Belgian Regions in Local and Global Value Chains*

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Abstract

We construct a novel world input-output table with regional detail for Belgium by integrating the Belgian MRIO tables with the World Input-Output Database (WIOD). The resulting dataset links sectoral activity in Brussels, Flanders, and Wallonia to international trade flows with 43 countries. We document the methodology for harmonizing and balancing the data, and use it to compute output, value added, and employment multipliers, Domar weights, and measures of upstreamness. The results highlight stark regional differences in global integration: Flanders is highly exposed to international production networks, while Brussels and Wallonia rely more on domestic linkages. This dataset enables region-level analysis of trade exposure and structural change within global value chains.

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1 Introduction

The sub-national component of economic activity is often scarcely considered when it comes to analyzing the effects of exogenous shocks to the economy. One of the main reasons for this lack of attention can be certainly attributed to the unavailability of data, due to the complexity in tracing trade flows between regions, both within and outside national borders. However, national economies are in fact largely disaggregated in reality, both in terms of sectors and regions, and the distribution of economic activity is quite uneven. This, in turn, implies that some regions and sectors will be more connected than others to other regions within and outside the national borders. Hence, specific shocks can propagate differently through the production network and have different impacts on different regions within the same country. For instance, a shock taking place in the US will hit differently Flanders than Wallonia in Belgium, depending on the direct and indirect linkages that connect each region with the US. Similarly, a shock taking place in Flanders will propagate differently through the international production network than if the same shock was hitting Wallonia.

The need to use regional trade data has led researchers to provide new models and methodologies to retrieve these data from the national input output tables. These are usually known as "non-survey" methods, and are of course easier and less expensive to implement than the more accurate surveys. For example, Anagnostou and Gajewski (2021) construct an inter-regional Input-Output table for Poland using country-level tables. Zheng et al. (2021) use a partial survey approach to create a multi-regional Input-Output table for 31 Chinese provinces spanning several years. Koutaniemi and Louhela (2006) use a partial survey method to compile regional tables for Finland both using national tables and freight data.

However, while there are not many studies aimed at constructing these tables for European countries, some countries are trying to fill this gap by making efforts to produce national Input-Output tables with regional detail. For instance, in Italy, the regional public body for economic planning IRPET has compiled the input-output tables for four macro-regions (at the NUTS1 level) using a combination of both survey and non-survey methods[1]. For Belgium, the Federal Planning Bureau has collected regional trade data from its three regions (Brussels, Flanders and Wallonia) and has combined this with individual firm-level data, obtaining a full national Input-Output table describing the intra-regional and interregional trade flows between the three Belgian regions for the year 2015 (Avonds et al. (2021)). However, when it comes to international trade flows, data are unilateral and they are all aggregated into imports or exports, without any information about shipping or target location, respectively.

This paper extends the Multi-Regional Input-Output (MRIO) table for Belgium developed by Avonds et al. (2021) with international input-output linkages derived by the World Input-Output Tables (WIOD), connecting Belgian sector-regions to the world economy. These data allow to assess the position and relative importance of Belgian sector-regions in global value chains and the world markets.

The starting point of our analytical framework is the Leontief inverse. This metric is central to input-output analysis, and appears in quasi all linear production network metrics as a key

[1] See Rosignoli et al. (2012).

building block to model direct and indirect exposure to supply and/or demand shocks.

This paper is the first to conduct this work for Belgium. Moreover, due to the high level of sectoral disaggregation provided by the Belgian data (which contains 124 sectors), we can match the sectors in our data exactly to the ones in the WIOD, allowing to keep a good level of sectoral information with respect to other studies.

We use the resulting table to calculate regional output multipliers, decomposing them into intra-regional, inter-regional and international components. We also present results in terms of Domar weights, upstreamness and centrality of Belgian sector-region pairs, to evaluate their position and relative importance both in national and in the world markets.

Similar work has been carried out by Dietzenbacher et al. (2012), who combine Brazilian regional input-output tables with the WIOD to assess the position of Brazilian regions in the global supply chains. Similarly, Los and Cherubini (2012) integrate sub-national input-output tables for the four macro-regions of Italy with the WIOD. Krebs (2020) uses a dataset of trade linkages between German counties and the WIOD to construct an interregional input-output table for more than 400 German counties and several countries. Finally, the Joint Research Centre of the European Commission has promoted two different projects aimed at creating input-output tables with regional detail for the whole EU28. First, the EUREGIO dataset, developed by Thissen et al. (2018), which combines the WIOD with regional economic accounts and interregional trade estimates data, constructing input-output tables covering years 2000 to 2010. Second, the RHOMOLO dataset constructed by Thissen (2020), which regionalizes trade flows using the WIOD and regional freight data.

The paper is structured as follows. In Section 2 we describe the extraction of the data from the raw files and the structure given to merge the two sets of data at a later stage. Section 5 presents the results of the input-output analysis.

2 Constructing a world input-output table for Belgian regions

We develop a harmonised world input-output table that integrates regional detail for Belgium into a global cross-country framework. The resulting dataset combines information from the Belgian Multi-Regional Input-Output (MRIO) tables with the World Input-Output Database (WIOD), providing sector-location level data on trade flows, value added, and final demand across 55 ISIC Rev.4 sectors and 47 geographies. Appendix A provides additional details on the data construction.

2.1 Source tables and harmonization

The first dataset consists of Belgium's MRIO tables for 2015, compiled by the Federal Planning Bureau in collaboration with the regional statistical agencies Statistiek Vlaanderen (Flanders), IWEPS (Wallonia), and BISA (Brussels).[2] These tables report sector-region information on intermediate goods and services flows, value added, imports, and final demand across 124 NACE Rev.2 (2008) industries at the NUTS1 level. All values are expressed in millions of euros at current 2015 prices. To align these data with the WIOD, this data is harmonized in three

[2]MRIO documentation from the Federal Planning Bureau is available in Dutch and French.

steps. First, transactions reported under a separate "extra-territorial" region (including for example transactions by embassies or military missions) are proportionally reallocated to the three main Belgian regions following Planbureau (2021). These adjustments affect less than 0.002% of total intermediate flows. Second, the eight final demand categories are grouped into household consumption, government consumption, gross fixed capital formation, and changes in inventories. The seven value-added components are aggregated into two categories: value added and net taxes. These aggregations preserve total sector-region values. Finally, the 124 NACE industries are mapped to 55 ISIC Rev.4 sectors that are used in WIOD.

The second dataset is the World Input-Output Database (WIOD), developed by Timmer et al. (2015) and maintained at the University of Groningen.[3] The dataset reports inter-sectoral transactions, value added, imports, and final demand for 43 countries and a Rest of the World (RoW) aggregate, disaggregated into 56 industries at the two-digit ISIC Rev.4 level. All values are expressed in millions of US dollars at current 2014 prices. To harmonize the WIOD with the Belgian MRIO data, three adjustments are implemented. First, all monetary values are converted from US dollars to euros using the average 2015 exchange rate, USD/EUR = 0.9013.[4] Second, observations related to sector U ("Activities of extraterritorial organizations and bodies") are excluded, as this sector is not reported in the Belgian MRIO tables. Third, even after adjusting for exchange rates, total Belgian output for 2014 recorded in the WIOD can differ from the MRIO data in 2015. To reconcile the datasets, the WIOD entries for Belgium are adjusted using the RAS algorithm, a bi-proportional matrix balancing procedure introduced by Stone (1962), and commonly used to update IO tables for intermittent years. This method guarantees that the resulting matrix for Belgium is consistent with both the WIOD structure and MRIO totals.

Finally, although the MRIO tables include total exports and imports by sector and region, they do not identify destination or origin countries. Conversely, WIOD reports Belgium's bilateral trade by sector, but not its regional composition. To link both datasets, we proportionally allocate each WIOD sector-country flow involving Belgium to the three Belgian regions based on their share in national exports (or imports) in that sector. For example, Belgian exports in the Manufacture of Basic Metals sector (ISIC C24) to the Motor Vehicles sector (ISIC C29) in Germany are allocated to Flanders, Wallonia, and Brussels based on each region's share in Belgium's total C24 exports, irrespective of destination. This ensures consistency between regional MRIO constraints and WIOD's country-sector granularity.

2.2 Final dataset

The world input-output table with regional detail for Belgium is defined over 55 ISIC sectors and 47 geographies: the 3 Belgian regions, 43 countries, and one Rest of the World aggregate. Figure 1 illustrates the structure of the dataset. Sectors are indexed by $i, j \in N$, and geographies by $r, s \in S$. Let $\mathcal{B} \subset S$ denote the set of Belgian regions, and $\mathcal{F} = S \setminus \mathcal{B}$ the set of foreign

[3] The WIOD data is publicly available at https://www.rug.nl/ggdc/valuechain/wiod/.
[4] Exchange rate obtained from the European Central Bank.

countries. The intermediate transaction matrix $\mathbf{Z}$ consists of geographical sub-matrices $\mathbf{Z}^{rs}$, where diagonal blocks represent local flows and off-diagonal blocks represent inter-regional or international flows. The same structure applies to the vectors of final demand $\mathbf{f}$ and value added $\mathbf{v}$.

			Use													
			Intermediate use							Final demand						
			Location r			…	Location s			Location r			…	Location s		
			Sector 1	…	Sector 55		Sector 1	…	Sector 55	C	I G	E		C	I G	E
Supply	Location r	Sector 1	$z^{r,r}_{1,1}$	…	$z^{r,r}_{1,55}$		$z^{r,s}_{1,1}$	…	$z^{r,s}_{1,55}$	$f^{r,r}_{1,c}$	…	$f^{r,r}_{1,e}$		$f^{r,s}_{1,c}$	…	$f^{r,s}_{1,e}$
		⋮	⋮	⋱	⋮	…	⋮	⋱	⋮	⋮	⋱	⋮	…	⋮	⋱	⋮
		Sector 55	$z^{r,r}_{55,1}$	…	$z^{r,r}_{55,55}$		$z^{r,s}_{55,1}$	…	$z^{r,s}_{55,55}$	$f^{r,r}_{55,c}$	…	$f^{r,r}_{55,e}$		$f^{r,s}_{55,c}$	…	$f^{r,s}_{55,e}$
	⋮			⋮		⋱		⋮			⋮		⋱		⋮	
	Location s	Sector 1	$z^{s,r}_{1,1}$	…	$z^{s,r}_{1,55}$		$z^{s,s}_{1,1}$	…	$z^{s,s}_{1,55}$	$f^{s,r}_{1,c}$	…	$f^{s,r}_{1,e}$		$f^{s,s}_{1,c}$	…	$f^{s,s}_{1,e}$
		⋮	⋮	⋱	⋮	…	⋮	⋱	⋮	⋮	⋱	⋮	…	⋮	⋱	⋮
		Sector 55	$z^{s,r}_{55,1}$	…	$z^{s,r}_{55,55}$		$z^{s,s}_{55,1}$	…	$z^{s,s}_{55,55}$	$f^{s,r}_{55,c}$	…	$f^{s,r}_{55,e}$		$f^{s,s}_{55,c}$	…	$f^{s,s}_{55,e}$
	Imports		m^{r}_{1}	…	m^{r}_{55}	…	m^{s}_{1}	…	m^{s}_{55}							
	Value added		v^{r}_{1}	…	v^{r}_{55}	…	v^{r}_{1}	…	v^{r}_{55}							

Figure 1: Schematic representation of the WIOD structure with Belgian regional disaggregation.

These tables satisfy standard input-output accounting identities. The first identity states that total gross output equals the sum of all intermediate sales and sales to final demand. For any sector i located in a Belgian region $r \in \mathcal{B}$, gross output is:

$$x_i^r = \underbrace{\sum_{j \in N} z_{ij}^{rr}}_{\text{intra-regional}} + \underbrace{\sum_{s \in \mathcal{B} \setminus \{r\}} \sum_{j \in N} z_{ij}^{rs}}_{\text{inter-regional}} + \underbrace{\sum_{s \in \mathcal{F}} \sum_{j \in N} z_{ij}^{rs}}_{\text{international}} + \underbrace{\sum_{s \in S} f_i^{rs}}_{\text{final demand}} \tag{1}$$

where the first term represents intra-regional intermediate sales within Belgian region r, the second term captures inter-regional sales to other Belgian regions, the third term captures international intermediate sales to foreign countries, and the fourth term aggregates all final demand for output from (i, r), regardless of the destination.

