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A Roadmap for Policy Choices after the Lock-down: the Role of Supply Chains, Networks and Key Strategic Sectors

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A Roadmap for Policy choices after the lock-down: the role of supply chains, networks and key strategic sectors

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Executive Summary

This report provides a beginning of a '*roadmap*' which can guide policy makers in response to the COVID-19 pandemic. The supply chain network has been severely disrupted by the lock-down measures and even with the exit from the lock-down this network remains disturbed. We provide a framework to allow identifying key strategic segments in the economy in terms of the central role in the supply chain they take and hence in terms of their potential multiplier impact and growth potential for the overall economy. We use Input-Output tables to estimate which sectors in the economy are crucial and have a high multiplier potential. The COVID-19 shock ripples down the entire economy through the interconnectivity of various firms and sectors in the economy. Likewise, stimulus will ripple down through the entire economy in a similar fashion.

While old industrial policy was targeted to particular sectors, such as steel, in the past, these policies were not inspired by hard economic evidence related to their growth potential and their central role in the supply chain. The new industrial policy (e.g. Aghion et al. (2015)) as proposed by the European Union and embraced by most European countries is about supporting activities which typically have important spillovers to many other sectors and firms (which are active across various sectors). This is exactly what the current analysis is about through the multiplier analysis and the centrality of particular sectors in the supply-chain network (as in Acemoglu et al (2012)).

Our main results can be summarized as follows:

- By way of motivating the current work, we use machine learning to simulate the impact of the COVID-19 crisis on jobs: Under relatively mild assumptions the crisis will result in a loss of 65,000 private jobs (full time equivalent). With a mild second wave early 2021, this increases to 80,000 jobs lost in the private sector.
- These job losses are persistent: by 2025, aggregate employment has not fully recovered and is still below pre-crisis levels. These job losses are triggered by job destruction at incumbent firms, but importantly also a lost generation of start-ups, which is contributing to the persistency in job loss. These simulations stress the importance of introducing growth policies, with special attention for supporting entrepreneurship and young high potential firms, to limit the scarring effect of a lost generation of start-ups.

- To focus growth policies, it is relevant to study supply chain networks, which show the interconnectivity between supplying sectors and final demand, and which matter for the rippling down of economic shocks. Similarly, they matter when state aid is considered.
- To assess the potential impact of such rippling down effects, we identify key strategic sectors by computing their share of value added in GDP and their multiplier effect based on Input-Output tables. We assess such sectors by looking at their EU growth performance (as an indicator of growth potential) and by looking at their investment in ICT (as the key enabling technology of ICT enhanced productivity growth). These effects are lower bounds, as within sectors there is still a lot of heterogeneity in terms of growing and declining firms and in terms of the firm size distribution.
- Key strategic sectors with high multipliers, a large contribution to GDP, high ICT investment and/or in which there is substantial EU growth in the past include: *chemicals*, *manufacturing of food & beverages*, *distribution (wholesale)*, *construction, legal and accounting services (head offices)*, *information service activities, education* and *financial services*.
- We use Input-Output tables and a model of imperfect competition to simulate the impact of the COVID-19 crisis on the economy. The estimated supply-side impact of a 9-week lockdown on 2020 GDP is around 7%, a lower-bound, as the assumption is that the economy is back to business as usual after 9 weeks.
- At the same time, there is a wide variety in severity of the shock on different sectors, ranging from -12% value added to modest reductions in output. The hardest hit sectors are mostly services industries: *professional activities*, *legal and accounting*, *financial services*, *telecom*, and *creative industries (video, sound, music)*.

The roadmap offered in this study suggests to combine insights from an analysis of the key strategic sectors (in terms of growth potential, ICT investment, contribution to GDP and their multipliers) and the sectors which are hit most by the lock-down to target growth enhancing measures. Hence state-aid with the context of the state-aid rules is best targeted towards a group of firms active in the following broadly defined sectors:

- important growth/ICT sectors, high multipliers, hit heavily by the lockdown measures: *legal and accounting services*, *wholesale*, *IT services* and *financial services*.
- important growth sectors/ICT, high multipliers: *chemicals*, *construction*, *food & beverages* and *education*.

1. Introduction

The COVID-19 pandemic has caused the largest decline in aggregate supply and demand since the second World War. GDP in most countries is expected to fall in the order of 10% in 2020, due to lockdown policies that affect production and consumption, as well as uncertainty about both short- and long-term economic outlooks[1].

While the shock to the economy has been common, there is a wide variation in the effects across firms and sectors, ranging from full closures or severely reduced capacity for e.g. manufacturing, travel, accommodation and retail, to increased spending for supermarkets, pharmacies etc. (Carvalho et al. (2020), National Bank of Denmark (2020)). The effects of these measures not only affect the impacted sectors directly, but their whole supply chains as well: restaurant closures affect the manufacturing of food industry, and the production of agricultural produce in turn (Barrot et al. (2020)). On the other hand, a sharp increase in supermarket spending also affects the food industry, albeit in a positive way. The total effect of these shocks depends on the network structure of production, not only on the direct size or importance of a sector in terms of GDP (Acemoglu et al. (2012); Magerman et al. (2016); Grassi (2017); Baqaee (2018), Baqaee and Farhi (2019, 2020)). For a survey, see Carvalho and Tahbaz-Salehi (2019).

Despite the gradual relaxation of the lockdown measures in Belgium, supply chains will continue to be disrupted worldwide for a while, preventing firms from resuming business as usual. Furthermore, policy has chosen to open all firms at the same time, without distinguishing between crucial firms and sectors. Policy measures in Belgium so far have been taken in an *ad hoc* manner, with a lack of which support measures should be or should not be in place and how they should be targeted. More importantly, if governments want to get deficits and debt under control it is more than ever important to engage in growth policies: where do you get the largest bang for your invested buck.

It is clear that the continued disruption of international supply chains, the collapse in international trade and the various phases in which countries worldwide are implementing the

[1] See www.learningfromthecurve.net for real-time EU economic indicators and the spread of the COVID pandemic in selected EU countries.

exit strategies, including increased state aid in various countries, will trigger a recession for a small and open economy such as Belgium. The increased and uncoordinated state aid in various countries will also shake up the level playing field of fair competition, resulting in less creative destruction, reduced competition and hence lower productivity growth with less jobs. Karimov and Konings (2020) for instance use a machine learning approach to show how the lock down of the economy in March alone is likely to destroy 20,000 jobs in Belgium, with a lasting effect of jobs lost due to a missing generation of start-up firms. On an annual basis the job loss is likely going to be a multiple of that.

While the usual response is that more investment and innovation is needed (often triggered by new firm entry), it is not clear how governments should stimulate these, and more importantly how to target particular activities in the economy. The present study therefore provides a beginning of a '*roadmap*' which can guide policy makers to make such tough decisions, given the budget available is limited.

We start with documenting and simulating expected job loss using machine learning techniques under various scenarios. The simulations are based on detailed micro level data of quarterly social security records of employment in Belgian firms using full time equivalent jobs. The job simulator can be used to allow for different scenarios and can be freely accessed at https://skarimov.shinyapps.io/job_simulator/. Aggregate job loss in Belgium is substantial and persistent, ranging between 65 thousand and 80 thousand private jobs one year ahead. The recovery is slow and painful: even by 2030 aggregate employment is still far below pre-crisis levels. These job losses are triggered by job destruction with incumbent firms, but importantly also a lost generation of start-ups, which is contributing to the persistency in job loss.

Next, we provide a framework to identify the 'super star' sectors of the future for Belgium, based on their contribution to value added for the Belgian economy, the growth of these sectors in a EU context, and their multiplier effect for the economy. Key strategic sectors with high multipliers, a large contribution to GDP and in which there is substantial EU growth in the past include*: chemicals*, *manufacturing of food & beverages*, *distribution (wholesale)*, *construction, legal and accounting services (head offices)*, *information service activities, education* and *financial services*.

