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The Role of Exporters and Domestic Producers in GVCs
Evidence for Belgium Based on Extended National Supply and Use Tables Integrated into a Global Multiregional Input-Output Table

Bernhard Michel, Caroline Hambÿe, and Bart Hertveldt

10.1 Introduction

Trade liberalization and technological developments have largely contributed to increasing global economic integration between the early 1990s and the late 2000s by reducing trade costs (e.g., transport costs, communication costs). This went hand in hand with profound changes in firm organization that still shape production processes today. Firms have reorganized their production processes by dividing them into a growing number of separate stages and by outsourcing more and more of those production stages to domestic and foreign suppliers. Due to these changes, value chains have become increasingly fragmented and international or even global. Input-output tables and models are among the foremost tools for the macroeconomic analysis of value chains because they enable mapping of the full set of upstream and downstream links in the chain. The calculation of multipliers and linkages based on input-output tables yields information on how and to what extent industries are integrated into value chains. Such analyses were traditionally based on national input-output tables and hence restricted to domestic value chains in individual countries. However, the statistical development of global input-output tables over the past decade has

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widened the scope and looks at the integration of countries and industries into global value chains (Koopman et al. 2010; Johnson and Noguera 2012; Inomata 2017; Los 2017).

For input-output-based analyses of value chains, fragmentation also poses a challenge in terms of the granularity of underlying industry-level data. In input-output tables, firms are traditionally grouped into industries according to the type of goods and services they produce. But within fragmented value chains, patterns of specialization are likely to be related to other firm characteristics. Therefore, the analysis of value creation in the context of fragmented value chains can be improved through a breakdown of industries into different types of firms. As suggested in OECD (2015), it is desirable to disaggregate industries in supply-and-use and input-output tables according to firm characteristics such as size, ownership, or exporter status because these characteristics may actually be the source of technological differences between firms within industries that are traditionally defined in terms of product similarity. The same point is made by Los, who argues that "such differences can only be captured in value chain trade indicators if each industry is split in two subindustries" (2017, 317).

This insight has prompted several efforts to account for firm heterogeneity in supply and use tables (SUTs) and input-output tables (IOTs)—that is, to generate so-called heterogeneous or extended tables. This work was initially triggered by the desire to isolate firms engaged in processing trade, as these firms differ from other firms in terms of technology and import patterns. Processing traders were isolated in IOT for China (Koopman, Wang, and Wei 2012; Ma, Wang, and Zhu 2015), and firms operating under special export regimes were separated out in Mexico's IOT (de la Cruz et al., 2011). Both these disaggregations have also been integrated into the OECD's inter-country input-output tables (Yamano and Webb 2018). In a similar vein, firms active in free trade zones have been isolated in tables for Costa Rica (Saborío 2015). Beyond special trade regimes, Ahmad et al. (2013) provide a proof of concept for a micro-data-based split of industries in Turkish IOT into exporters and other firms. Several other initiatives have been gathered in the context of the OECD's Expert Group on Extended Supply and Use Tables: they come, among others, from Austria (disaggregation by exporter status and ownership, see Lais and Kolleritsch, 2017); the Netherlands (disaggregation by size class, see Chong et al. 2017); and the United States (disaggregation by ownership, see Fetzer et al. 2018). Finally, Piacentini and Fortanier (2015), and Cadestin et al. (2018), introduce firm heterogeneity into multicountry input-output tables in terms of firm size and ownership. They do so in a proportional way based on aggregated international firm-level databases.

In this work, we break down manufacturing industries in the 2010 Belgian SUTs and IOT into firms that are export oriented and firms that mainly serve the domestic market. For this purpose, we use the full set of individual firm-level data sources that serve for the construction of Belgium's official SUTs and IOT for 2010. The resulting export-heterogeneous tables allow us to test for differences in input structures and import patterns of export-oriented firms and other firms, and to analyze their respective integration into domestic value chains based on input-output multipliers and linkages as defined in Miller and Blair (2009), and Hambÿe (2012). We also compare our results with those for homogeneous industries derived from the official 2010 Belgian IOT to show that accounting for export heterogeneity in those tables yields important new insights. Moreover, we integrate the export-heterogeneous Belgian IOT into the global tables of the World Input-Output Database (WIOD) to determine how export-oriented and domestic market manufacturing firms contribute to Belgium's participation and position in global value chains. The analysis of contributions to value creation based on data disaggregated along these lines provides a clearer picture of the sources of a country's competitiveness.