The second identity states that total input expenditures of a sector-region pair equal the sum of all intermediate inputs sourced from other sector-locations, plus the value added generated locally. For any sector j located in Belgian region $s \in \mathcal{B}$, total input expenditures are:

$$y_j^s = \underbrace{\sum_{i \in N} z_{ij}^{ss}}_{\text{intra-regional inputs}} + \underbrace{\sum_{r \in \mathcal{B} \setminus \{s\}} \sum_{i \in N} z_{ij}^{rs}}_{\text{inter-regional inputs}} + \underbrace{\sum_{r \in \mathcal{F}} \sum_{i \in N} z_{ij}^{rs}}_{\text{international inputs}} + \underbrace{v_j^s}_{\text{value added}} \tag{2}$$

Here, intermediate inputs may be sourced from the same region (intra-regional, z_{ij}^{ss}), from other Belgian regions (inter-regional, z_{ij}^{rs} with $r \in \mathcal{B}$), or from abroad (international, z_{ij}^{rs} with $r \in \mathcal{F}$). Value added v_j^s includes returns to labour and capital, as well as net taxes on production.

3 Descriptives

- For sure describe dimensions of the final dataset: 3 BE regions with Maybe show regional variables (GDP per region, export values per region) + biggest sectors per region?

4 Analytical framework

This section presents the metrics used to extract structural properties of the Belgian regional production network and its integration into global value chains. We focus on three key metrics: output and value-added multipliers, Domar weights, and measures of upstreamness. These metrics allow us to quantify the strength of input-output linkages within and across regions, the relative influence of sectors in the economy, and the position of each sector-region pair along the value chain. Formal derivations are provided in Appendix B.

4.1 Leontief multipliers

The starting point of our analytical framework is the Leontief inverse. Let $\mathbf{x} \in \mathbb{R}_{+}^{NR}$ denote the vector of gross output across all Belgian sector-regions, and let $\mathbf{f} \in \mathbb{R}_{+}^{NR}$ denote the corresponding vector of final demand. Output satisfies the standard accounting identity:

$$\mathbf{x} = \mathbf{Z}\mathbf{1} + \mathbf{f}, \tag{3}$$

where $\mathbf{Z}_{+} \in \mathbb{R}^{NR \times NR}$ is the intermediate input matrix, and $\mathbf{1}$ is a vector of ones to sum over all column entries in a row. Let the input coefficient matrix $\mathbf{A} \equiv \mathbf{Z} \cdot \text{diag}(\mathbf{x})^{-1}$ where entries $a_{is,js} = \frac{z_{is,js}}{x_{js}}$ denote the share of inputs from supplier sector-region i, r to user sector-region j, s in total sales of j, s. The canonical Leontief equation is then:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}. \tag{4}$$

In words, total sales of sector-region i, r is the weighted sum of sales of all other sector-regions, with weights the respective technical coefficients, plus sales to final demand in all regions. Next, solving for $\mathbf{x}$ yields:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \equiv \mathbf{L}\mathbf{f}, \tag{5}$$

where $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse matrix. The element $\ell_{ir,js}$ of $\mathbf{L}$ measures the total direct and indirect output in sector-region i, r required to satisfy one unit of final demand in sector-region j, s.

From this, the output multiplier $\mu_{i,r}^{x}$ of sector-region i, r is defined as the total output generated in the economy by a one-unit increase in final demand for output from i, r:

$$\mu_{i,r}^{x} = \sum_{j,s} \ell_{js,ir} \tag{6}$$

Since this multiplier is linear, it can be decomposed into intra-regional, inter-regional, and international components:

$$\mu^x_{i,r} = \underbrace{\sum_{j=1}^{N} \ell^{rr}_{ij}}_{\text{intra-regional}} + \underbrace{\sum_{s\neq r}^{R}\sum_{j=1}^{N} \ell^{rs}_{ij}}_{\text{inter-regional}} + \underbrace{\sum_{s=1}^{R} f^{rs}_{i}}_{\text{final demand}} \tag{7}$$

This decomposition allows to isolate the domestic propagation potential of demand shocks from their international spillovers.

While the output multiplier captures the amplification of demand in gross output terms, it does not account for differences in value-added intensity or employment content. These dimensions are explored in the following subsection.

4.2 Domar weights and sector-region influence

4.3 Upstreamness

where $(\mathbf{I} - \mathbf{A})^{-1}$ is often called the Leontief matrix, which we denote here $\mathbf{\Psi}$. This matrix is the link between final demand and sectoral production. When final demand changes, it gives by how much sectoral production will have to change to keep respecting the accounting identities. Hence, this matrix became the central tool of final demand study. This equality can equally be decomposed as an infinite sum of direct and indirect demand for the production of the sectors in $\mathbf{X}$ for final demand $\mathbf{F}$:

$$\mathbf{X} = \mathbf{F} + \mathbf{AF} + \mathbf{AAF} + \dots$$

Taking a specific element of $\mathbf{X}$, namely the sales of sector i in country c, we have that these sales are directly and indirectly related to final demand for all sectors in all countries as follow:

$$x^c_i = f^c_i + \sum_d \sum_j a^{cd}_{ij} f^d_j + \sum_d \sum_e \sum_j \sum_k a^{cd}_{ij} a^{de}_{jk} f^e_k + \dots$$

The elements of the Leontief matrix Ψ capture all these direct and indirect effects for a change in final demand:

$$x^c_i = \sum_d \sum_j \Psi^{cd}_{ij} f^d_j$$

Hence, we have that the total change in sales for all sectors in all countries given a change in final demand in sector i in country c is given by:

$$L^c_i \Delta f^c_i = \sum_d \sum_j \Psi^{dc}_{ji} \Delta f^c_i$$

A similar exercise can be done when studying the change in sales in a specific sector and country when final demand change in all countries and sectors:

$$\Delta x^c_i = \sum_d \sum_j \Psi^{cd}_{ij} \Delta f^d_j$$

Furthermore, we are able to find the impact of demand shocks on total jobs and value-added by weighting the leontief multipliers using respectively the jobs and value-added per euro's worth of sectoral output. This allows a reweighting of the Leontief multipliers matrix in terms of jobs and value-added.
Now, going back to our accounting identity , a second statistics emerge when we divide both sides by GDP:

$$\frac{x_i^c}{\sum_e \sum_k f_k^e} = \sum_d \sum_j \Psi_{jd} \frac{f_j^d}{\sum_e \sum_k f_k^e}$$

where $\sum_e \sum_k f_k^e$ is world GDP, the sectoral sales divided by GDP $\frac{x_i^c}{\sum_e \sum_k f_k^e}$ are called the Domar weights λ and where $\frac{f_j^d}{\sum_e \sum_k f_k^e}$ are the final demand shares in world GDP ϕ_j^d for sector j in country d. The size of these Domar weights λ are interpreted as the importance of a sector for final demand and therefore for world GDP:

$$\lambda_i^c = \sum_d \sum_j \Psi_{jd} \phi_j^d$$

The Domar weights are also used to measure the impact of a supply shock on real GDP (GDP corrected for inflation). The computations are beyond the scope of this paper but the interested reader can refer to [Hulten, 1978] for the derivations in an economy with perfect competition. We have that, up to a first-order, the impact of the percent change in productivity in sector i in country c $d \ln \zeta_i^c$, leads to an increase in real GDP equal to $\lambda_i^c d \ln \zeta_i^c$:

$$d \ln RGDP = \sum_d \sum_j \lambda_j^d d \ln \zeta_j^d$$

4.4 Upstreamness and bilateral upstreamness

Finally, starting from these basic statistics, recent research has developed new statistics to study specifically the upstreamness/downstreamness of a sector with respect to final demand. A sector that is relatively more upstream compared to others is closer to the raw materials used at the beginning of the production and further away from final demand. The contrary applies for downstreamness. This statistics is computed by taking the square of the Leontief matrix, multiply it by the vector of final demand and divide it by sectoral sales:

$$\mathbf{U} = \mathbf{\Psi}^2 \mathbf{f} \oslash \mathbf{\Psi f}$$

where $\mathbf{U}$ is the vector of upstreamness by sector and $\oslash$ is the element-wise division of matrices, also called the Hadamard division. The interested reader can refer to [Antras and Chor, 2013] and [Alfaro et al., 2019] for the computations.
A second statistics measure the relative upstreamness of a sector with respect to another sector. It is given by taking the square of the Leontief matrix and multiply it by the technical coefficient

matrix:

$$\mathbf{B} = \mathbf{\Psi}^2\mathbf{A} \oslash \mathbf{\Psi}\mathbf{A}$$

where **B** is the bilateral upstreamness matrix, whose ij-th element B_{ij} is the relative upstreamness of sector i with respect to sector j. The interested reader can refer to [Alfaro et al.,2019].

5 Belgian regions in local and global value chains

We now proceed to apply the measures of input-output analysis for the interpretation of the importance of Belgian regions and sectors in the economy-wide production process.

5.1 Leontief multipliers

5.1.1 Output multipliers

Figure 2 shows the decomposition of output multipliers for the three regions of Belgium and all its sectors. The three regions show a vast heterogeneity, both in terms of top sectors and magnitude of the different components. As an example, sector C19 (*i.e.* Manufacture of coke and refined petroleum products) has the largest Leontief multiplier in Flanders, meaning that any increase in final demand in that sector will generate around a 3.2 additional increase in final world output. Digging more into the different components of this multiplier, we can notice that its value is mostly due to the large international component. In other words, this means that sector C19 in Flanders is the most integrated globally, importing goods that are either coming from that same sector or from other ones[5]. As Figure 3 illustrates, the Netherlands occupy the largest share in the international component of the Flemish output multiplier of sector C19, weighting for 27% of the entire amount. Another 20% is made of imports coming from the rest of the world.

The direct reason of this large international dependence is explained in Figure C.1, which shows the total imports of sector C19 in Flanders from other countries. Aside from the mining sector in the rest of the world (*i.e.* ROW_B), the second largest exporter to sector C19 in Flanders is the Netherlands, which mainly exports service activities (mainly legal and accounting activities through sector M69_M70) and inputs coming from the mining sector to be used in production of coke and petroleum products. Besides, the Netherlands also export to sector C19 in Flanders chemicals and construction materials (respectively, sectors C20 and F). On the other hand, Leontief multipliers also take into account the indirect links, making the dependence of sector C19 in Flanders on the Netherlands and on the rest of the world even larger. As a result, any change in final demand coming from Flanders would cause dramatic changes in total output in the Netherlands and worldwide through direct and indirect linkages.

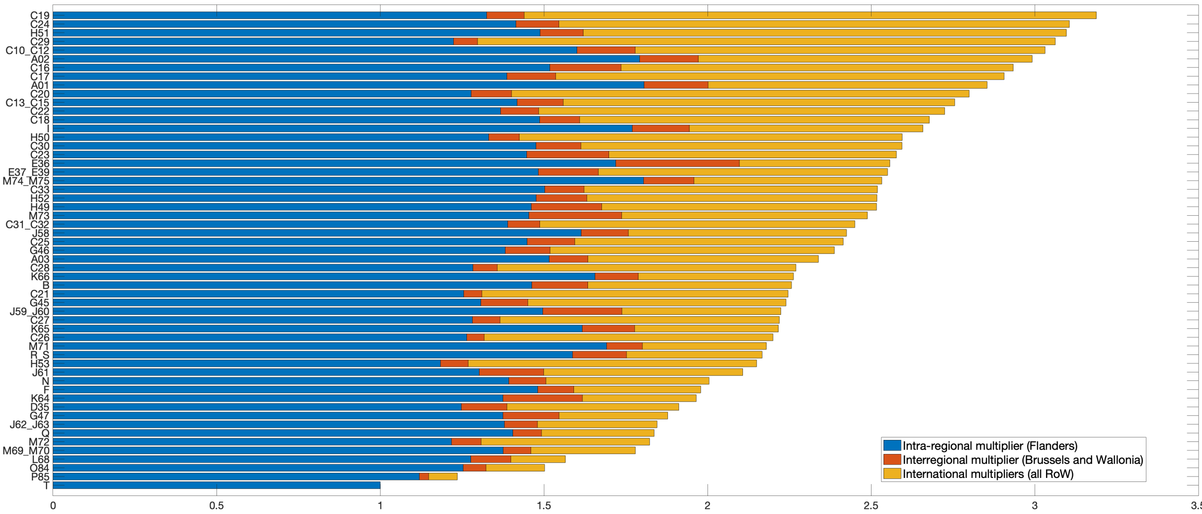
As for the region of Brussels, sector A03 (*i.e.* Fishing and aquaculture) has the highest output multiplier, most of it being composed by the intra-regional component. In contrast to

[5]Output multipliers are indeed derived from the demand-side Leontief inverse, and for this reason they are also known as total backward linkages: the higher the multiplier, the more an industry is located downstream in the production process.