Finally, we estimate the impact of COVID-19 on Belgian output, taking into account the centrality of key economic sectors. We use information on the lockdown measures (administrative closures, ability to telework and the impact of lack of childcare) to simulate a reduction in labor supply across sectors. Implemented policies imply a reduction in labor, and subsequently a drop in economic output (GDP). These labor shocks do not only affect sectors directly hit by the policies, but also indirectly through supplier-buyer linkages (value chains). These disruptions affect aggregate output along several dimensions: jobs, production, consumption, etc. Our framework quantifies and estimates these effects for the Belgian economy. The estimated supply-side impact of a 9-week lockdown on 2020 GDP is around 6%. At the same time, there is a wide variety in severity of the shock on different sectors, ranging from -12% value added to modest reductions in output. The hardest hit sectors are mostly services industries: *professional activities*, *legal and accounting*, *financial services*, *telecom*, and *creative industries (video, sound, music)*.

2. Data sources and methodology

We exploit a combination of data sources for the analysis in this report. First, we use the industry-by-industry Input-Output (IO) tables for Belgium for the year 2015 (Federal Planbureau, 2018) for the analysis of sectoral rankings, multiplier effects and the impact of COVID-19 on the economy's output. IO tables describe the sales and input relationships between producers and consumers in an economy. The tables contain the sources of inputs (material and services sourced from other Belgian sectors, imported inputs) and sources of value added (labor, capital and operating surplus) on the one hand, and the allocation of outputs on the other. Outputs can be sold to other sectors to be used as inputs again, and to final demand. Final demand includes household consumption, government expenditures, investment and exports. These tables provide the gross value added created in Belgium, and together with taxes and subsidies constitute GDP.

There are 64 sectors (codes are labeled as A64 codes) across all economic activities, including primary and extraction, manufacturing, utilities, construction, market services and non-market services. We drop sectors A64_68a "Imputed rents of owner-occupied dwellings", and A64_64, "Activities of households as employers", as they contain no production, and thus we end up with 62 sectors. See Table A.1 for the list of sectors and their description. Column (1) shows the A64 sector code, column (2) the corresponding NACE 2-digit Rev.2 (2008) code, and column (3) provides a verbal description of the sector activities. We also use additional data on ICT investment taken from Dhyne et al. (2020) and Eurostat data on European growth.

Finally, we use additional data sources to estimate the impact of COVID-19 labor shocks on Belgian output. These sources are obtained from very recent French survey data, which are not (yet) available for Belgium (see Barrot et al. (2020)). We use French Census data to determine the share of workers per sector affected by administrative closings, hotels and restaurants, and school closings. The Census data is also used to estimate the impact of lack of childcare for parents that can telework. We also leverage French survey data on telework to quantify the share of workers in each sector that remain active through remote working, despite the confinement. The shocks are calibrated on the French data, but the impact on output is fed through the Belgian IO tables. Ideally, we would like to exploit comparable data for Belgium to further calibrate the model. For the time being, the French data provides a plausible substitute given the similarities in production structure of the economy (e.g. labor shares in production, the amount of teleworking and demographic structure of the working population) and policies implemented in response to the COVID crisis (administrative closings of sectors, school closings etc.).

3. Many jobs lost with unchanged policy

In this section, we start by way of motivation, results from a job simulator as described in Karimov and Konings (2020)[2]. We use a machine learning technique to simulate the impact of COVID-19 under different scenarios, in which incumbent firms lose jobs as a result of the collapse in GDP, but also in which a lost generation of start-ups firms is having a permanent and lasting effect on aggregate employment. The latter feeds through in that there will be less high growth firms, which means fewer large employers in the future. It also may mean less innovation, but this is beyond the scope of the present study. The simulations are based on detailed micro level data of quarterly social security records of employment in Belgian firms using full time equivalent jobs. The job simulator can be used to allow for different scenarios and can be freely accessed at https://skarimov.shinyapps.io/job_simulator/. The impact on jobs refers to the *private sector* only. We report two simulations.

Figure 1a shows the results of a simulation in which it is assumed that GDP growth in the first two quarters of 2020 shrinks by 3.6%, the last two quarters by 1%, resulting in an annual collapse in GDP of about 9%. It is also assumed that the entry of new firms is reduced to 50% compared to a year earlier in the first two quarters of 2020 and to 70% of the normal entry rate in the last two quarters. These numbers are based on actual entry rates in the first two quarters of 2020 (Unizo; Graydon). We assume for 2021 and the years after normal growth figures, based on an extrapolation of the year prior to 2020; and firm start-up rates we also assume similar rate as the ones prior to 2020. In Figure 1b we simulate the same scenario except we assume that start-up rates are not affected. The third simulation, in Figure 1c, assumes that due to a second wave aggregate growth in the first quarter of 2021 is still negative -1% and in the second quarter it is assumed to be zero percent, thereafter growth rates are assumed to resume as before 2020.

It is clear from Figure 1a,b and c that aggregate job loss in Belgium is substantial and persistent. The job destruction is driven by incumbent firms and less entrants which are not turning into high growth firms. In fact, the lost generation of entrants is contributing to the persistence of poor aggregate employment performance in the long run. Based on the

[2] See https://skarimov.shinyapps.io/job_simulator/

assumptions above there would be an aggregate impact of 65 thousand private jobs one year ahead, in scenario 1. Note that in Figure 1b we show the impact when we assume start-up rates were not affected. The job loss is lower, however, more importantly 5 years later, aggregate employment has recovered again and is again above pre-crisis levels. Thus, the lost generation of start-ups, as modelled in Figure 1a, is resulting in lasting effect on aggregate employment and it is making it harder for the aggregate economy to reach pre-crisis levels again. We illustrate in Figure 1c scenario 2 with a second wave early 2021, in which case jobs lost increases to 80 thousand jobs. It takes several years before aggregate employment catches up again with its pre-crisis levels. This implies potentially long and persistent unemployment, which can lead to structural long-term unemployment, lower productivity growth and hence adding to the effects currently estimated. We therefore see the simulations as a lower bound.

These simulations show the need for targeted growth policies, which enhance economic growth and stimulate entrepreneurship in the years to come. Given limited resources, state aid is best targeted towards those segments of the economy which can potentially generate the highest multipliers, i.e. which can generate most spillovers for overall growth. This is typically through the supply chain which governs the granular relationships between firms in the economy. We tune in on this in the next section.

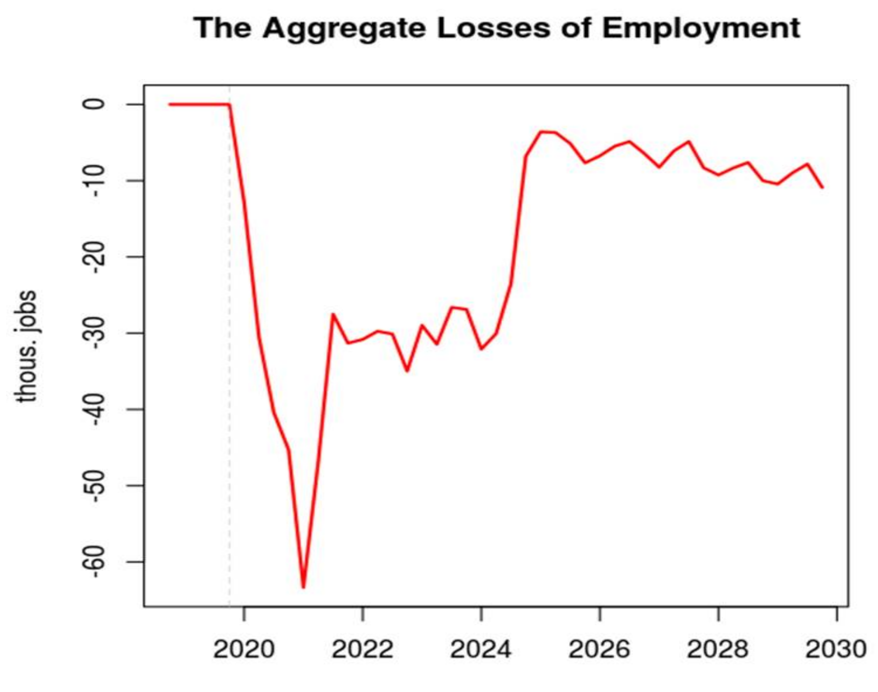

Figure 1a: *Start up rates in Q1 and Q2 at 50% of Q1 and Q2 2019; at 70% of Q3 and Q4 2019, GDP growth rates Q1 -3.6, Q2 -3.6 Q3 -1, Q4* -1

