (IIA) assumption. This assumption means that a product's market share is determined by its characteristics. An implication of this is that the introduction of a new product that is a direct substitute for one of the existing products in the product set will reduce the market shares of all other products in proportion to their market shares, including any product that is a direct substitute. This seems unreasonable since we would expect the new product to take significantly more market share from its direct substitute than from distant alternatives.

A mixed logit model, which does not rely on the IIA assumption, is a possible alternative approach and is discussed next.

5.5.2 Approach II: Mixed logit

The utility function for consumer i and product j in the mixed logit function is given by (see, for example, Davis& Garces, 2010):

$$U_{ij}(p_j, r_j, z_i; \theta) = V_{ij}(p_j, r_j, z_i; \theta) + \epsilon_{ij} \tag{6}$$

where the key difference between this and Equation 1 above is that consumers are allowed to have different co-efficients on prices, α_i. The latter are assumed to have a normal distribution and a density function given by $\alpha_i \tilde{f}(\alpha|\mu, \sigma^2)$, where α_i has mean μ and variance σ^2.

The α_i are assumed to be uncorrelated with the error term ϵ_{ijt} and the explanatory variables p_j, r_j, z_i.

The probability of consumer i choosing product j is given by:

$$P_{ij}(\alpha) = Pr[j|p_i, ., \alpha] = \frac{exp(V_{ij}(\alpha_i))}{\sum_{k \in C_i} exp(V_{ik}(\alpha_i))} \tag{7}$$

where p_j is the vector of prices available to consumer i. The unconditional choice probability is, in the mixed logit model:

$$\bar{P}_{ij} = \int_\alpha P_{ij} f(\alpha|\mu, \sigma^2) d\alpha \tag{8}$$

The probabilities in Equation 8 are estimated by simulation. We first draw a vector of values α^r from the normal distribution $N(\mu, \sigma)$ and label it $r = 1$. We then calculate the probabilities in Equation 8. We iterate this approach R times and then calculate the choice probability:

$$\bar{P}_{ij} = \frac{1}{R}\sum_{r=1}^{R}[\frac{exp(V_{ij}(\alpha^r))}{\sum_{k\in J} exp(V_{ik}(\alpha^r))}] \tag{9}$$

$$\mathcal{L}(\alpha, r, \gamma, \mu, \sigma) = y_{ij}\sum_{i}^{N}\sum_{j} log(\hat{P}_{ij}) \tag{10}$$

where the values α, r and γ and the distribution parameters $N(\mu, \sigma)$ maximise the estimator $\mathcal{L}$.

6 Contribution 2: Do any of the network operators in South Africa have market power? (using AMPS)

6.1 Motivation and contribution

This component of the research will provide a contribution towards understanding the elasticity of demand for fixed and mobile services in South Africa, which has not been undertaken previously. As discussed above, demand estimation for these services will assist policymakers in selecting policy choices for the telecommunications sector in South Africa.

As discussed above, the literature suggests that households largely view fixed and mobile voice services as substitutes, though the literature is not conclusive (Vogelsang, 2010). The inconclusive nature of the literature is partly due to the fact that finding high quality price data for different countries is difficult given the complexities of telecommunications prices (installation, access and usage prices) and service qualities (such as high speed broadband vs. low speed and the variety of mobile services that are bundled with tradition mobile voice services). Furthermore, significantly different results for fixed to mobile substitution (FMS) arise depending on the basket of fixed and mobile services included in the analysis. While fixed and mobile voice services may be substitutes for some households, once fixed line broadband is included in the customer choice set fixed and mobile services become complements rather than substitutes (Grzybowski & Verboven, 2014). There is also considerable heterogeneity between countries and between households in results for fixed and mobile substitutability.

6.2 Research objectives and questions

The objective of the research is to estimate a model of demand for telecommunications services in South Africa. This will allow for the calculation of own-price and cross-price elasticities of demand for telecommunications services. This in turn will establish whether fixed and mobile broadband services are substitutes in South Africa, and will enable the identification of market power in markets for telecommunications services.