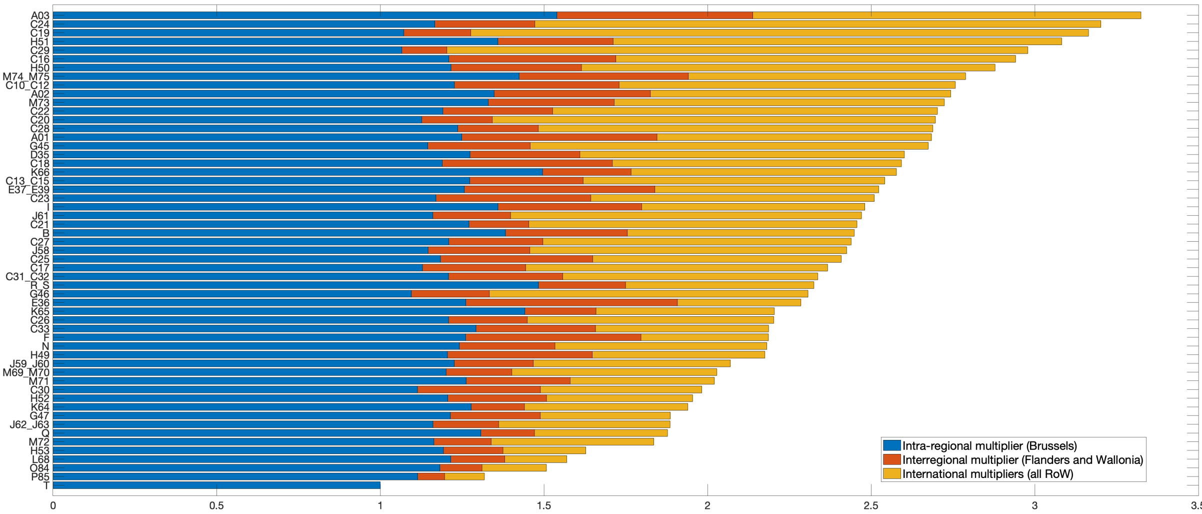
sector C19 in Flanders, sector A03 in Brussels is mostly integrated domestically, importing a large part of goods in that sector from other sectors in the same region. Besides, also the inter-regional component is quite prominent compared to other sectors, showing that this industry imports relatively more from other industries in Belgium rather than from foreign ones. Indeed, panel (b) in Figure 3 shows that the international portion of the multiplier has a quite hererogeneous composition in terms of supplying countries. Similarly, panel (b) in Figure C.1 shows that foreign imports to this sector are quite small compared to the top sectors in the other regions.

Finally, sector H51 (*i.e.* Air transport) is the largest in Wallonia in terms of output multiplier. As it could be expected, this sector is made up by a large international component which can be explained by the presence of one of the largest freight transport airports in Europe in the area of Liège. On the other hand, the sector is not very integrated within the country, having a small inter-regional multiplier. Panel (c) in Figure 3 and Figure C.1 show that most of the international component is made up by imports coming from the rest of the world, mostly from the same H51 sector, from sector H52 (*i.e.* Support activities for transportation) or from sector C19 for the fuel of the airplanes.

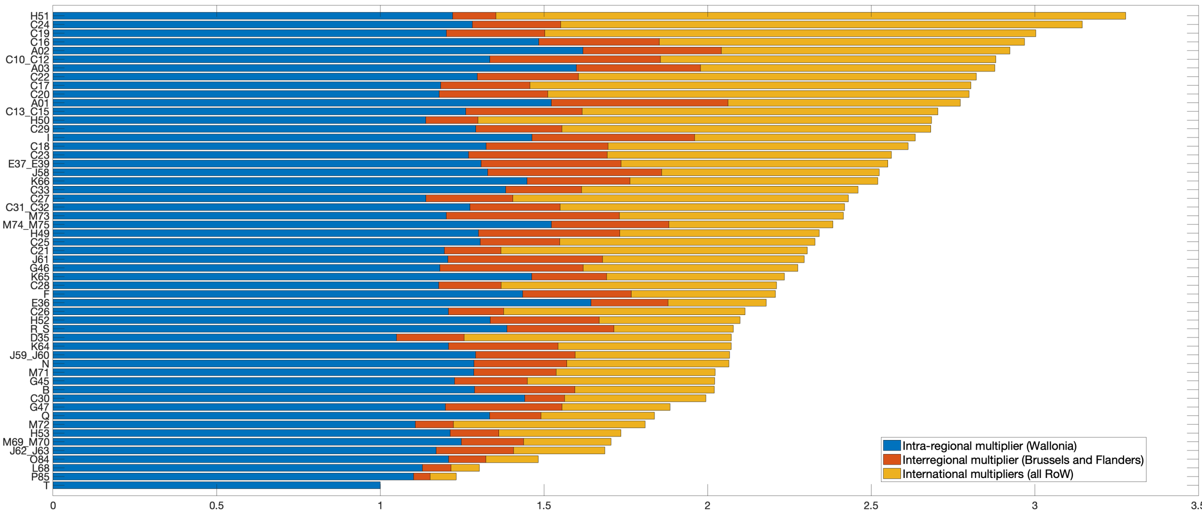
Overall, the degree of integration with international markets is quite heterogeneous across Belgian regions: Flanders is clearly the region with the highest number of backward linkages in the international value chains, having on average small values for the inter-regional multiplier for all the sectors. On the other hand, Brussels presents the largest inter-regional multipliers among the three regions, showing that a big part of its imports come from Flanders and Wallonia, where the industries are located.



(a) Flanders

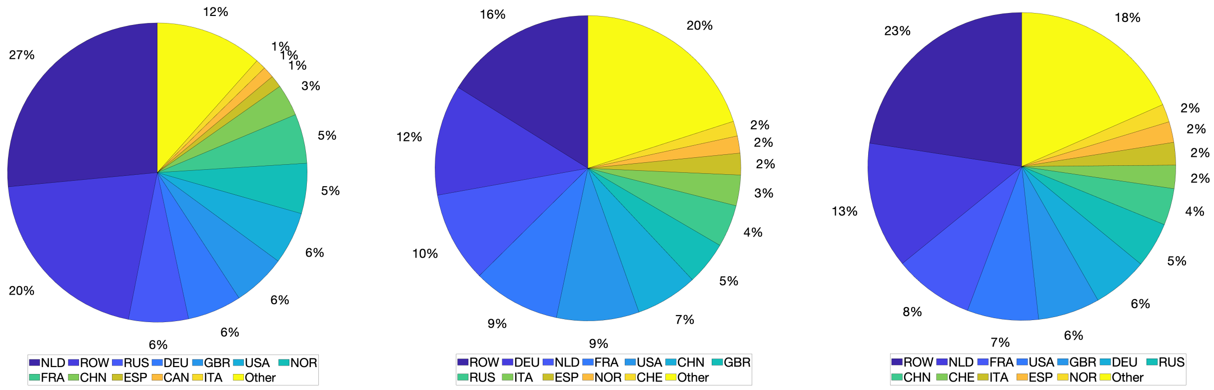


(b) Brussels



(c) Wallonia

Figure 2: Decomposition of output multipliers for the three regions.



(a) Flanders (b) Brussels (c) Wallonia

Figure 3: Contribution to the international component of the top output multiplier for the three regions.

5.1.2 Value added multipliers

Figure Figure C.2 in Appendix illustrates the decomposition of value added multipliers for the three Belgian regions. Flanders presents a higher multiplier for sector I (*i.e.* Accomodation and food service activities): for every euro increase in final demand in this sector in Flanders, aggregate value added increases by 1.2 points. In addition, this increase in mainly driven by the intra-regional multiplier, implying that Flanders itself will mostly benefit from the rise in value added. As for the other two regions, they both present a large multiplier for sector J61 (*i.e.* Telecommunications). However, the international component is much larger in Brussels than in Wallonia, the latter being less connected with the rest of the world through international trade. Thus, any increase in final demand by 1 euro in that sector in Wallonia will mostly generate an increase in value added in Wallonia itself. On the other hand, the same increase taking place in Brussels will generate a larger increase in value added in the other countries in the world.

The results are in line with what we found for the output multipliers: any increase in final demand in Flanders will generate small rises in value added in Belgium, while increasing value added mostly in the other countries. On the other hand, increases in final demand in Brussels and Wallonia will generate rises in value added also to the other Belgian regions, having stronger inter-regional links.

5.1.3 Employment multipliers

Figure C.3 shows the results in terms of employment multipliers. Sector T (*i.e.* Activities of households as employers) presents the largest multipliers in all the regions: an increase of 1 euro in final demand in that sector generates, on average, 80 new jobs in each region. It is important to note that the increase takes place only within the region as this sector does not trade with other sectors or regions.

Sector I is the one that generates most jobs worldwide following an increase in final demand in Flanders. However, the manufacturing sectors C13-C15 (*i.e.* Manufacture of textiles, wearing apparel and leather products) and C10-C12 (*i.e.* Manufacture of food products, beverages and tobacco) are much more connected internationally, generating most of the new jobs abroad.

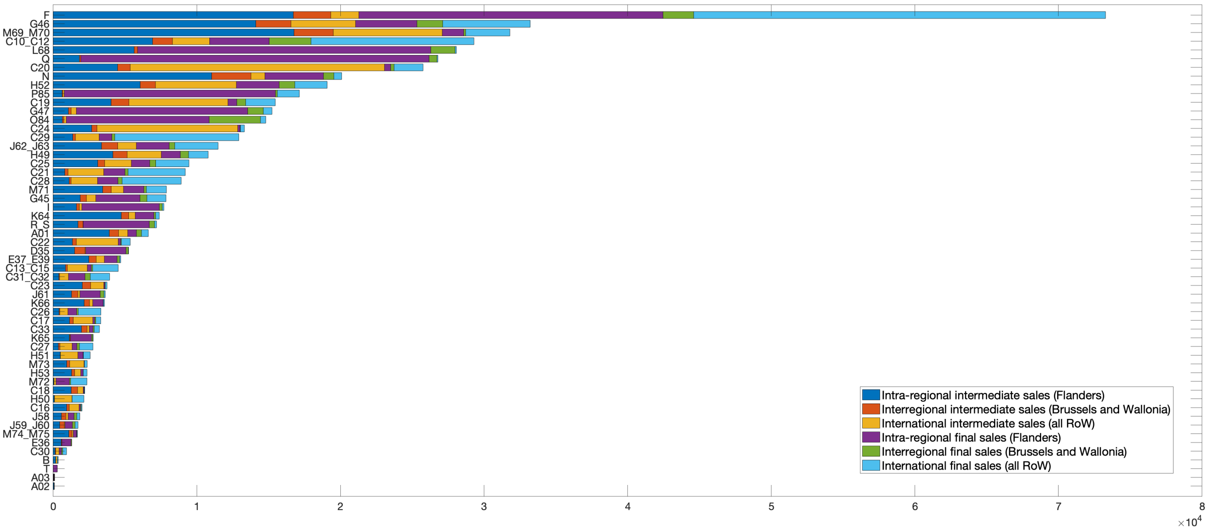
Sector C13-C15 presents a high multiplier also in Brussels, but contrarily to Flanders, this is composed for around a half by the intra and inter-regional components, and by the international one by the other half. Besides, the sector with the highest employment multiplier in Brussels (after sector T) is sector A03, in line with the results of output multipliers. This multiplier, on the contrary, is mainly composed by the intra-regional component, thus generating most jobs within the Brussels region.

Finally, an increase in final demand in Wallonia would generate most jobs in the Water transport sector (sector code H50). In particular, most of them would be created in Wallonia itself, due to the large value of the intra-regional multiplier.

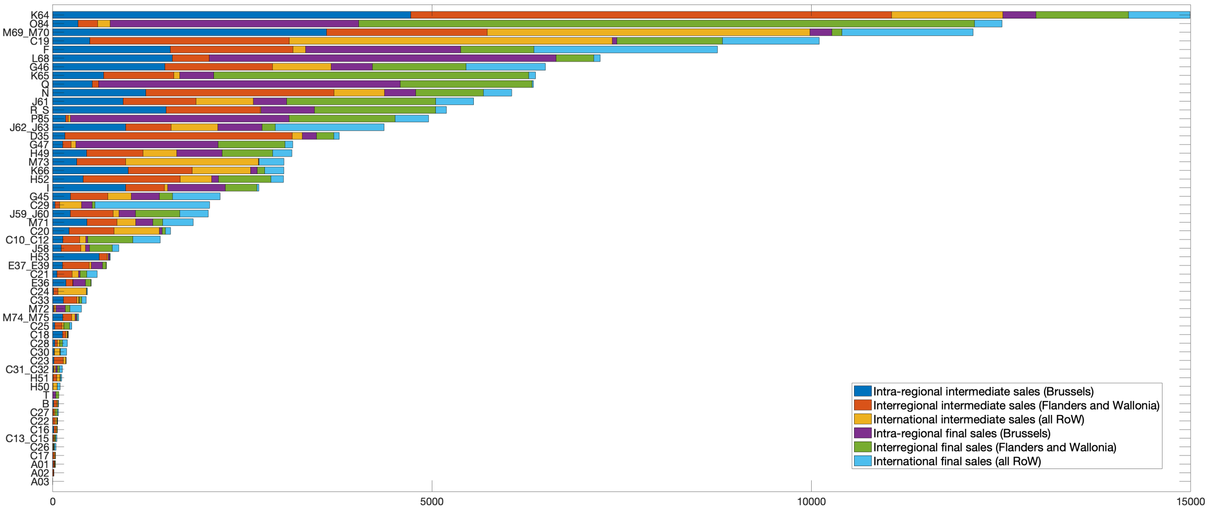
Overall, it is worth noticing again that increases in final demand in Brussels and Wallonia would generate more jobs within Belgium than any increase in final demand in Flanders in any sector, due to the larger inter-regional multipliers.