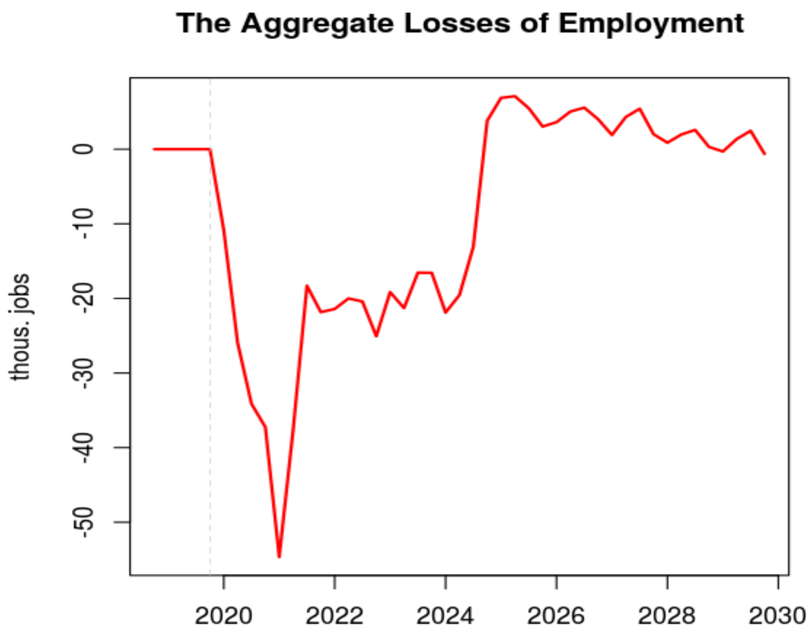

Figure 1b: *Impact when start-up rate stays the same, while GDP declines as in Figure 1a.*

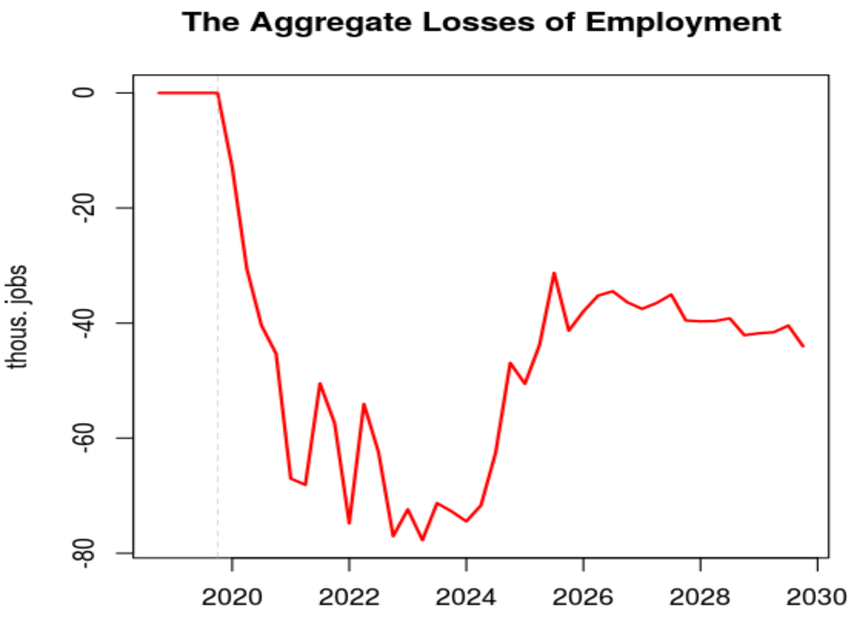

Figure 1c: *Start up rates in Q1 and Q2 at 50% of Q1 and Q2 2019; at 70% of Q3 and Q4 2019, GDP growth rates Q1 -3.6, Q2 -3.6 Q3 -1, Q4 -1 2021 Q1 at -1 and 2021 Q2 at 0. Growth resumes after Q2 2021.*

Summary 1:

- *Using machine learning, we simulate the impact of the COVID-19 crisis on jobs in Belgium: Under relatively mild assumptions the crisis will result in a loss of 65,000 jobs, with a mild second wave early 2021, this increases to 80,000 jobs lost.*
- *These job losses are persistent, by 2025 aggregate employment has not fully recovered and is still below pre-crisis levels.*
- *These job losses are triggered by job destruction with incumbent firms, but importantly also a lost generation of start-ups, which is contributing to the persistency in job loss.*
- *Policies should target supporting entrepreneurship to limit the scarring effect of a lost generation of start-ups.*

4. The production network and multiplier effects

Sectors are linked to each other through supplier-buyer relationships: a sector sources inputs from upstream sectors, combined with factors of production such as labor and capital, to produces output that is sold again to other sectors and final demand. These relationships are represented by the IO tables at the industry-by-industry level. Figure 2 shows the input intensity of sectoral output used by other sectors. Each cell represents the input use of a row sector's output in a column's sector input consumption. Values represent the share of domestic inputs sourced from a particular sector. For example, most sectors source from their own outputs, as is visible from the diagonal. On the off-diagonal entries, we see that some sectors provide general inputs to many other sectors in the economy: *wholesale, transportation, legal and accounting services etc.*

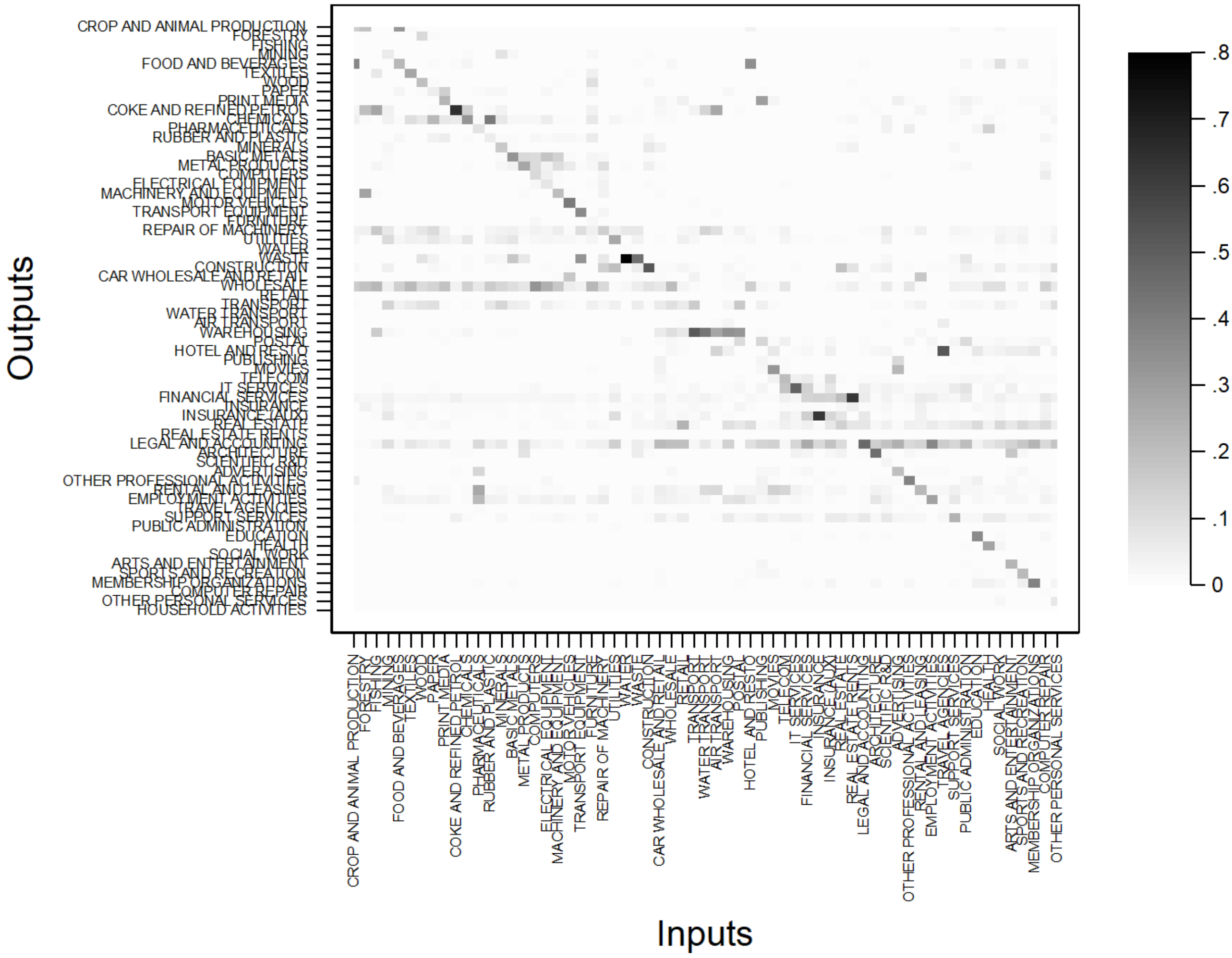

Figure 2: *The input-output structure of the Belgian economy (2015).*

Figure 3 shows a network representation of the IO structure of the Belgian economy. Each node represents a sector, and each arrow represents the output provided by one sector and consumed by another, with the arrow pointing towards the buying sector. The size of each node is given by the share in value added the sector contributed to GDP. This network view highlights the supply chain structure of the economy: for example, *legal and accounting* services are important inputs for a variety of sectors. Also, *crop and animal production* serves as an important input for the *food and beverages* sector, which in turn supplies the hotel and restauration sector etc.