6.3 Research hypotheses

The main research hypothesis is that the demand for fixed line telecommunications is quality elastic: poor quality results in less uptake of fixed line telecommunications products.

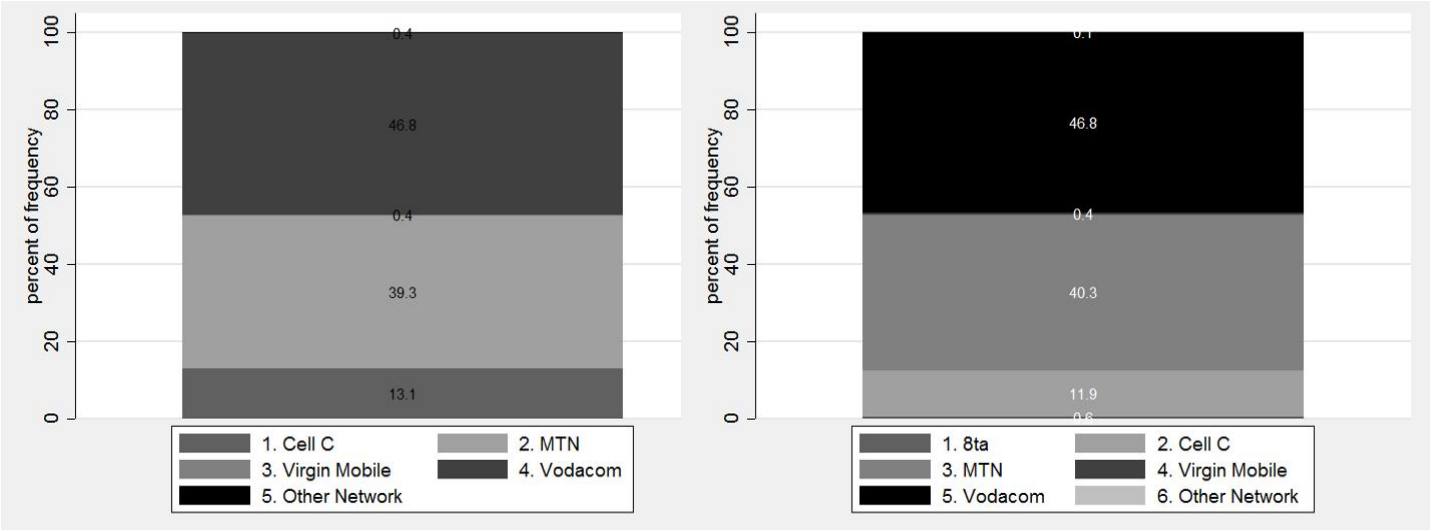
The alternative hypothesis is that quality of fixed line services does not have a significant impact on demand for fixed lines once demand for mobiles is taken into account.

The main relationship between the variables to be assessed is whether the choice of fixed and / or mobile broadband is linked to the available quality of fixed line connections.