5.2 Sales' decomposition

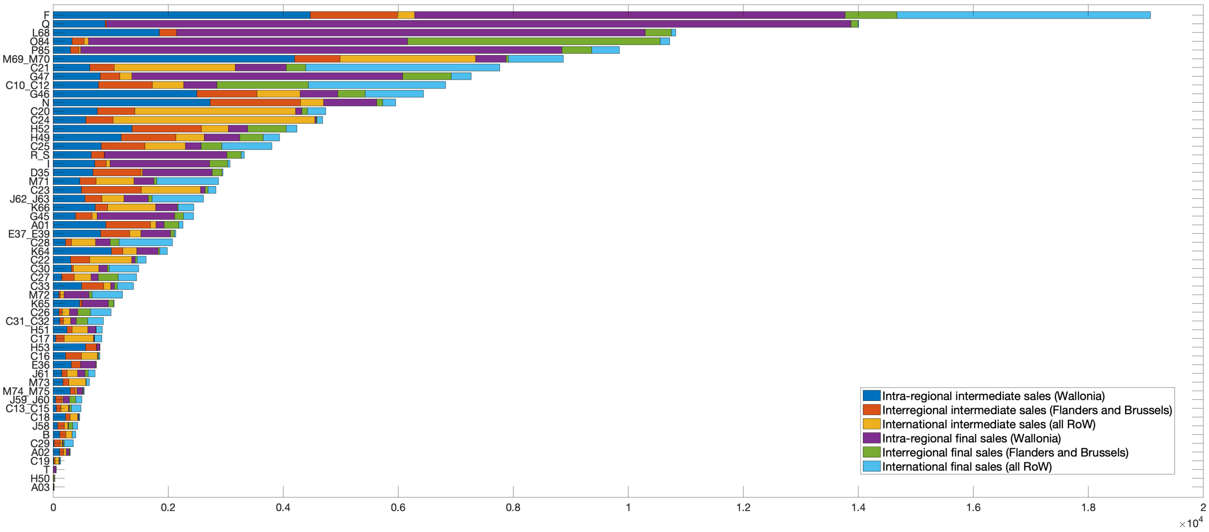
To get a grasp on what sectors dominate in each region and how these sectors are linked to domestic and international markets, we can examine the decomposition of their sales. Figure 4 presents the results.



(a) Flanders



(b) Brussels



(c) Wallonia

Figure 4: Sales' decomposition for the three regions.

5.3 Domar weights and upstreamness

As a second exercise, we study jointly how the world economy would react to sectoral supply and demand shocks as a function of upstreamness. As can be observed in Figure 5 for the sectors in Flanders, the output Leontief multipliers seem to be correlated with sectoral upstreamness. Hence, this would mean that a demand shock to a more upstream sector would increase more world total output than a shock to a more downstream sector. According to our upstreamness measures, the chemicals sector and the sector of basic metals manufacturing are the two most upstream. This means that when final demand is produced, the goods from these sectors are the furthest away from final demand in the value chain.
Second, sectoral importance[6] seems to be uncorrelated with sectoral upstreamness. As a consequence, sectoral importance seems also uncorrelated with upstreamness. We find large sectors in all the corners of the picture, indicating therefore that supply and demand shocks in the same sector might be orthogonal in their impact to output. However, it is important to note that Domar weights should give the impact on real value-added while output multipliers should give the impact on gross output. Hence, to compare both supply and demand shocks impact on value-added, we replace output Leontief multipliers by value-added Leontief multipliers in Figure 6.
Finally, we observe that manufacture and agriculture/mining industries tend to be more upstream and therefore to have higher output Leontief multipliers than service sectors. On the other hand, service sectors tend to have a greater sectoral importance which is due to their larger share in value-added and the evolution of advanced economies in past decades going toward more service-oriented products. The way we divided these sectors is also available in the appendix of the present work.

[6] We use total sectoral output rather than Domar weights but this does not weight any consequence on the relative importance between sectors as Domar weights are simply a re-weighting of sectoral output

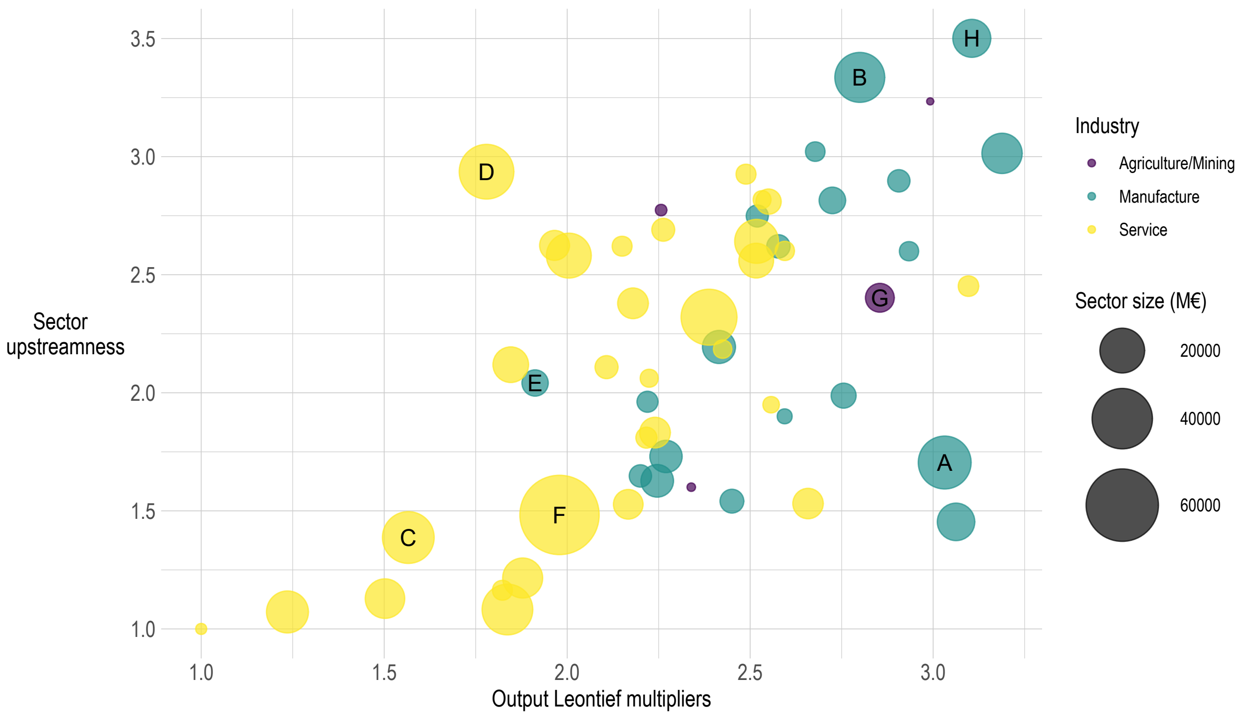


Figure 5: Sectoral importance along several dimensions

A: Manufacture of food products, beverages and tobacco products; **B**: Manufacture of chemicals and chemical products; **C**: Real estate activities; **D**: Legal and accounting activities; activities of head offices; management consultancy activities; **E**: Electricity,gas,steam and air conditioning supply; **F**: Construction; **G**: Crop and animal production, hunting and related service activities; **H**: Manufacture of basic metals

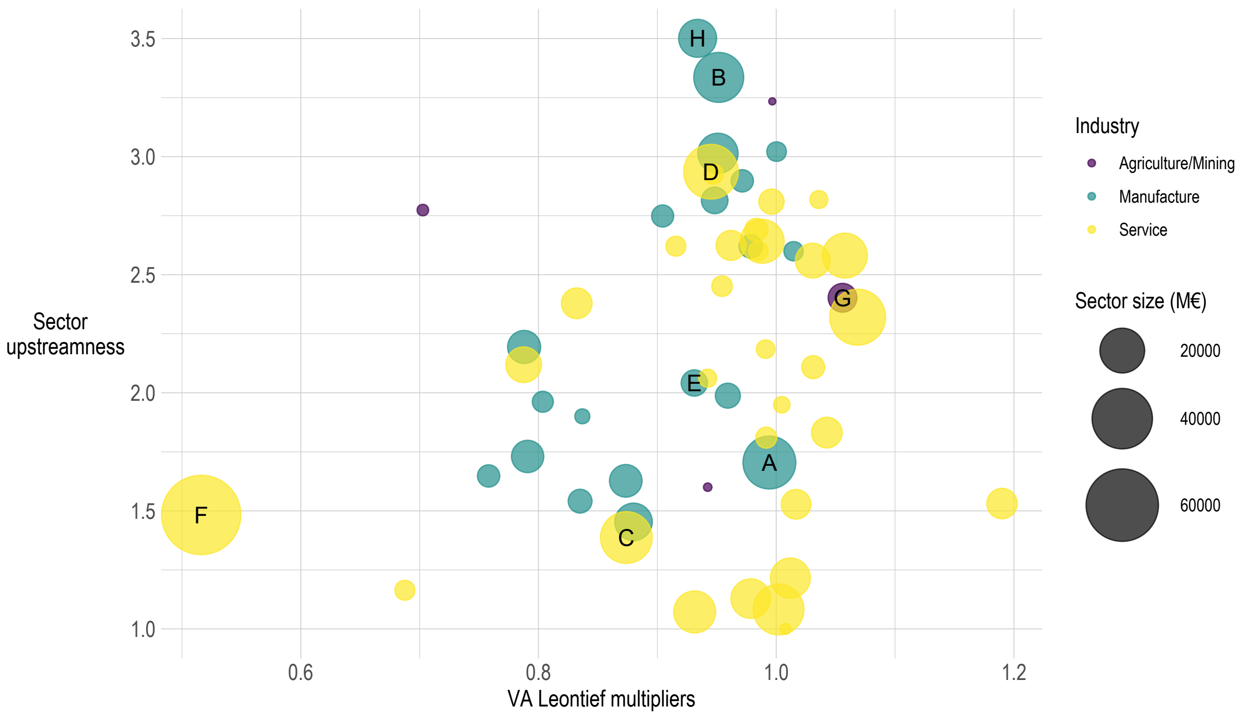


Figure 6: Sectoral importance along several dimensions

A: Manufacture of food products, beverages and tobacco products; **B**: Manufacture of chemicals and chemical products; **C**: Real estate activities; **D**: Legal and accounting activities; activities of head offices; management consultancy activities; **E**: Electricity,gas,steam and air conditioning supply; **F**: Construction; **G**: Crop and animal production, hunting and related service activities; **H**: Manufacture of basic metals

5.4 Bilateral upstreamness

In this last section, we study the upstreamness of chosen supplying sector over using sectors. As developed in the theoretical section, this bilateral upstreamness is the corresponding measure of upstreamness between two sectors. When there is a large bilateral upstreamness between a supplying and a using sector, this means that the supplying sector tend to be further away from the using sector in the supply chain. When this bilateral upstreamness is small, this means that the supplying and using sectors tend to be closer in the supply chain.
To illustrate this statistic with our dataset, we choose to look at the bilateral upstreamness for sectors in the Flanders region of Belgium and in Germany on Figure 8 (we also provide the same graph for bilateral upstreamness between Flanders and the Netherlands in Figure C.4). The matrices on the diagonal give the bilateral upstreamness for sectors in the same region/country while the matrices off-diagonal give the bilateral upstreamness between sectors that are not in the same region/country.
A first take-away from these graphs is that sectors that are not in the same region/country tend to be more bilaterally upstream that sectors which are in the same region/country. This means that even though some sectors in other countries might be more competitive to produce a specific good, sectors tend to still be further away in the supply chain if they are further geographically. Nevertheless, as can be observed of the graph, it is not a general rule and some supplying sectors in Germany can be closer in the supply chains to Flanders' sectors than their Flanders' counterpart.