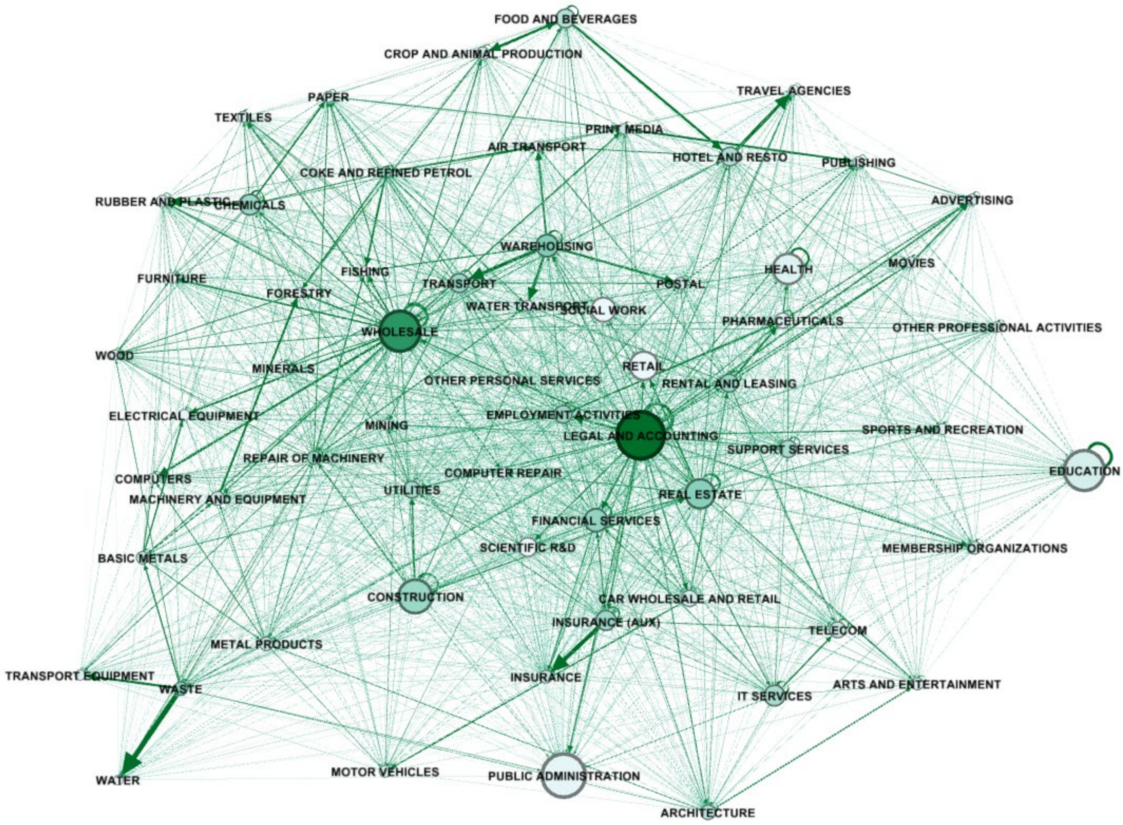

Figure 3: *The network structure of production (2015).*

From here, we can further quantify the strategic importance of sectors, taking into account their total (direct + indirect) contribution to the output of the Belgian economy.

The direct contribution to GDP of sector i is given by its value-added share in GDP, $\beta_i = \frac{VA_i}{GDP}$ (or equivalently its share in final demand). Even if sector i does not directly sell to final demand, it can contribute through selling to sectors j which sell to final demand. Its indirect contribution can be expressed as $\sum_j \omega_{ij}\beta_j$, where $\omega_{ij} = \frac{m_{ij}}{\sum_i m_{ij}}$ represents the share of domestic inputs expenditures used by j and sourced from i.

Sector i can serve several downstream sectors j, and conversely, j can source from several upstream sectors i. Moreover, other sectors in turn supplying sector i can also affect final demand etc. Hence, more generally, let $\Omega = \{\omega_{ij}\}_{i,j=1}^{n}$ denote the matrix of input shares across all sectors i and j, and $(I-\Omega)^{-1}$ the corresponding Leontief inverse. The total (direct + indirect) contribution of each sector to the economy's output can be expressed in matrix notation as

$$v = (I-\Omega)^{-1}\beta = \beta + \Omega\beta + \Omega^2\beta + \cdots \Omega^n\beta$$

where $\boldsymbol{\Omega^n}$ denotes the n^{th} power of the matrix. This expression is known as Bonacich (1987) centrality, and measures the importance of a sector as a supplier to the economy at large. The total contribution of sector i can be written as

$$v_i = \beta_i + \sum_j \omega_{ij}\beta_j + \sum_k \omega_{ik}\omega_{kj}\beta_j + \cdots$$

In words, v_i represents the total impact of sector i on aggregate output. This total impact is the sum of the direct contribution to final demand β_i, the indirect impact on final demand through serving sectors that themselves directly sell to final demand, $\sum_j \omega_{ij}\beta_j$, sectors that serve sectors that serve sectors that sell to final demand $\sum_k \omega_{ik}\omega_{kj}\beta_j$ etc., ultimately combining all paths of all lengths to final demand, and so capturing the whole effect of a shock to sector i on the aggregate economy.

Under fairly general conditions on sectoral production functions and the competition structure of the economy (see Appendix 2), this centrality measure coincides with the well-known Domar weights in national and growth accounting: $v_i = \frac{S_i}{GDP}$, or the sector's gross output over GDP. Finally, the use of gross output (and not value added) in the numerator implies that these shares will sum to a number larger than 1. This is exactly the multiplier effect of the production network on the economy. Each sector's multiplier effect can be obtained as the ratio of its value added to GDP over its Domar weight, or its sales over value added ratio: $\mu_i = \frac{S_i}{GDP} / \frac{VA_i}{GDP} = \frac{S_i}{VA_i}$.

Sectors with a high Domar weight are important contributors to the economy's output. Sectors that then also have high multiplier effects are moreover catalysts for leveraged effects on the economy. We discuss these in the next section.

5. Key strategic sectors

With information on value added shares, total contribution to an economy's output, and exploiting the Belgian IO tables, we present the key strategic sectors for Belgium. We define strategic sectors based on the measures derived above: (i) their value-added share in GDP, (ii) Domar weights, and (iii) multiplier effects. See Appendix 2 for a ranking of the top 20 sectors in terms of each measure.

In Figure 4a we summarize the key strategic sectors (ranked on top 20) based on their value added share in GDP (horizontal axis), the average EU growth of these sectors (vertical axis) and their multiplier effect (size of the bubble). This graph captures important sectors, that have a growth potential in the EU, and that can provide a multiplier effect to the Belgian economy. Clearly the *wholesale or distribution sector* contributes to a large extent to value added and its multiplier effect is substantial. It is also a strong growth sector in the EU. Likewise, *legal, accounting and head office activities* has a strong multiplier effect and contributes to a large extent to GDP. This is a strong growth sector and reflects the global nature of firms, with a lot of multinationals heaving head office activities. It reflects the fact that there is an increasing number of very large firms which need proper administrative and legal support. Also '*Construction*' contributes a lot to GDP and has a large multiplier effect. Other important sectors are '*food and beverages'*, while not a large share of GDP its multiplier effect is large, likewise '*chemicals*'. Moreover, due their growth, these sectors can be drivers of transformation of the Belgian economy in the medium term. In Figure 4b shows a different representation based on the intensity of ICT investment, which is considered as an important key enabling technology, with a strong positive impact on productivity as recently shown in Dhyne et al (2020). They show that an additional euro invested in ICT generates 1.35 euro additional value added in Belgian firms on average. Interestingly, using this second approach yields by and large the same top 20 key sectors, except that financial services and financial activities enters the list.