6.4 Data

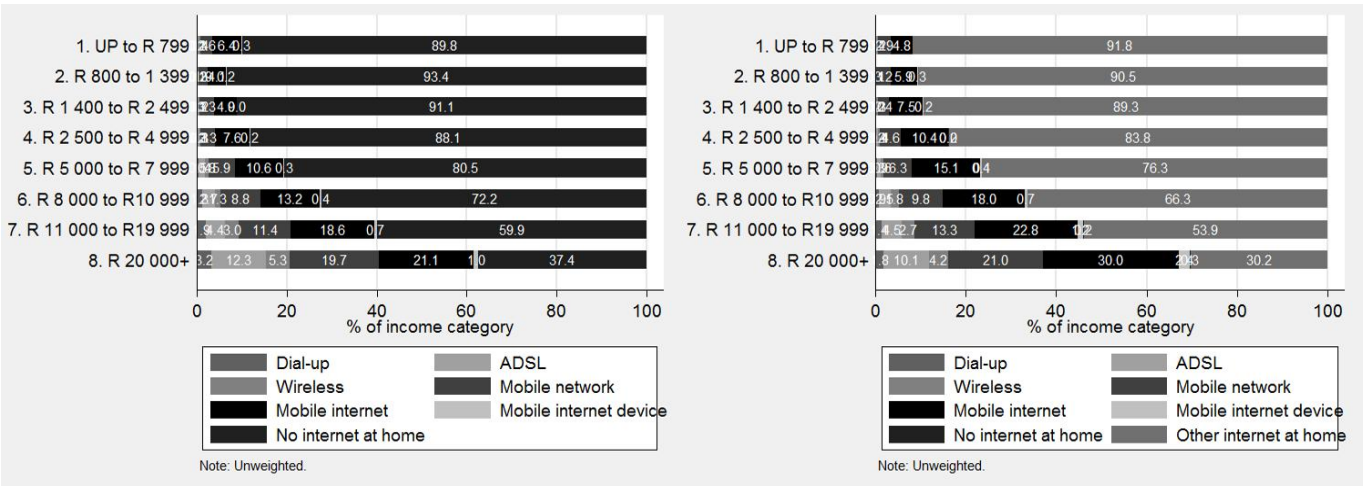
The All Media Products Survey (AMPS) will be used to estimate demand for broadband and evaluate whether any of the network operators has market power.[4] AMPS surveys more than $20,000$ households on a rolling 12 month basis. Prices for broadband packages will be sourced from either ICASA (the regulator). A price index for prepaid, top-up (hybrid) and postpaid services will be developed (hopefully together with

[4]The University of Cape Town School of Economics Data First Resource Unit (DFRU) is in the process of acquiring AMPS.



(a) 2011 **(b) 2012**

Figure 7: Mobile network operator market shares (AMPS)



(a) 2011 **(b) 2012**

Figure 8: Choice of network for internet, by income category (AMPS)

ICASA staff), using a blend of the various packages offered by each of the operators, and assuming an average usage profile similar to that developed by Teligen for the European Commission (see Teligen, 2010).

The variability in mobile network operator (MNO) market shares over time, particularly in recent years due to Cell C's growth, will be exploited to estimate demand for mobile services, and combined fixed and mobile services (see Figure 7).

There is also variability in the selection of network type for internet across time and between households that will be exploited to estimate demand for fixed and mobile broadband.

6.5 Methodology

As discussed above, there are several behavioural modelling approaches to estimating discrete choice models of demand for consumer level data (Davis & Garces, 2010). These include multinomial logit, generalised extreme values (including nested logit), mixed logit and probit.

An important part of this contribution will be to evaluate these alternative methods and select the best option for the questions being asked and the data available. Two possible approaches are presented above in relation to the first contribution: the multinomial logit and mixed logit models of demand. These models of demand will be assessed in this contribution too, testing for market power using the AMPS data rather

than the NIDS data.

7 Contribution 3: How should open access policies be implemented in South Africa?

7.1 Motivation and contribution

The purpose of this contribution is to evaluate the policy options available to policymakers in South Africa in the context of the results of the first two contributions, particularly in relation to how and where open access policies ought to be implemented. As discussed above, there is a gap in the literature as to how and whether to implement open access policies in countries with limited coverage fixed line networks and almost full coverage mobile networks.

There is a debate on the impact of open access fixed line policies on a range of policy outcomes, including competition, broadband penetration, pricing and speeds. While some research, such as that developed by Hausman & Sidak (2005), suggests that LLU has not had the desired impact on developing facilities based entry upstream and has not resulted in lower prices to consumers, other research, such as that developed by the Berkman Centre (2010) find that open access policies, implemented by a engaged regulator, have had a significant impact on expanding broadband penetration and resulting in lower prices and faster speeds. More recent research on the impact of LLU in the UK shows that while LLU did not have a significant impact on broadband penetration, it had a significant impact on the quality provided by new entrants, who offer speeds that are on average 20% faster than those provided by the incumbent, BT (Nardoto *et al*, 2013).