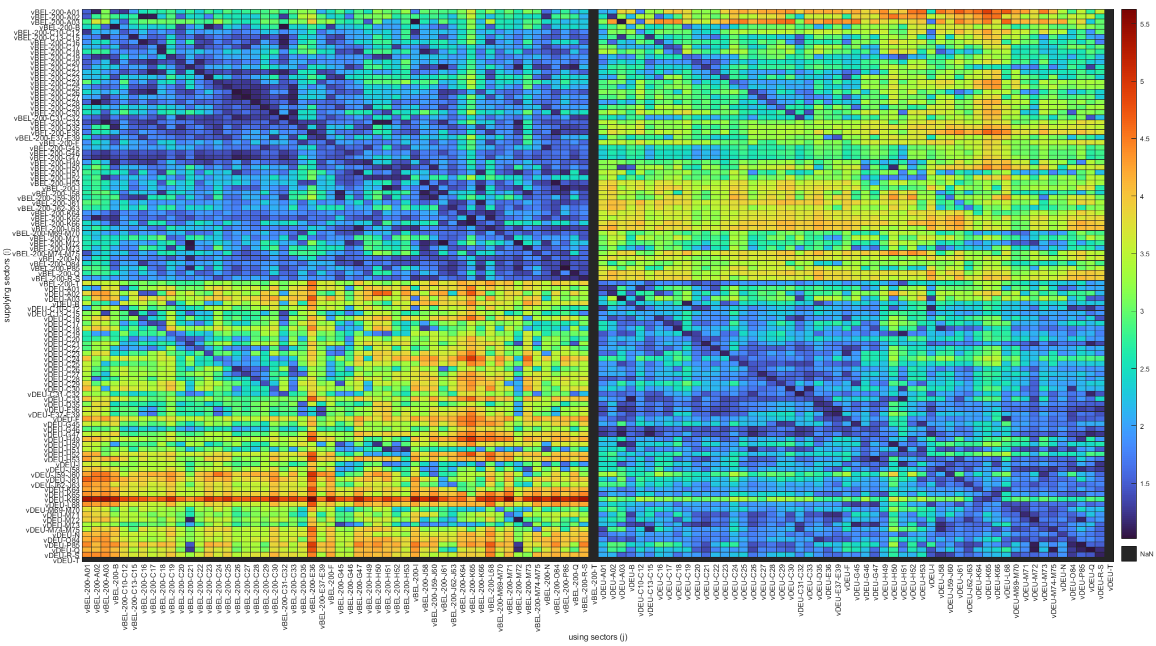


Figure 7: Bilateral upstreamness between sectors in Flanders and Germany

BEL-200 preceding the sector number means that is that sector in the Flanders region of Belgium while the DEU prefix means the sectors in Germany.

To better observe these outstanding sectors, we take the difference of the bilateral upstreamness that supply to the same sector but that are in different regions. Taking the difference between the sector that supplies from the same region as the using sector and the sector from the other region, we know that a negative value means that the sector supplying from the same country as the using sector is closer in the supply chain of this using sector than the other sector. This is what we would expect. Now, when the value is positive, it means that a sector supplying from another region/country is closer in the supply chain than the same sector that is in the same region/country than the using sector.

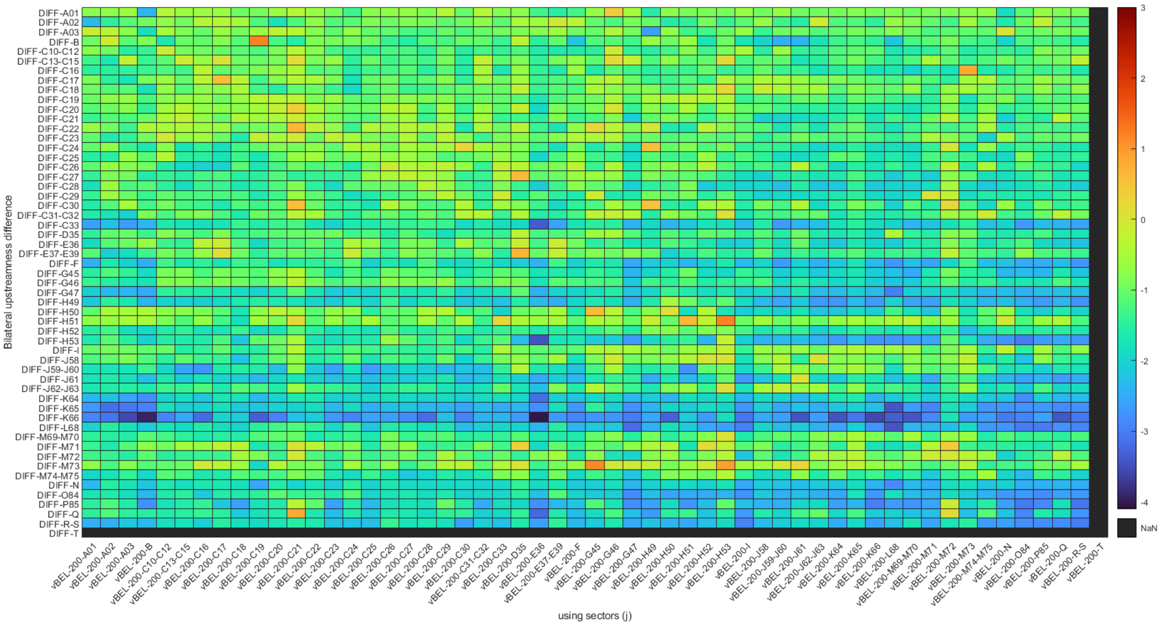
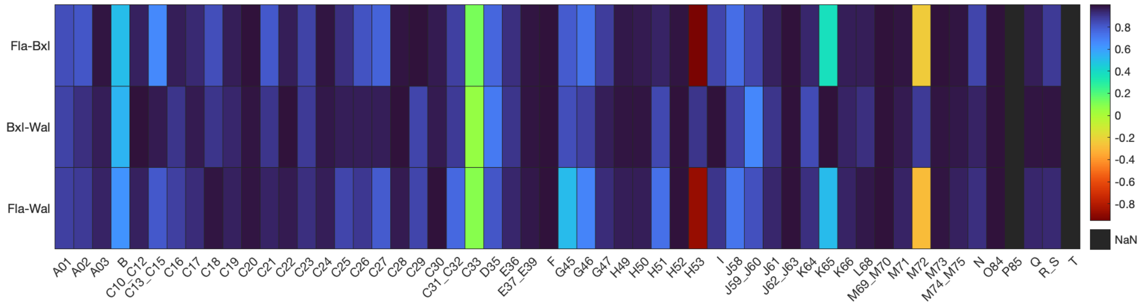
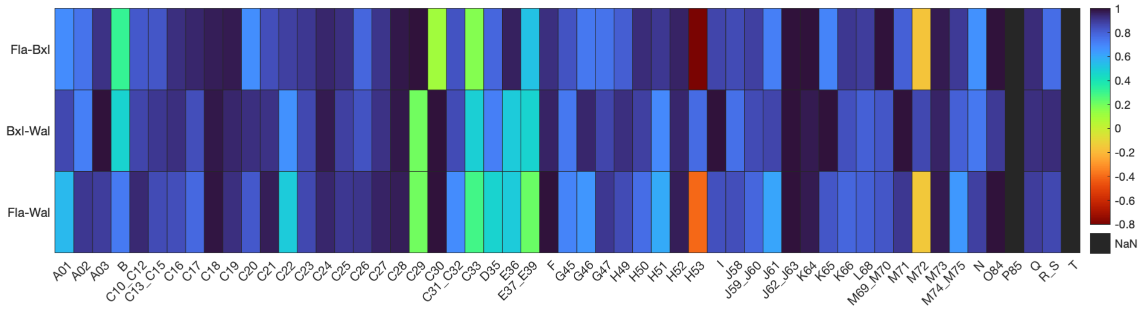


Figure 8: Bilateral upstreamness difference between sectors supplying in Flanders

On the graph above, the values from green to dark blue mean that the sector supplying from the same region (Flanders) is closer in supply chain to the using sector. We see that most sector combinations follow that patter for the bilateral relationship between Flanders and German sectors. On the other hand, values that go from yellow to dark red are for supplying sectors from another country (here Germany) that are closer in the supply chain from the using sector than the same sector in Flanders. As can be observed, there is only few of them and most values are between -2 and 0.

Most of the outliers to that rule supply to the same sectors in Flanders. The sectors C21 ”Manufacture of basic pharmaceutical products and pharmaceutical preparations”, G45 ”Wholesale and retail trade and repair of motor vehicles and motorcycles”, H53 ”Postal and courier activities” and M72 ”Scientific research and development”. This means that one or several sectors in Germany are closer than their Flanders’ counterpart to these sectors in the supply chain, indicating a competitive production of these sectors in Germany.





6 Conclusion

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Appendix

A Data sources and construction

In this appendix, we provide additional details on the MRIO and WIOD data, and on the construction of the final dataset.

A.1 Redistribution of region 400

First, we redistribute all entries of the extra-regional territories (NUTS 400) to the three Belgian regions Brussels (100), Flanders (200), and Wallonia (300). We implement the same proportionality procedure as in Planbureau (2021). In particular, the value of shipments from sector i in region 400 to sector j in region $r \in \{100, 200, 300\}$, $z_{ij}^{400,r}$, is redistributed across the other three regions with weights given by $\omega_{ij}^{sr} = \frac{z_{ij}^{sr}}{\sum_{s \in \{100,200,300\}} z_{ij}^{sr}}$. There are no intra-regional flows for region 400. A similar redistribution is performed for the value of total expenditures of sector j in region 400 supplied by sector i in region s, $z_{ij}^{s,400}$, with weights given by $\nu_{ij}^{sr} = \frac{z_{ij}^{sr}}{\sum_{r \in \{100,200,300\}} z_{ij}^{sr}}$. Adjusted sales flows from sector i in region s to sector j in region r are then:

$$\tilde{z}_{ij}^{sr} = z_{ij}^{sr} + \underbrace{\omega_{ij}^{sr} z_{ij}^{400,r}}_{\text{supply (400)}} + \underbrace{\nu_{ij}^{sr} z_{ij}^{s,400}}_{\text{use (400)}} \tag{8}$$

The same methodology is applied to final demand entries f_{ij}^{sr} (where $j = \{C, I, G, E\}$), imports m_j^r, and value added entries v_j^r. A graphical explanation is provided in Figure A.1. The blue areas represent the entries that are to be distributed across the other regions and the grey areas are the entries of the sub-matrix which represent transactions within the extra-regional territories (400), always equal to zero.

	100	200	300	400	100	200	300	400
100	$\mathbf{Z}^{11}$	$\mathbf{Z}^{12}$	$\mathbf{Z}^{13}$	$\mathbf{Z}^{14}$	$\mathbf{f}^{1}$	$\mathbf{f}^{2}$	$\mathbf{f}^{3}$	$\mathbf{f}^{4}$
200	$\mathbf{Z}^{21}$	$\ddots$		$\vdots$	$\mathbf{f}^{2}$	$\ddots$		$\vdots$
300	$\mathbf{Z}^{31}$		$\ddots$	$\vdots$	$\mathbf{f}^{3}$		$\ddots$	$\vdots$
400	$\mathbf{Z}^{41}$	$\dots$	$\dots$	$\varnothing$	$\mathbf{f}^{4}$	$\dots$	$\dots$	$\varnothing$
Imports	$\mathbf{m}^{1}$	$\mathbf{m}^{2}$	$\mathbf{m}^{3}$	$\mathbf{m}^{4}$	$\mathbf{m}^{f1}$	$\dots$	$\dots$	$\mathbf{m}^{f4}$
Value added	$\mathbf{v}^{1}$	$\mathbf{v}^{2}$	$\mathbf{v}^{3}$	$\mathbf{v}^{4}$				

Figure A.1: Redistribution of region 400 to the main regions.

A.2 Final demand and value added aggregates

Next, we aggregate final demand and value added categories in the MRIO and the WIOD where needed to obtain harmonized categories in the final dataset. The mapping is provided in Table A.1. In the MRIO, Consumption (C) contains *"Consumption by households"* (UN SNA code P31.S14) and *"Consumption by non-profit institutions serving households (NPISH)"* (P31.S15).