Of course, there is still a lot of heterogeneity within sectors, with declining and growing firms, creative destruction, market power etc. Nevertheless, this picture gives a first idea of which activities in the economy contribute a lot to overall growth. Further detailed analysis on key firms, competition and market shares within sectors, as in Magerman et al. (2016), Bernard et al. (2020), Kikkawa et al. (2020) can be considered in future steps.

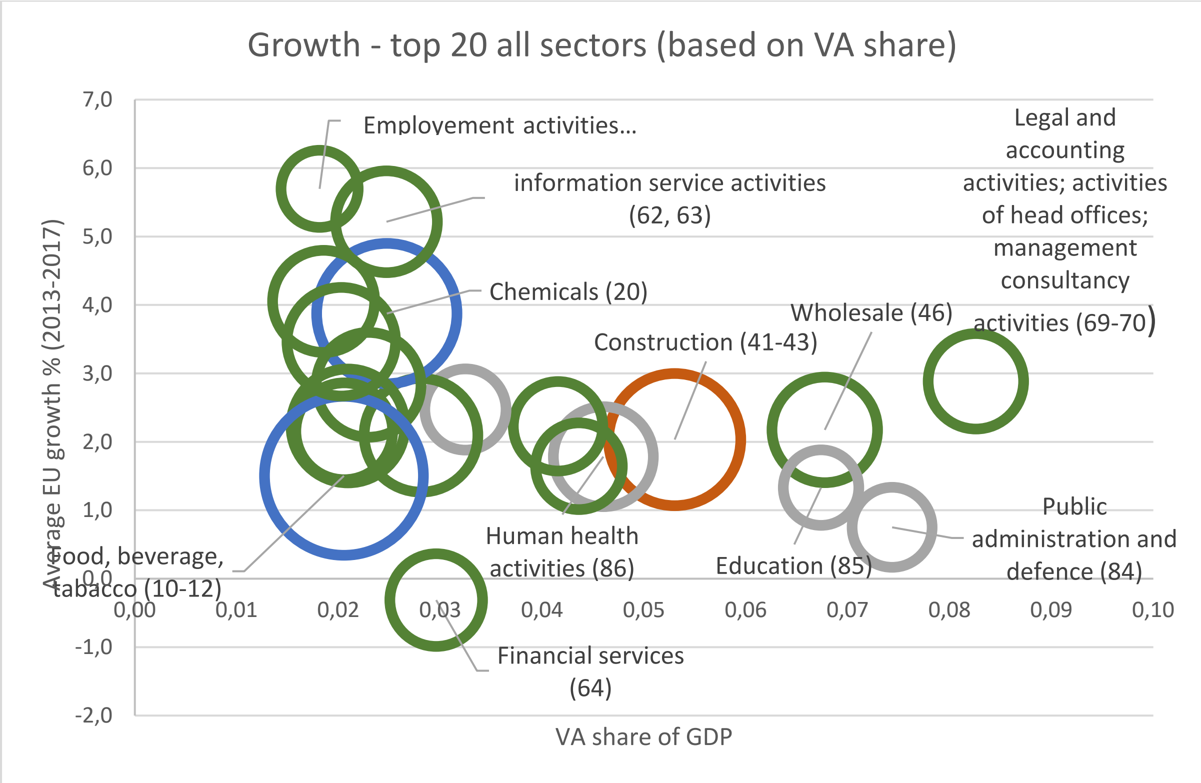

Figure 4a: *Key sectors of the Belgian economy.*

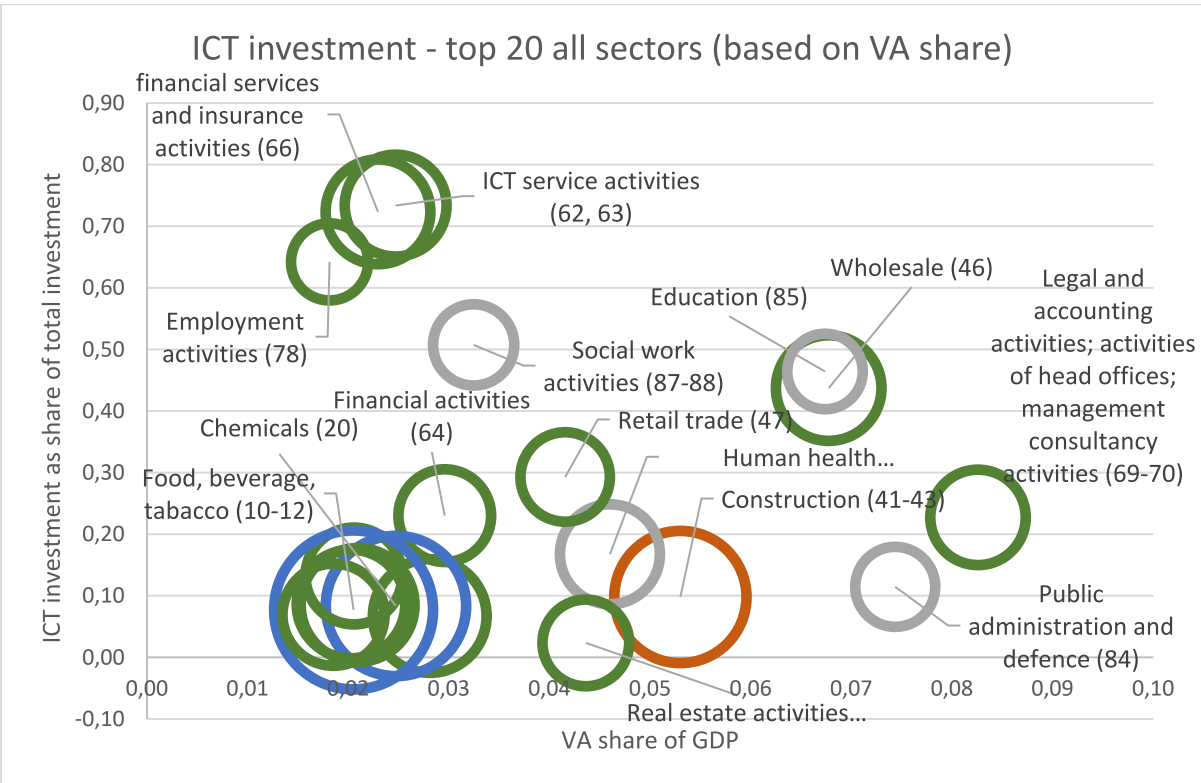

Figure 4b: Key sectors of the Belgian economy, based on ICT intensity

Summary 2:

- *Some sectors take a central position in the Belgian value chains as a key supplier to other sectors and ultimately final demand. Disruptions in these sectors can have a large impact on the economy's output, as shocks ripple through these value chains.*
- *Networks in the economy matter for the rippling down of economic shocks, likewise they matter when state aid is considered.*
- *While there is a lot of heterogeneity within sectors in terms of growing and declining firms and in terms of the firm size distribution, it is important to gauge the relative importance of broad economic activities in GDP. This is done by looking at the share of value added in GDP and the multiplier effect based on Input-Ouput tables.*
- *Key strategic sectors with high multipliers, a large contribution to GDP and in which there is substantial EU growth/ICT investment in the past include: Chemicals, Manufacturing of Food & Beverages, Distribution (wholesale), Construction, Legal and Accounting Services (head offices), information service activities, Financial Services, Education.*

6. The impact of COVID-19 on the Belgian economy

Finally, we evaluate the impact of the current COVID-19 pandemic on Belgian output. Belgium, like other countries, has implemented several forced administrative closures to curb the spread of the COVID-19 virus outbreak. These policies imply a reduction in labor, and subsequently a drop in economic output (GDP). These labor shocks do not only affect sectors directly hit by the policies, but also indirectly through supplier-buyer linkages (value chains).