There is therefore considerable debate as to how the telecommunications sector ought to be regulated in future, including whether open access policies should be followed at all, and if they should be implemented whether they should be implemented for fixed or mobile services or both, or whether indeed the regulator should employ a 'light touch' approach.

7.2 Research objectives and questions

The main research question is: how have countries that are similar to South Africa implemented open access network policies successfully?

The research objective is to evaluate open access policies ought to be implemented in South Africa, given experience with these policies in other countries.

7.3 Research hypotheses

There are two competing hypotheses internationally for the regulation of telecommunications services:

- There is very little that telecommunications regulators ought to do, given the significant levels of 'inter-modal' competition between different technologies (such as fixed and mobile) (see discussion in Hausman & Sidak (2005) for example, set out above);
- There is significant scope for intervention in telecommunications markets in bringing about greater competition through open access policies (see discussion in the Berkman Centre (2010) report for example, explained above).

These two hypotheses will be evaluated in the context of the results of the analysis to be developed in contributions 1 and 2, taking into account the limited coverage of fixed line networks and almost universal coverage mobile networks in South Africa.

7.4 Methodology

The methodology to be employed will include the selection of relevant comparator countries, and a review of the success or failure of open access policies and open access network policy and regulatory decisions there.

Comparator countries will be selected on the basis of similar levels of development, governance structures and level of telecommunications sector development.

Key indicators of successful policy and regulatory decisions will include the prices, quality and penetration of broadband in those comparator countries.

These policy choices and outcomes will be evaluated in the context of the assessment of market power in the first two contributions.

7.4.1 Conclusion on methodology

There is very little existing research on the implementation of open access policies, including local loop unbundling, in developing countries. While LLU may not be suited to all developing countries, such as Chile where inter-modal competition with cable networks exists, or Nigeria where the fixed line incumbent essentially isn't operating, many developing countries have already implemented it or are considering doing so. The methodology to be employed for this contribution will be to evaluate policy choices that succeeded in relevant comparator countries.

8 Conclusion

The proposed Vodacom/Neotel and MTN/Telkom transactions raise considerable competition concerns, exacerbated by high costs to communicate in South Africa, particularly as regards broadband services. ICASA is reviewing these transactions, as well as considering implementing local loop unbundling. The effects of the transactions and local loop unbundling depend on the extent to which network operators in South Africa have market power.

In order to evaluate whether the fixed line incumbent has market power, a unique dataset will be developed, combining the National Income Dynamics Survey (NIDS) dataset with that of Broadbandstats.co.za, in order to develop a quality variable for fixed lines. Using the NIDS dataset will also enable controlling for other variables such as household size and income. In the first contribution, this dataset will be used to estimate demand for fixed lines relative to the outside option of using mobile or not using a telecommunications service. In the second contribution, the AMPS and broadbandstats.co.za data will be used to estimate demand, and therefore market power, in the telecommunications sector in South Africa. This includes assessing the extent and nature of fixed to mobile substitution. A third and final contribution will be the evaluation of telecommunications sector policy options implemented in benchmark countries.

This research addresses an important gap in the literature on fixed to mobile substitution and policy options for developing countries where the extent of mobile coverage far exceeds fixed line coverage. While FMS has been researched for voice services extensively, research on broadband services is more limited. Where it does exist, it does not take into account the varying levels of quality available for broadband services. The policy options chosen by policymakers and regulators in benchmark countries will also be evaluated in order to select an optimal policy approach for South Africa. There is a considerable gap in the research on telecommunications policies in respect of the implementation of open access policies, including LLU, in developing countries with limited coverage fixed line networks and near ubiquitous mobile coverage. These gaps will be addressed through the research proposed here.

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