Government expenditures (G) contain *"Individual consumption of the government"* (P31.S13) and *"Collective consumption of the government"* (P32.S13). Investment (I) contains *"gross fixed capital formation"* (P51) and *"Changes in inventories and valuables"* (P52.P53). Finally, Exports (X) contain *"Exports in goods"* (P61) and *"Exports in services"* (P62). Similarly, Value Added (VA) contains *"Compensation of employees"* (D1), *"Use of fixed assets"* (P51C), and *"Net exploitation surplus and net mixed income"* (B2N+B3N). Net Taxes (NT) contains *"Taxes on value added"* (D211), *"Other taxes on products (excluding value added)"* (D21), *"Other taxes on production"* (D29), *"Subsidies on products"* (D31), and *"Other subsidies on products"* (D39). Similar categories exist in the WIOD. Exports and imports are not reported separately as the WIOD contains all international trade flows within the interconnected national IO tables. We drop the categories related to purchases made by residents and non-residents and trade margins. Finally, we harmonize the MRIO and WIOD categories for final demand and value added for the final dataset.

Category		MRIO	WIOD	Final dataset
Final demand	C	Final consumption of households	Final consumption of households	Final consumption of households
		Final consumption of non-profit organizations serving households (NPISH)	Final consumption of non-profit organizations serving households (NPISH)	
	G	Individual consumption of government	Final consumption of government	Final consumption of government
		Collective consumption of government		
	I	Gross fixed capital formation	Gross fixed capital formation	Gross fixed capital formation
		Changes in inventories and valuables	Changes in inventories and valuables	Changes in inventories and valuables
	X	Exports of goods	-	-
		Exports of services	-	-
Value added	VA	Net operating surplus and net mixed income	Value added at basic prices	Value Added
		Compensation of employees		
	NT	Taxes on value added	Taxes less subsidies on products	Net Taxes
		Other taxes on products (excluding value added)		
		Other taxes on production		
		Subsidies on products		
		Other subsidies on products		
	M	Imports of goods	-	-
		Imports of services	-	-
		-	Direct purchases abroad by residents	
		-	Purchases on domestic territory by non-residents	
		-	International transport margins	

Table A.1: Harmonization of final demand and value added categories.

A.3 List of countries in WIOD

Table A.2 provides an overview of the 43 countries contained in the WIOD Tables. There is also a Rest of the World (RoW) aggregate that contains major flows for other countries in the world.

A.4 Sector correspondences

We convert the NACE codes in the MRIO to the ISIC sector codes in WIOT using the NACE Rev 2 and ISIC Rev 4 correspondences provided by Eurostat. In particular, the MRIO tables are constructed by the Federal Planbureau at a custom granularity of 143 sectors. After accounting for confidentiality concerns, the final MRIO tables are reported for 124 NACE sectors. These can be linked to the ISIC sectors using the correspondences reported in Table A.3.

Country	ISO Code	Country	ISO Code
Austria	AUT	Lithuania	LTU
Belgium	BEL	Luxembourg	LUX
Bulgaria	BGR	Malta	MLT
Croatia	HRV	Netherlands	NLD
Cyprus	CYP	Poland	POL
Czech Republic	CZE	Portugal	PRT
Denmark	DNK	Romania	ROU
Estonia	EST	Slovakia	SVK
Finland	FIN	Slovenia	SVN
France	FRA	Spain	ESP
Germany	DEU	Sweden	SWE
Greece	GRC	United Kingdom	GBR
Hungary	HUN	Australia	AUS
Ireland	IRL	Brazil	BRA
Italy	ITA	Canada	CAN
Latvia	LVA	China	CHN
India	IND	Mexico	MEX
Indonesia	IDN	Norway	NOR
Japan	JPN	Russia	RUS
South Korea	KOR	Switzerland	CHE
Taiwan	TWN	Turkey	TUR
United States	USA		

Table A.2: List of countries and ISO codes in WIOD.

NACE	NACE143 sector name	NACE124	NACE124 sector name	ISIC	ISIC sector name
01A	Crop and animal production, hunting and related service activities	01A	Crop and animal production, hunting and related service activities	A01	Crop and animal production, hunting and related service activities
02A	Forestry and logging	02A	Forestry and logging	A02	Forestry and logging
03A	Fishing and aquaculture	03A	Fishing and aquaculture	A03	Fishing and aquaculture
05A	Mining of coal and lignite	05A	Mining of coal and lignite	B	Mining and quarrying
06A	Extraction of crude petroleum and natural gas	06A	Extraction of crude petroleum and natural gas		
07A	Mining of metal ores	07A	Mining of metal ores		
08A	Other mining and quarrying	08A09A	Other mining and quarrying and mining support service activities		
09A	Mining support service activities				
10A	Processing and preserving of meat and production of meat products	10A	Processing and preserving of meat and production of meat products	C10-C12	Manufacture of food products, beverages and tobacco products
10B	Processing and preserving of fish, crustaceans and molluscs	10B	Processing and preserving of fish, crustaceans and molluscs		
10C	Processing and preserving of fruit and vegetables	10C10G	Processing and preserving of fruit and vegetables, manufacturing of bakery and farinaceous products		
10G	Manufacture of bakery and farinaceous products				
10D	Manufacture of vegetable and animal oils and fats	10D	Manufacture of vegetable and animal oils and fats		
10E	Manufacture of dairy products	10E	Manufacture of dairy products		
10F	Manufacture of grain mill products, starches and starch products	10F	Manufacture of grain mill products, starches and starch products		
10H	Manufacture of sugar, chocolate and sugar confectionery	10H	Manufacture of sugar, chocolate and sugar confectionery		
10I	Manufacture of other food products n.e.c.	10I	Manufacture of other food products n.e.c.		
10J	Manufacture of prepared animal feeds	10J	Manufacture of prepared animal feeds		
11A	Manufacture of beverages, except for mineral waters	11A12A	Manufacture of beverages (except for mineral waters) and tobacco products		
12A	Manufacture of tobacco products				
11B	Production of mineral waters and other bottled waters	11B	Production of mineral waters and other bottled waters		
13A	Manufacture of textiles	13A	Manufacture of textiles	C13-C15	Manufacture of textiles, wearing apparel and leather products
13B	Manufacture of other textiles	13B	Manufacture of other textiles		
14A	Manufacture of wearing apparel	14A	Manufacture of wearing apparel		
15A	Manufacture of leather and related products	15A	Manufacture of leather and related products		
16A	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	16A	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17A	Manufacture of paper and paper products	17A	Manufacture of paper and paper products	C17	Manufacture of paper and paper products
18A	Printing and reproduction of recorded media	18A	Printing and reproduction of recorded media	C18	Printing and reproduction of recorded media
19A	Manufacture of coke and refined petroleum products	19A	Manufacture of coke and refined petroleum products	C19	Manufacture of coke and refined petroleum products
20A	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	20A20B	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms, and other inorganic basic chemicals	C20	Manufacture of chemicals and chemical products
20B	Manufacture of other inorganic basic chemicals				
20C	Manufacture of pesticides and other agrochemical products	20C20F	Manufacture of pesticides and other chemical products		
20F	Manufacture of other chemical products				
20D	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	20D	Manufacture of paints, varnishes and similar coatings, printing ink and mastics		
20E	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	20E	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations		
20G	Manufacture of man-made fibres	20G	Manufacture of man-made fibres		
21A	Manufacture of basic pharmaceutical products and pharmaceutical preparations	21A	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22A	Manufacture of rubber products	22A	Manufacture of rubber products	C22	Manufacture of rubber and plastic products
22B	Manufacture of plastic products	22B	Manufacture of plastic products		
23A	Manufacture of glass and glass products	23A	Manufacture of glass and glass products	C23	Manufacture of other non-metallic mineral products
23B	Manufacture of refractory products, clay building materials and other porcelain and ceramic products	23B23C	Manufacture of refractory products, clay building materials, cement and plaster and other porcelain and ceramic products		
23C	Manufacture of cement, lime and plaster				

23D	Manufacture of articles of concrete, cement and plaster; Cutting, shaping and finishing of stone; Manufacture of abrasive products and non-metallic mineral products n.e.c.	23D	Manufacture of articles of concrete, cement and plaster; Cutting, shaping and finishing of stone; Manufacture of abrasive products and non-metallic mineral products n.e.c.		
24A	Manufacture of basic iron and steel, tubes, pipes, hollow profiles of steel	24A	Manufacture of basic iron and steel, tubes, pipes, hollow profiles of steel	C24	Manufacture of basic metals
24B	Manufacture of other products of first processing of steel, basic precious and other non-ferrous metals, casting of metals	24B	Manufacture of other products of first processing of steel, basic precious and other non-ferrous metals, casting of metals		
25A	Manufacture of fabricated metal products, except machinery, equipment and cutlery and general hardware	25A	Manufacture of fabricated metal products, except machinery, equipment and cutlery and general hardware	C25	Manufacture of fabricated metal products, except machinery and equipment
25B	Treatment and coating of metals; machining	25B	Treatment and coating of metals; machining		
25C	Manufacture of cutlery, tools and general hardware and other fabricated metal products	25C	Manufacture of cutlery, tools and general hardware and other fabricated metal products		
26A	Manufacture of electronic components and boards, computers and peripheral equipment	26A	Manufacture of electronic components and boards, computers and peripheral equipment	C26	Manufacture of computer, electronic and optical products
26B	Manufacture of communication equipment and consumer electronics	26B	Manufacture of communication equipment and consumer electronics		
26C	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks; electromedical equipment, optical equipment and magnetic and optimal media	26C	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks; electromedical equipment, optical equipment and magnetic and optimal media		
27A	Manufacture of electric motors, generators, batteries and accumulators, wiring and wiring devices, electric lighting equipment	27A	Manufacture of electric motors, generators, batteries and accumulators, wiring and wiring devices, electric lighting equipment	C27	Manufacture of electrical equipment
27B	Manufacture of domestic appliances and other electrical equipment	27B	Manufacture of domestic appliances and other electrical equipment		
28A	Manufacture of general-purpose machinery	28A28B	Manufacture of machinery	C28	Manufacture of machinery and equipment n.e.c.
28B	Manufacture of agricultural and forestry machinery and other special-purpose machinery				
29A	Manufacture of motor vehicles	29A29B	Manufacture of motor vehicles, parts and accessories for motor vehicles	C29	Manufacture of motor vehicles, trailers and semi-trailers
29B	Manufacture of bodies, trailers and other parts and accessories for motor vehicles				
30A	Building of ships and boats	30A30B30D	Building of ships and boats, manufacture of railway locomotives and transport equipment	C30	Manufacture of other transport equipment
30B	Manufacture of railway locomotives and rolling stock				
30D	Manufacture of military fighting vehicles and transport equipment				
30C	Manufacture of air and spacecraft and related machinery	30C	Manufacture of air and spacecraft and related machinery		
31A	Manufacture of furniture	31A	Manufacture of furniture	C31-C32	Manufacture of furniture; other manufacturing
32A	Manufacture of jewellery, bijouterie and related articles	32A	Manufacture of jewellery, bijouterie and related articles		
32B	Manufacture of musical instruments, sports goods, games and toys, medical supplies	32B	Manufacture of musical instruments, sports goods, games and toys, medical supplies		
33A	Repair and installation of machinery and equipment	33A	Repair and installation of machinery and equipment	C33	Repair and installation of machinery and equipment
35A	Electric power generation, transmission and distribution; steam and air conditioning supply	35A35B	Electric power generation, steam and air conditioning supply, manufacture of gas	D35	Electricity, gas, steam and air conditioning supply
35B	Manufacture of gas; distribution of gaseous fuels through mains				
36A	Water collection, treatment and supply	36A	Water collection, treatment and supply	E36	Water collection, treatment and supply
37A	Sewerage	37A	Sewerage	E37-E39	Sewerage, waste collection, treatment and disposal activities; materials recovery, remediation activities and other waste management services
38A	Waste collection, treatment and disposal	38A	Waste collection, treatment and disposal		
38B	Materials recovery	38B	Materials recovery		
39A	Remediation activities and other waste management services	39A	Remediation activities and other waste management services		
41A	Construction of buildings	41A	Construction of buildings	F	Construction
42A	Civil engineering	42A	Civil engineering		
43A	Demolition and site preparation	43A	Demolition and site preparation		
43B	Electrical, plumbing and other construction installation activities	43B	Electrical, plumbing and other construction installation activities		
43C	Building completion and finishing	43C	Building completion and finishing		
43D	Other specialised construction activities	43D	Other specialised construction activities		
45A	Wholesale and retail trade and repair of motor vehicles and motorcycles	45A	Wholesale and retail trade and repair of motor vehicles and motorcycles	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46A	Wholesale trade, except of motor vehicles and motorcycles and solid, liquid and gaseous fuels and related products	46A	Wholesale trade, except of motor vehicles and motorcycles and solid, liquid and gaseous fuels and related products	G46	Wholesale trade, except of motor vehicles and motorcycles