This section presents the results of these labor shocks on Belgium's output, using a calibrated model of sectoral value chains (Barrot et al., 2020). The model provides estimates for

- the reduction in aggregate output (GDP),
- the reduction in total sales, sales to final demand, and market shares by sector,
- the gains in GDP from opening up particular sectors.

The framework takes into account a combination of 3 plausible sources of labor shocks: (i) forced administrative closures, (ii) the ability to telework, and (iii) the impact of lack of childcare for parents that can telework. The model is calibrated using data on Input-Output tables for Belgium, and information on telework ability and census data for parenting from France. It allows for rich substitution patterns, with 3 elasticities of substitution: (i) between factors (labor) and intermediate inputs, (ii) between different intermediate inputs, and (iii) between final consumption goods. Model setup and assumptions are provided at the end of the report.

Some remarks are important to point out at this stage. We present results for a shock of a 9-week policy. The assumption is that after this confinement, we are back to "business as usual", which is highly unlikely. Estimates are thus an under-estimation of the impact of the shocks. Alternative lengths of policies can be readily pro-rated. The calibration of the model targets the short-run implications on production, i.e. fairly low elasticities of substitution that reflect the limited possibilities to substitute away inputs and consumption across alternative choices. Elasticities are calibrated at 3 (across consumption goods), 0.4 (across intermediate inputs), and 0.5 (between labor and inputs). The choice of the final demand elasticity is of second order importance in the impact on GDP. The amount of teleworking (as a share of labor supply) is measured before the shock. Most probably higher propensities to telework are possible as firms shift their production capacities and operations. The assumption in the model is rather strong: If you cannot work from home, you cannot work at all. This adds to a large contribution of the third policy on output. We assume the sector as a whole survives, and do not model sector-level bankruptcies. Individual firms can go bankrupt, but are replaced from the pool of surviving firms within that sector. With bankruptcies and firm-level reallocation of market shares, non-linearities will become significant, exacerbating the impact of the input-output dependencies, and the drop in GDP.

6.1 Impact on GDP

Estimates for the impact on GDP are presented for 3 increasingly stringent shocks:

Scenario 1 - administrative closing,

Scenario 2 - administrative closing + school closing,

Scenario 3 - administrative closing + school closing + teleworking.

Naturally, more stringent policies have a higher cost in terms of output. These numbers can be interpreted as roughly the excess capacity at which the Belgium economy runs given its pool of otherwise active labor in the market. We also provide estimates for how much of the GDP shock is due to accumulated indirect effects in the production network: the impact of sectors that are hit are not restricted to the sector itself, but can affect both upstream and downstream sectors. The cumulated impact of the various lockdown polices through the labor supply is huge (table 1 below): a decrease in Belgian GDP of up to 6.3%. This estimate takes into account both the direct (share of value added in GDP) and indirect effects (accumulated effects through the value chains) of the shocks. Moreover, it accounts for non-linearities through imperfect competition and imperfect substitutability of inputs. At the same time, this is a lower bound estimate, as additional demand-side effects can aggravate the impact on GDP, and we assume we are back at business as usual after 9 weeks of confinement. Moreover, some sectors (such as events, movies etc.) currently face much longer lockdowns than 9 weeks. On the upside, if demand follows swiftly, there will be a minimal aggregate demand effect, only perhaps shifted some months.

Policy	**Impact on 2020 GDP**
Policy 1 – admin	- 1.7%
Policy 2 – admin + schools	- 2.9%
Policy 3 – admin + schools + telework	- 6.3%

Table 1: *impact of 9-week policies on Belgian GDP (2020).*

5.2 Impact on sectors

The shock to GDP captures the total effect on the economy, but obfuscates how hard individual sectors are hit. We present the top 20 sectors that are hardest hit in terms of value added, total sales, sales to final demand, and labor income.

Figure 5 shows the decline in a sector's value added, as a % drop from its previous (steady state) value. Each bar represents the decline in the variable due to administrative closings (green), the additional effect of school closings (red), and the residual effect of teleworking (blue). Generally, the economic impact of administrative closings and ability to telework have the largest impact, while the additional effect of school closings is minor. "Other professional activities", which include professional, scientific and technical activities (NACE 74-75) are hardest hit, with a drop of around 12% of gross value added from a 9-week policy. Note that longer or additional lock-downs would have pro-rated additional effects on output. Eg. a second 9-week lockdown results in an additional 12% drop in value added over the output of 2020. Similar results can be read for the other sectors. Generally, services industries (which are large contributors to GDP) have been hit most.

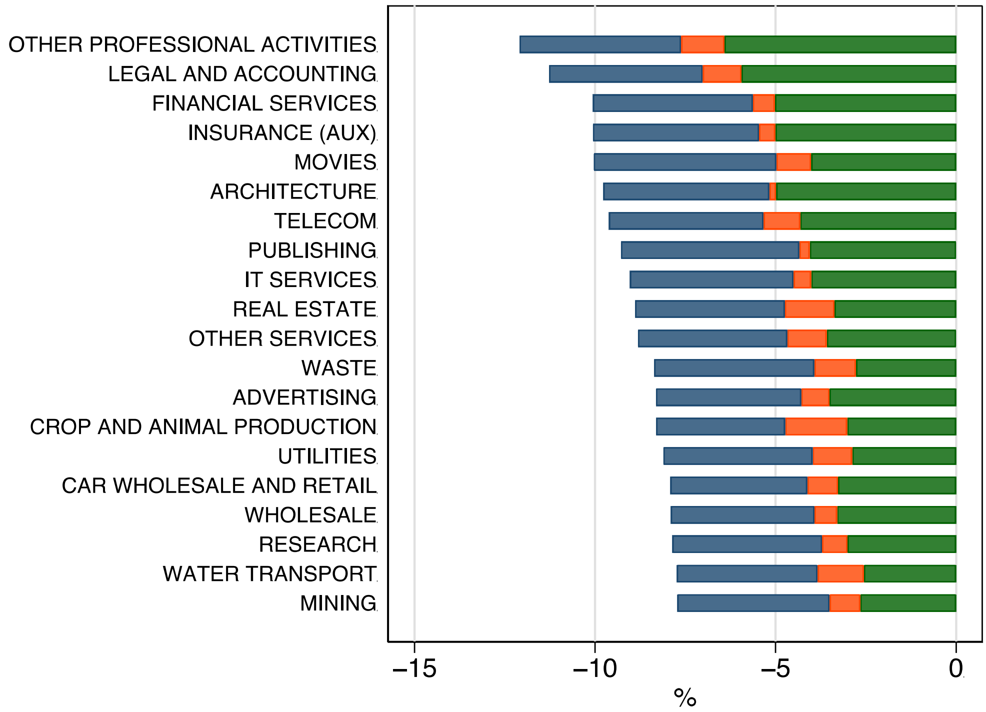

Figure 5: *Value added growth of top 20 hit sectors. Compound effect of administrative closings (green), school closings (red) and ability to telework (blue).*

Next, figure 6 shows the drop in total sales for the top 10 hardest hit sectors in terms of output. Total sales is expressed as sales to all downstream sectors (intermediate inputs) and final demand. Here again, a lot of services industries are severely affected.