46B	Wholesale of solid, liquid and gaseous fuels and related products	46B	Wholesale of solid, liquid and gaseous fuels and related products		
47A	Retail trade, except of motor vehicles and motorcycles	47A	Retail trade, except of motor vehicles and motorcycles	G47	Retail trade, except of motor vehicles and motorcycles
47B	Retail sale of automotive fuel in specialised stores	47B	Retail sale of automotive fuel in specialised stores		
49A	Rail transport	49A49B	Land transport	H49	Land transport and transport via pipelines
49B	Other passenger land transport				
49C	Freight transport by road and removal services and transports via pipeline	49C	Freight transport by road and removal services and transports via pipeline		
50A	Sea and coastal water transport	50A50B	Water transport	H50	Water transport
50B	Inland water transport				
51A	Air transport	51A	Air transport	H51	Air transport
52A	Warehousing and support activities for transportation	52A	Warehousing and support activities for transportation	H52	Warehousing and support activities for transportation
53A	Postal and courier activities	53A	Postal and courier activities	H53	Postal and courier activities
55A	Accommodation	55A	Accommodation	I	Accommodation and food service activities
56A	Food and beverage service activities	56A	Food and beverage service activities		
58A	Publishing activities	58A	Publishing activities	J58	Publishing activities
59A	Motion picture, video and television programme production, sound recording and music publishing activities	59A	Motion picture, video and television programme production, sound recording and music publishing activities	J59-J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
60A	Programming and broadcasting activities	60A	Programming and broadcasting activities		
61A	Telecommunications	61A	Telecommunications	J61	Telecommunications
62A	Computer programming, consultancy and related activities	62A	Computer programming, consultancy and related activities	J62-J63	Computer programming, consultancy and related activities; information service activities
63A	Information service activities	63A	Information service activities		
64A	Financial service activities, except insurance and pension funding	64A	Financial service activities, except insurance and pension funding	K64	Financial service activities, except insurance and pension funding
65A	Insurance, reinsurance and pension funding, except compulsory social security	65A	Insurance, reinsurance and pension funding, except compulsory social security	K65	Insurance, reinsurance and pension funding, except compulsory social security
66A	Activities auxiliary to financial services and insurance activities	66A	Activities auxiliary to financial services and insurance activities	K66	Activities auxiliary to financial services and insurance activities
68A	Real estate activities except for rental and operating of own or leased real estate	68A	Real estate activities except for rental and operating of own or leased real estate	L68	Real estate activities
68B	Rental and operating of own or leased real estate	68B	Rental and operating of own or leased real estate		
69A	Legal and accounting activities	69A	Legal and accounting activities	M69-M70	Legal and accounting activities; activities of head offices; management consultancy activities
70A	Activities of head offices; management consultancy activities	70A	Activities of head offices; management consultancy activities		
71A	Architectural and engineering activities; technical testing and analysis	71A	Architectural and engineering activities; technical testing and analysis	M71	Architectural and engineering activities; technical testing and analysis
72A	Scientific research and development	72A	Scientific research and development	M72	Scientific research and development
73A	Advertising and market research	73A	Advertising and market research	M73	Advertising and market research
74A	Other professional, scientific and technical activities	74A	Other professional, scientific and technical activities	M74-M75	Other professional, scientific and technical activities; veterinary activities
75A	Veterinary activities	75A	Veterinary activities		
77A	Rental and leasing of motor vehicles	77A	Rental and leasing of motor vehicles	N	Administrative and support service activities
77B	Rental and leasing of personal and household goods	77B	Rental and leasing of personal and household goods		
77C	Rental and leasing of other machinery, equipment and tangible goods; Leasing of intellectual property and similar products, except copyrighted works	77C	Rental and leasing of other machinery, equipment and tangible goods; Leasing of intellectual property and similar products, except copyrighted works		
78A	Employment activities	78A	Employment activities		
79A	Travel agency, tour operator and other reservation service and related activities	79A	Travel agency, tour operator and other reservation service and related activities		
80A	Security and investigation activities	80A	Security and investigation activities		
81A	Combined facilities support activities and landscape activities	81A	Combined facilities support activities and landscape activities		
81B	Cleaning activities	81B	Cleaning activities		
82A	Office administrative, office support and other business support activities	82A	Office administrative, office support and other business support activities		
84A	Public administration	84A84B	Public administration and defense	O84	Public administration and defence; compulsory social security
84B	Defense				
84C	Compulsory social security activities	84C	Compulsory social security activities		
85A	Education	85A	Education	P85	Education
86A	Hospital activities	86A	Hospital activities	Q	Human health and social work activities

86B	Medical activities	86B	Medical activities		
86C	Dental practice activities	86C	Dental practice activities		
86D	Other human health activities	86D	Other human health activities		
87A	Residential care activities	87A	Residential care activities		
88A	Social work activities without accommodation	88A	Social work activities without accommodation		
90A	Creative arts and entertainment activities	90A	Creative arts and entertainment activities		
91A	Libraries, archives, museums and other cultural activities	91A	Libraries, archives, museums and other cultural activities		
92A	Gambling and betting activities	92A	Gambling and betting activities		
93A	Sports activities and amusement and recreation activities	93A	Sports activities and amusement and recreation activities	R-S	Other service activities
94A	Activities of membership organisations	94A	Activities of membership organisations		
95A	Repair of computers and personal and household goods	95A	Repair of computers and personal and household goods		
96A	Other personal service activities	96A	Other personal service activities		
97A	Activities of households as employers of domestic personnel	97A	Activities of households as employers of domestic personnel	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
-	-	-	-	U	Activities of extraterritorial organizations and bodies

Table A.3: NACE to ISIC correspondences.

A.5 RAS matrix adjustment

After accounting for exchange rate differences in EUR and USD between the MRIO and WIOD data, total output values for Belgium might still differ between both datasets. To ensure consistency before merging, we perform a RAS matrix adjustment that rescales WIOD entries to match MRIO aggregates. The procedure is similar to the standard application of the RAS adjustment to input-output tables, with two key differences. First, standard applications aim to update the IO matrix to a new year, with information on value added and final demand for a next year from e.g. national accounts. We do not have this information and thus construct this as part of the algorithm. Second, since our datasets contain negative values (e.g. for net taxes and changes in inventories), we follow Junius and Oosterhaven (2003) and treat these entries separately from the RAS adjustment.

Figure A.2 illustrates the matrix structure of the WIOD tables, where the sub-matrix $\mathbf{Z}$ contains intermediate goods transactions, $\mathbf{F}$ final demand, and $\mathbf{V}$ value added. Let vectors $\mathbf{x} = [x_1^1, \ldots, x_N^C]'$ and $\mathbf{y} = [y_1^1, \ldots, y_N^C]$ be the row and column sums including intermediate goods, and final demand or value added, respectively for sector i in country $c = 1, ..., C$. Let $\mathbf{x}(0)$ and $\mathbf{y}(0)$ denote the initial values in the WIOD data. Then, if entries of the input-output matrix would be rescaled to a new target vector $\mathbf{x}(1)$ of row sums, the column sum property is violated. Conversely, if entries are rescaled to the target vector $\mathbf{y}(1)$ of column sums, the row sum property is violated. The RAS adjustment solves this by iteratively rescaling the entries along both dimensions until the system of equations satisfies all constraints.

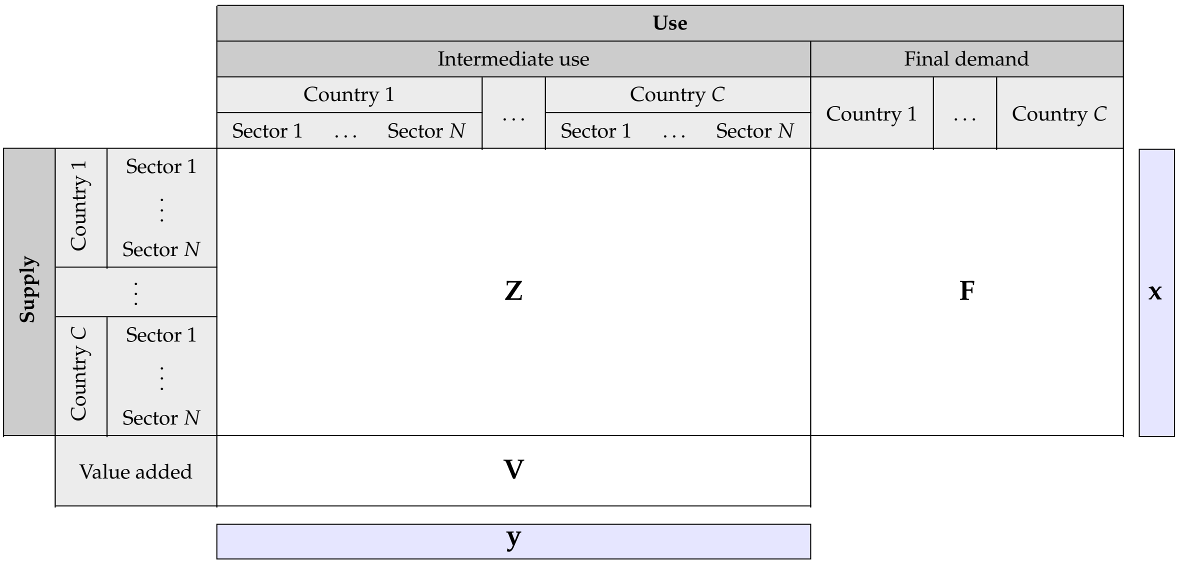

Figure A.2: Matrix structure of the WIOD tables.

The procedure is as follows. We first need values for the new vectors $\mathbf{x}(1)$ and $\mathbf{y}(1)$ as the target sums of the updated WIOD matrix. Let the weight of gross output x_i^c of country c in total world output of sector i be $w_i^c = \frac{x_i^c}{\sum_{c=1}^{C} x_i^c}$. Initial entries in the WIOD for Belgium are denoted by $w_i^{BEL}(0)$. We ensure consistency for Belgium throughout the MRIO and WIOD by keeping the weights for Belgium fixed in the initial and target vectors: $w_i^{BEL}(0) = w_i^{BEL}(1) =$

w_i^{BEL}. Then, the target vector of row sums is $\mathbf{x}(1) = [w_1^1 x_1^1, \ldots, w_N^C x_N^C]'$. The procedure for $\mathbf{y}(1) = [v_1^1 y_1^1, \ldots, v_N^C y_N^C]'$ is the same, with weights given by total expenditure shares in world expenditures $v_j^d = \frac{x_j^d}{\sum_{d=1}^{C} x_j^d}$.

Next, we apply the RAS algorithm. As the entries for Belgium are already consistent in the MRIO tables, we do not need to apply the algorithm for the corresponding matrix entries. Following Miller and Blair (2009), we incorporate exogenous information in the RAS calculation by replacing all known entries in the starting matrix by zero and defining a new matrix $\mathbf{K}$ as a null matrix with the ex ante known transactions for entries $k_{ij}^{BEL,BEL}$. We then decompose the WIOD into $\mathbf{P} - \mathbf{N}$, where $\mathbf{P}$ contains the nonnegative entries of the WIOD (referring to e.g. net taxes and changes in inventories) and $\mathbf{N}$ contains the absolute values of the negative entries, which will be added back after rescaling the WIOD matrix with non-negative entries $\mathbf{P}$. Hence, the target vectors $\mathbf{x}(1)$ and $\mathbf{y}(1)$ are adjusted so that:

$$\tilde{\mathbf{x}}(1) = \mathbf{x}(1) - \mathbf{Ki} + \mathbf{Ni} \quad \text{and} \quad \tilde{\mathbf{y}}(1) = \mathbf{y}(1) - \mathbf{i'K} + \mathbf{i'N}$$

where $\mathbf{i}$ refers to a vector of all ones. Next, the matrices in Figure A.2 can be decomposed as:

$$\mathbf{B} = \begin{bmatrix} \mathbf{Z}_\mathbf{P}, \mathbf{F}_\mathbf{P} \end{bmatrix} \text{ and } \mathbf{C} = \begin{bmatrix} \mathbf{Z}_\mathbf{P} \\ \mathbf{V}_\mathbf{P} \end{bmatrix}$$

where $\mathbf{Z}_\mathbf{P}$, $\mathbf{F}_\mathbf{P}$ and $\mathbf{V}_\mathbf{P}$ represent the same sub-matrices defined above, but with only nonnegative entries. Let $\hat{\mathbf{r}}^1$ and $\hat{\mathbf{s}}^1$ be the diagonal matrices containing the adjustment terms on the main diagonal:

$$\hat{\mathbf{r}}^1 = \left[\hat{\mathbf{x}}(1)\right] \left(\hat{\mathbf{x}}^0\right)^{-1} \quad \text{and} \quad \hat{\mathbf{s}}^1 = \left[\hat{\mathbf{y}}(1)\right] \left(\hat{\mathbf{y}}^0\right)^{-1}$$

where the superscript indexes the iteration number. Then, the algorithm proceeds as follows:
Step 1: adjust rows so that their sum is equal to the target vector $\tilde{\mathbf{x}}(1)$:

$$\mathbf{B}^1 = \begin{bmatrix} \mathbf{Z}_\mathbf{P}^1, \mathbf{F}_\mathbf{P}^1 \end{bmatrix} = \hat{\mathbf{r}}^1 \mathbf{B}(0)$$

Step 2: decompose $\mathbf{B}^1$ and use the updated matrix, $\mathbf{Z}_\mathbf{P}^1$:

$$\mathbf{C}(0) = \begin{bmatrix} \mathbf{Z}_\mathbf{P}^1 \\ \mathbf{V}_\mathbf{P}(0) \end{bmatrix}$$

Step 3: adjust the columns to the target sum $\tilde{\mathbf{y}}(1)$:

$$\mathbf{C}^1 = \begin{bmatrix} \mathbf{Z}_\mathbf{P}^2 \\ \mathbf{V}_\mathbf{P}^1 \end{bmatrix} = \mathbf{C}(0)\hat{\mathbf{s}}^1$$

Step 4: decompose $\mathbf{C}^1$ and use $\mathbf{Z}_\mathbf{P}^2$ again in Figure A.5.
Step 5: repeat step 1-4 until convergence for some $\varepsilon > 0$, *i.e.*:

$$\|\tilde{\mathbf{x}}(1) - \tilde{\mathbf{x}}^n\| \leq \varepsilon \quad \text{and} \quad \|\tilde{\mathbf{y}}(1) - \tilde{\mathbf{y}}^n\| \leq \varepsilon$$

Step 6: after convergence insert back values for $\mathbf{K}$ and $\mathbf{N}$.

A.6 Merging MRIO with WIOD

Finally, we merge the harmonized MRIO and WIOD datasets. We connect both datasets by allocating sector-country flows from/to Belgium in the WIOD to Belgian regions in the MRIO, using ex- port/import shares of each BE region in total exports or imports for that sector.

First, we divide the WIOD dataset into sub-matrices as shown in Figure A.3. In blue are the sub-matrices for all domestic flows of intermediate goods $\mathbf{Z}_{\mathbf{BEL,BEL}}$, value added $\mathbf{V}_{\mathbf{BEL,BEL}}$, and final demand $\mathbf{F}_{\mathbf{BEL,BEL}}$. Entries for these sub-matrices are filled with values from the MRIO data. We also define all sub-matrices in which which Belgium is the exporter ($\mathbf{E}_{\mathbf{BEL}}$), the importer ($\mathbf{M}_{\mathbf{BEL}}$), or both. Entries in these sub-matrices are to be proportionally imputed to the Belgian regions. All other sub-matrices remain unchanged.

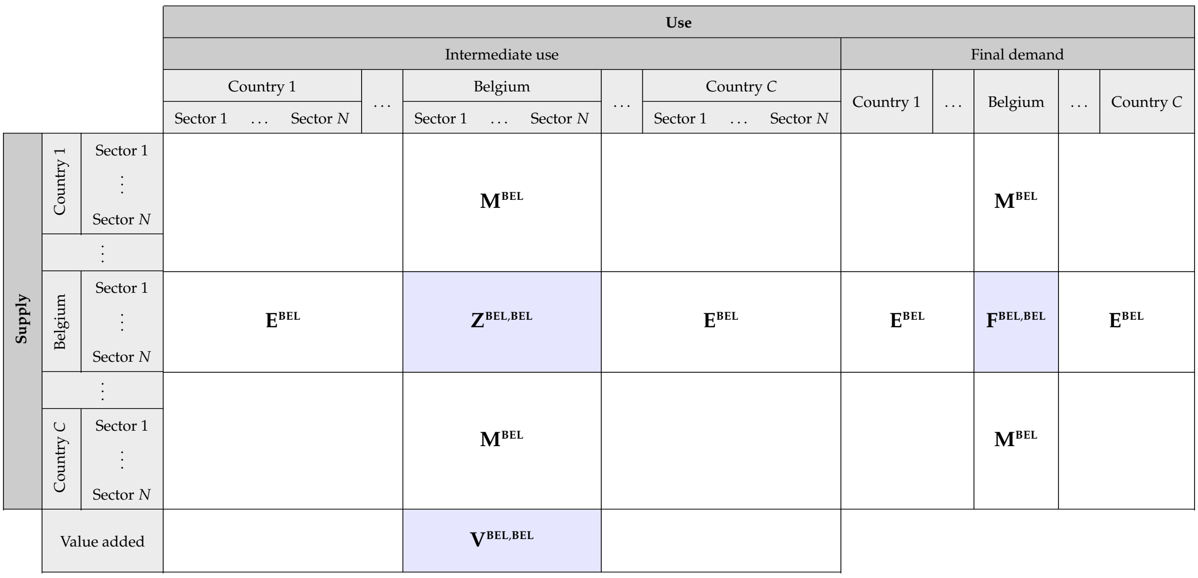

Figure A.3: Sub-matrices of WIOD for regionalizing trade flows from/to Belgium.

Second, for exports from and imports to Belgium, we proceed as follows. Starting with the matrix containing Belgian exports:

$$\mathbf{E}^{\mathbf{BEL}} = \begin{bmatrix} \mathbf{e}_1^{\mathbf{BEL}} \\ \vdots \\ \mathbf{e}_N^{\mathbf{BEL}} \end{bmatrix} = \begin{pmatrix} e_1^{BEL,1} & \dots & e_1^{BEL,C} \\ \vdots & \ddots & \vdots \\ e_N^{BEL,1} & \dots & e_N^{BEL,C} \end{pmatrix} \tag{9}$$

where each row vector $\mathbf{e}_\mathbf{i}^{\mathbf{BEL}}$ contains the exports of sector i in Belgium to every other country c. Note that exports are considered irrespective of the use industry j in destination country c. Next, let $\sigma_i^r = \frac{e_i^r}{\sum_i e_i^r}$ be the export share of sector i in shipping region r, where e_i^r is the export value of that sector-region. Then, each entry of $\mathbf{E}^{\mathbf{BEL}}$ is to be redistributed to the three Belgian regions, proportionally to their export shares. I.e., we expand the matrix by repeating each row for each of the Belgian regions:

$$\hat{\mathbf{E}}^{\mathbf{BEL}} = \begin{bmatrix} \mathbf{e}_1^{\mathbf{BEL}} \\ \mathbf{e}_1^{\mathbf{BEL}} \\ \mathbf{e}_1^{\mathbf{BEL}} \\ \vdots \\ \mathbf{e}_N^{\mathbf{BEL}} \\ \mathbf{e}_N^{\mathbf{BEL}} \\ \mathbf{e}_N^{\mathbf{BEL}} \end{bmatrix} = \begin{pmatrix} e_1^{BEL,1} & \dots & e_1^{BEL,C} \\ e_1^{BEL,1} & \dots & e_1^{BEL,C} \\ e_1^{BEL,1} & \dots & e_1^{BEL,C} \\ \vdots & \ddots & \vdots \\ e_N^{BEL,1} & \dots & e_N^{BEL,C} \\ e_N^{BEL,1} & \dots & e_N^{BEL,C} \\ e_N^{BEL,1} & \dots & e_N^{BEL,C} \end{pmatrix}$$

Pre-multiplying by the diagonal matrix $\boldsymbol{diag}(\boldsymbol{\sigma})$, with regional export shares as entries, we obtain the matrix of exports of each Belgian region r to each destination country c:

$$\tilde{\mathbf{E}}^{\mathbf{BEL}} = \boldsymbol{diag}(\boldsymbol{\sigma}) \times \hat{\mathbf{E}}^{\mathbf{BEL}}$$

Redistributing imports to Belgium proceeds similarly. The matrix of Belgian imports is:

$$\mathbf{M}^{\mathbf{BEL}} = \begin{bmatrix} \mathbf{m}_1^{\mathbf{BEL}} & \dots & \mathbf{m}_N^{\mathbf{BEL}} \end{bmatrix} = \begin{pmatrix} m_1^{BEL,1} & \dots & m_N^{BEL,1} \\ \vdots & \ddots & \vdots \\ m_1^{BEL,C} & \dots & m_N^{BEL,C} \end{pmatrix}$$

where, each column vector $\mathbf{m}_s^{\mathbf{BEL}}$ contains the imports of sector j in Belgium from every country c, for $c \neq BEL$. Similarly to exports, we consider imports irrespectively of the shipping industry from each country c. Expanding each column of this matrix by the number of Belgian regions:

$$\hat{\mathbf{M}}_{\mathbf{BEL}} = \begin{pmatrix} m_1^{BEL,1} & m_1^{BEL,1} & m_1^{BEL,1} & \dots & m_N^{BEL,1} & m_N^{BEL,1} & m_N^{BEL,1} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ m_1^{BEL,C} & m_1^{BEL,C} & m_1^{BEL,C} & \dots & m_N^{BEL,C} & m_N^{BEL,C} & m_N^{BEL,C} \end{pmatrix}$$

Let $\mu_j^s = \frac{m_j^s}{\sum_j m_j^s}$ be the import share of receiving sector j in region s, with imports values m_j^s. Finally, by post-multiplying the above matrix by $\boldsymbol{diag}(\boldsymbol{\mu})$, *i.e.* the diagonal matrix with the import shares on the main diagonal, we obtain the matrix of imports of each Belgian region from any country j:

$$\tilde{\mathbf{M}}^{\mathbf{BEL}} = \hat{\mathbf{M}}^{\mathbf{BEL}} \boldsymbol{diag}(\boldsymbol{\mu})$$

We thus end up with two new matrices of exports and imports for Belgium, $\tilde{\mathbf{E}}^{\mathbf{BEL}}$ and $\tilde{\mathbf{M}}^{\mathbf{BEL}}$ respectively, with every other country c as trade partner, regionalizing the WIOD for Belgium. Note that the above methodology applies both for the intermediate transactions and for the final demand sub-matrix. The value added sub-matrix does not require adjustments as it only contains domestic value added for Belgium. Its values are filled with the data from the MRIO tables.

B Theory appendix

C Additional results

importsC19fl.png

importsA03b

(a) Sector C19 in Flanders

Figure C.1: Imports from foreign countries to top sectors in the three regions in terms of output multipliers.

vamultdecompfla.png

vamultdecom

(a) Flanders

Figure C.2: Decomposition of value added multipliers for the three regions.

emplmultdecompfla.png

emplmultdec

(a) Flanders

Figure C.3: Decomposition of employment multipliers for the three regions.

Sectors	Upstreamness
vBEL-200-C24	3.5011
vBEL-200-C20	3.3357
vBEL-200-A02	3.2342
vBEL-200-C18	3.0214
vBEL-200-C19	3.014
vBEL-200-M69-M70	2.9363
vBEL-200-M73	2.9259
vBEL-200-C17	2.8977
vBEL-200-M74-M75	2.8183
vBEL-200-C22	2.8148

Table C.1: Top 10 sector by upstreamness in Flanders

Sectors	Upstreamness
vBEL-200-I	1.531
vBEL-200-R-S	1.5278
vBEL-200-F	1.4827
vBEL-200-C29	1.4534
vBEL-200-L68	1.3871
vBEL-200-G47	1.2156
vBEL-200-M72	1.1637
vBEL-200-O84	1.1284
vBEL-200-Q	1.0822
vBEL-200-P85	1.0719
vBEL-200-T	1

Table C.2: Bottom 10 sector by upstreamness in Flanders

Sectors	Output
vBEL-200-F	73294.6186
vBEL-200-G46	33538.4859
vBEL-200-M69-M70	31825.3543
vBEL-200-C10-C12	29510.7717
vBEL-200-L68	28077.7672
vBEL-200-Q	26787.9237
vBEL-200-C20	25823.2749
vBEL-200-N	20092.4335
vBEL-200-H52	19082.1655
vBEL-200-P85	17141.7065

Table C.3: Top 10 sector by output (M) in Flanders

Sectors	Upstreamness
vBEL-200-C16	2145.19348
vBEL-200-H50	2141.38483
vBEL-200-J58	1858.23788
vBEL-200-J59-J60	1730.78148
vBEL-200-M74-M75	1690.95494
vBEL-200-E36	1292.25072
vBEL-200-C30	939.417545
vBEL-200-B	349.034607
vBEL-200-T	286.97212
vBEL-200-A03	103.627745
vBEL-200-A02	78.6309467

Table C.4: Bottom 10 sector by output (M) in Flanders bilateralFlandersNetherlandsEverything.png

Figure C.4: Bilateral upstreamness between sectors in Flanders and Netherlands

BEL-200 preceding the sector number means that is that sector in the Flanders region of Belgium while the NLD prefix means the sectors in the Netherlands.