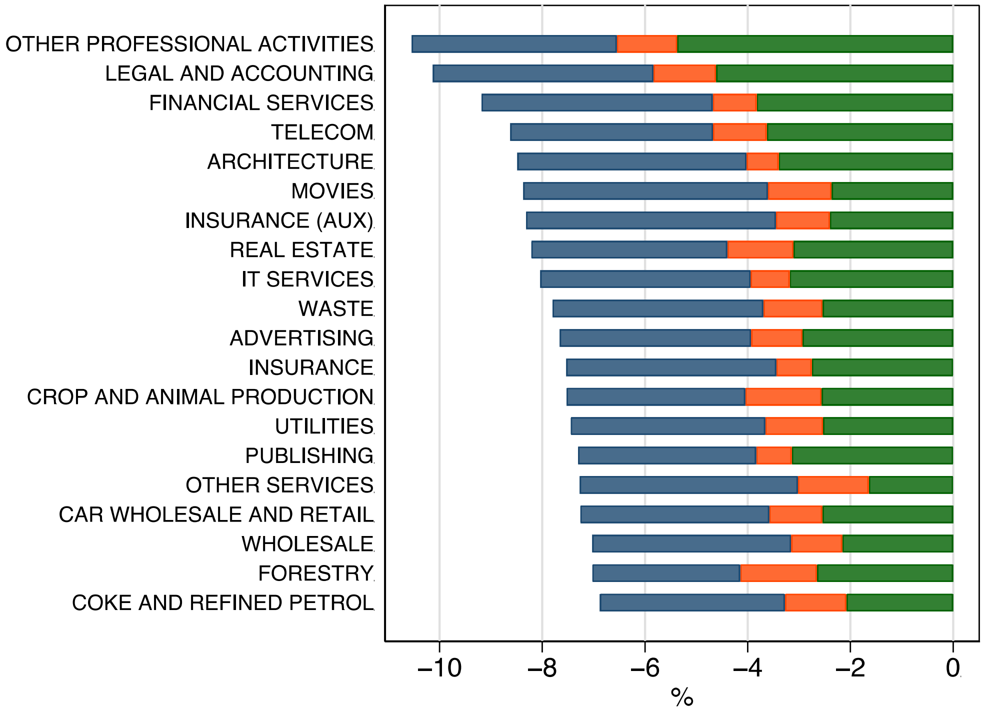

Figure 6: *Sales growth of top 20 hit sectors. Compound effect of administrative closings (green), school closings (red) and ability to telework (blue).*

Next, figure 7 shows the change in sales to final demand due to the different policies. Here we find sectors that are highly dependent on final demand that are hit hardest: again services industries.

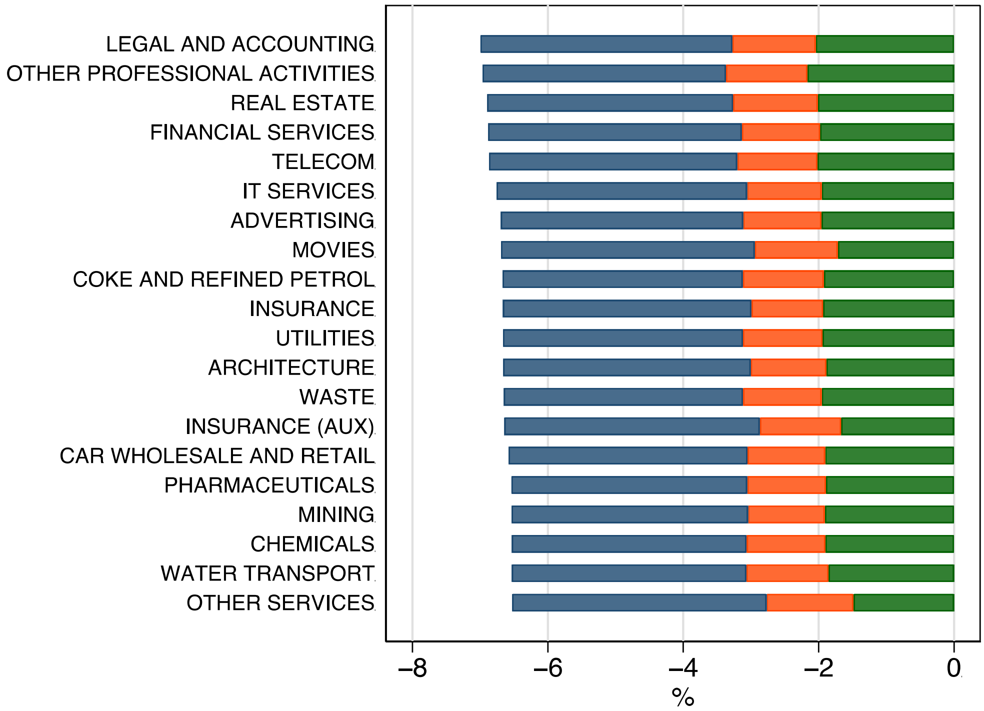

Figure 7: *Sales to final demand growth of top 20 hit sectors. Compound effect of administrative closings (green), school closings (red) and ability to telework (blue).*

Finally, figure 8 provides the change in total labor cost (or income) for the top 20 hit sectors. The total labor cost is expressed as total expenditure on wages, pensions and social schemes, and can also be viewed as total employment times wages paid. Hence, the change in labor cost reflects the combined impact of job loss (a decrease in employment) and changes in sectoral wages (general equilibrium effects in the model). But since wages are rigid, this is a good proxy to assess the impact on jobs lost.

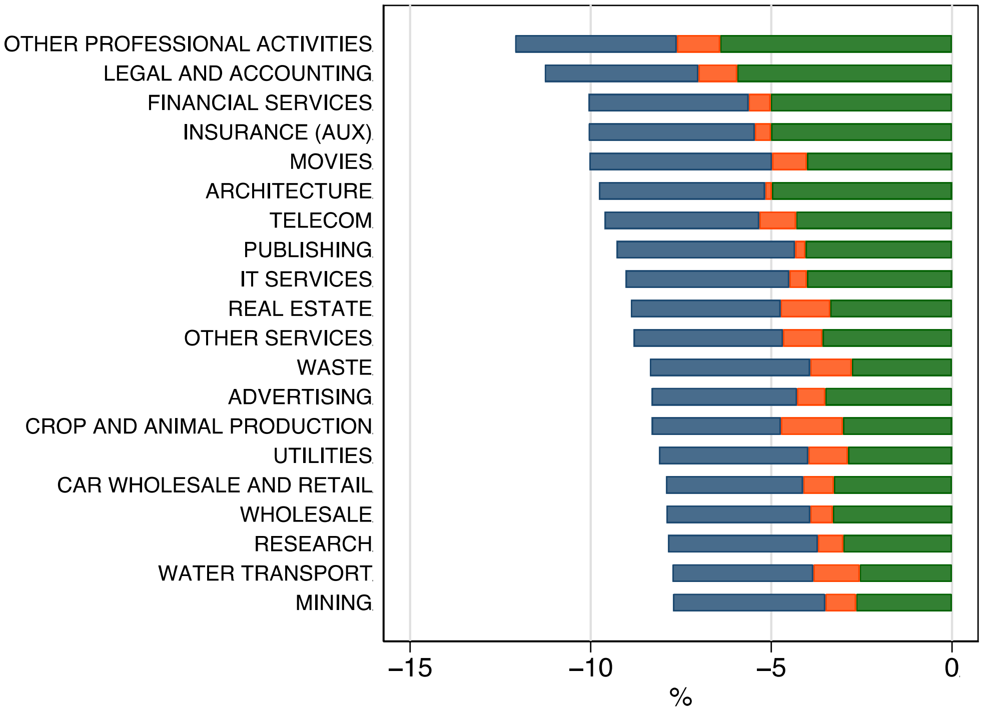

Figure 8: *Change in labor income of top 20 hit sectors. Compound effect of administrative closings (green), school closings (red) and ability to telework (blue).*

Summary 3:

- *We use Input-Output tables and a model of imperfect competition to simulate the impact of the COVID-19 crisis on the Belgian economy. Implemented policies imply a reduction in labor, and subsequently a drop in economic output (GDP).*
- *The framework takes into account a combination of 3 plausible sources of labor shocks: (i) forced administrative closures, (ii) the ability to telework, and (iii) the impact of lack of childcare for parents that can telework.*
- *The estimated impact of a 9-week lockdown on 2020 GDP is around 7%, of which 80% can be contributed to indirect effects that ripple through the value chains of the economy.*
- *At the same time, there is a wide variety in severity of the shock on different sectors, ranging from -12% value added to modest reductions in output. The hardest hit sectors are mostly services industries: professional activities, legal and accounting, financial services, telecom, and creative industries (video, sound, music).*

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Appendices

Appendix 1 – list of sectors in the IO estimation framework

Sector Code		Description
A64	NACE2	
1	1	Crop and animal production, hunting and related service activities
2	2	Forestry and logging
3	3	Fishing and aquaculture
4	05-09	Mining and quarrying
5	10-12	Manufacture of food products, beverages and tobacco products
6	13-15	Manufacture of textiles, wearing apparel and leather products
7	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
8	17	Manufacture of paper and paper products
9	18	Printing and reproduction of recorded media
10	19	Manufacture of coke and refined petroleum products
11	20	Manufacture of chemicals and chemical products
12	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	22	Manufacture of rubber and plastic products
14	23	Manufacture of other non-metallic mineral products
15	24	Manufacture of basic metals
16	25	Manufacture of fabricated metal products, except machinery and equipment
17	26	Manufacture of computer, electronic and optical products
18	27	Manufacture of electrical equipment
19	28	Manufacture of machinery and equipment n.e.c.
20	29	Manufacture of motor vehicles, trailers and semi-trailers
21	30	Manufacture of other transport equipment
22	31-32	Manufacture of furniture; other manufacturing
23	33	Repair and installation of machinery and equipment
24	35	Electricity, gas, steam and air conditioning supply
25	36	Water collection, treatment and supply
26	37-39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and waste mgt. services
27	41-43	Construction
28	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	46	Wholesale trade, except of motor vehicles and motorcycles
30	47	Retail trade, except of motor vehicles and motorcycles
31	49	Land transport and transport via pipelines
32	50	Water transport
33	51	Air transport
34	52	Warehousing and support activities for transportation
35	53	Postal and courier activities
36	55-56	Accommodation and food service activities
37	58	Publishing activities
38	59-60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
39	61	Telecommunications
40	62-63	Computer programming, consultancy and related activities; information service activities
41	64	Financial service activities, except insurance and pension funding
42	65	Insurance, reinsurance and pension funding, except compulsory social security

43	66	Activities auxiliary to financial services and insurance activities
44	68	Real estate activities (excluding imputed rents)
46	69-70	Legal and accounting activities; activities of head offices; management consultancy activities
47	71	Architectural and engineering activities; technical testing and analysis
48	72	Scientific research and development
49	73	Advertising and market research
50	74-75	Other professional, scientific and technical activities; veterinary activities
51	77	Rental and leasing activities
52	78	Employment activities
53	79	Travel agency, tour operator reservation service and related activities
54	80-82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities
55	84	Public administration and defence; compulsory social security
56	85	Education
57	86	Human health activities
58	87-88	Social work activities
59	90-92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
60	93	Sports activities and amusement and recreation activities
61	94	Activities of membership organisations
62	95	Repair of computers and personal and household goods
63	96	Other personal service activities

Table A.1 – *list of sectors in the IO estimation framework.*

Appendix 2 – Ranking of sectors (top 20) in terms of value added, Domar weights, and multiplier effects.

Rank	NACE Code	Sector	Share of VA in GDP
1	69-70	Legal and accounting activities; activities of head offices; management consultancy activities	0.0827
2	84	Public administration and defence; compulsory social security	0.0744
3	46	Wholesale trade, except of motor vehicles and motorcycles	0.0678
4	85	Education	0.0675
5	41-43	Construction	0.0531
6	86	Human health activities	0.0461
7	68	Real estate activities (excluding imputed rents)	0.0437
8	47	Retail trade, except of motor vehicles and motorcycles	0.0416
9	87-88	Social work activities	0.0325
10	64	Financial service activities, except insurance and pension funding	0.0296
11	52	Warehousing and support activities for transportation	0.0281
12	20	Manufacture of chemicals and chemical products	0.0248
13	62-63	Computer programming, consultancy and related activities; information service activities	0.0247
14	66	Activities auxiliary to financial services and insurance activities	0.0230
15	49	Land transport and transport via pipelines	0.0210
16	72	Scientific research and development	0.0206
17	10-12	Manufacture of food products, beverages and tobacco products	0.0206
18	55-56	Accommodation and food service activities	0.0203
19	77	Rental and leasing activities	0.0186
20	78	Employment activities	0.0182

Table A.2 – *Key strategic sectors as share of value added (2015).*

Rank	NACE Code	Sector	Domar weight
1	41-43	Construction	0.1880
2	46	Wholesale trade, except of motor vehicles and motorcycles	0.1533
3	69-70	Legal and accounting activities; activities of head offices; management consultancy activities	0.1527
4	44175	Manufacture of food products, beverages and tobacco products	0.1052
5	20	Manufacture of chemicals and chemical products	0.0989
6	84	Public administration and defence; compulsory social security	0.0966
7	86	Human health activities	0.0933
8	85	Education	0.0780
9	52	Warehousing and support activities for transportation	0.0737
10	47	Retail trade, except of motor vehicles and motorcycles	0.0675
11	68	Real estate activities (excluding imputed rents)	0.0665
12	19	Manufacture of coke and refined petroleum products	0.0554
13	49	Land transport and transport via pipelines	0.0551
14	62-63	Computer programming, consultancy and related activities; information service activities	0.0520
15	64	Financial service activities, except insurance and pension funding	0.0516
16	24	Manufacture of basic metals	0.0515
17	66	Activities auxiliary to financial services and insurance activities	0.0511
18	55-56	Accommodation and food service activities	0.0485
19	87-88	Social work activities	0.0435
20	77	Rental and leasing activities	0.0392

Table A.3 – *Key strategic sectors in total contribution (2015).*

Rank	NACE Code	Sector	Multiplier
1	19	Manufacture of coke and refined petroleum products	23.2033
2	24	Manufacture of basic metals	7.4662
3	29	Manufacture of motor vehicles, trailers and semi-trailers	7.3935
4	51	Air transport	7.0009
5	79	Travel agency, tour operator reservation service and related activities	6.2801
6	10-12	Manufacture of food products, beverages and tobacco products	5.1177
7	02	Forestry and logging	4.5589
8	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	4.4561
9	17	Manufacture of paper and paper products	4.3624
10	73	Advertising and market research	4.1688
11	20	Manufacture of chemicals and chemical products	3.9917
12	13-15	Manufacture of textiles, wearing apparel and leather products	3.5771
13	22	Manufacture of rubber and plastic products	3.5423
14	41-43	Construction	3.5422
15	01	Crop and animal production, hunting and related service activities	3.4284
16	50	Water transport	3.3824
17	31-32	Manufacture of furniture; other manufacturing	3.3795
18	36	Water collection, treatment and supply	3.2601
19	37-39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	3.1383
20	65	Insurance, reinsurance and pension funding, except compulsory social security	3.1289

Table A.4 – *Key strategic sectors as multipliers (2015).*

Appendix 3 – Modeling framework COVID-19 and the impact on Belgian output

The model is a static version of the sector-level general equilibrium model of Long and Plosser (1983), as used by Acemoglu et al. (2012). There are N goods produced by N sectors, each with a representative firm. Each sector has a sector-specific production function combining labor with intermediate inputs to produce output. There is a representative consumer that consumes all of the N goods. She supplies labor inelastically, specific to each sector i. Equilibrium is determined by firms that maximize profits, consumers that maximize utility, and markets clear in a perfectly competitive environment. For a more elaborate description, see Barrot et al. (2020).

Final consumption is given by a CES utility function, with a common elasticity of substitution across goods. Consumption of each good i is determined by a preference for the good and its price, subject to a budget constraint which is determined by income from labor. (The model can easily extended to include capital, which is not shocked). Firms take input and output prices as given, and produce following a CES aggregator of productivity, factors and a series of intermediate inputs. There is a separate elasticity between factors and inputs, and one between inputs). The production network (values of inputs and outputs) are determined by technology and prices.

The model takes into account a labor shock from (i) forced administrative closures, (ii) the ability to telework, and (iii) lack of childcare for parents that can telework. A reduction in labor due to a combination of these sources then leads to a drop in output. The total effect of this shock on the economy's output depends on the network structure of production ("value chains"): not only negative shocks to sectors hit affect aggregate output, but also supplying and buying sectors at several connected stages of the value chains. Sectors are not isolated islands of production, but depend on each other to produce an economy's output.

The model focuses on short run implications: labor is immobile across sectors, and elasticities of substitution (between factors and intermediate inputs, between different intermediate inputs, and for the final consumer) are low. There is perfect competition between sectors. While several assumptions can be discussed, they are a plausible first-order approximation for the short-run sectoral implications.

The model is operationalized by (i) Input-Output tables for Belgium, (ii) a survey on telework to quantify the share of workers in each sector that remain active despite of confinement for France, (iii) French census data for the amount of labor lost due to taking care of children during this period. The model can be further calibrated with Belgian data whenever this would become available for research.

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