The novelty of our approach is twofold: the estimation of the industry-level output, input, and import structures in the exporter heterogeneous SUTs and IOTs are data based rather than just proportional as in most prior contributions, and the integration of the Belgian tables into the global table is such that these Belgian data are not modified. Furthermore, as globalization has become a major challenge in the measurement of national accounts for individual countries, we also see this work as a contribution to determining whether the national accounts—which officially comprise SUTs and IOTs—can accommodate recent findings from the academic literature on international trade. Analyses of the characteristics of exporters based on firm-level data have indeed shown that exporters are different from domestic firms in terms of production technology. Exporters are not only bigger and more productive (Melitz 2003) but they also import more of the intermediates they use (Bas 2009).

This chapter is organized as follows. We start off by providing details on constructing export-heterogeneous supply and use and input-output tables for Belgium in section 10.2. This includes explanations on how we have disaggregated manufacturing industries in Belgian supply and use tables, derived a national heterogeneous input-output table, and integrated it into the global input-output table of the WIOD project. In section 10.3, we analyze differences in input structures between manufacturing exporters and non-exporters and look at their integration into both domestic and global value chains. Finally, we draw conclusions in section 10.4.

10.2 Export Heterogeneity in Supply and Use and Input-Output Tables: Sources and Data Construction

Supply and use tables (SUTs) are an integral part of national accounts (NA) and provide detailed information about economic flows in monetary terms: they describe production processes and income generated through production. As the central balancing tool for the national accounts, they match the supply and use of goods and services. While SUTs are mainly a statistical tool, symmetric input-output tables (IOTs) are an analytical tool derived from SUTs based on assumptions about the relation between output and inputs.[1]

SUTs are product-by-industry tables with domestic production and imports given in the supply table, and intermediate inputs, final uses (final consumption of households and government, gross fixed capital formation, changes in inventories, and exports of goods and services), and value added reported in the use table. Thus, the use table reveals the structure of production costs by industry. The classification of industries in SUTs is such that industries are made up of production units or firms that produce similar goods or services; for instance, all producers of chemicals or financial services are grouped together in one industry. Heterogeneity is traditionally conceived as depending on the detail of the industry classification. The broadly defined chemicals industry will lump together firms that produce different types of chemicals: industrial gases, fertilizers, etc. The standard approach to account for such heterogeneity is further disaggregation of the industry classification along the lines of detailed product categories. However, as emphasized in OECD (2015), there may also be other sources of firm heterogeneity within industries: firms in one industry differ in terms of size and ownership, and they are exporters or serve only the domestic market. Their production cost structure may then differ accordingly. Therefore, it is worthwhile considering alternative disaggregations of industries within SUTs and IOTs.

The focus here is on heterogeneity in terms of export behavior: we disaggregate manufacturing industries into export-oriented firms and firms serving mainly the domestic market. The literature on firm heterogeneity and international trade points to differences between exporters and nonexporters in terms of technology. In particular, exporters are found to have higher productivity levels (and markups), which allows them to cover the fixed cost related to exporting (Melitz 2003). Moreover, the more productive exporters tend to rely more on imported inputs. They have better access to global input markets, which allows them to purchase cheaper and/or higher-quality inputs abroad, thereby further boosting their productivity (Bas 2009). These technological differences may also shape and be shaped by the deeper integration of exporters into global value chains.

We introduce export heterogeneity into Belgian SUTs and IOT for the year 2010 by disaggregating manufacturing industries according to exporter status at the most detailed industry-level breakdown. The official Belgian

1. For a more detailed description of the construction of SUTs and IOTs and their role within the system of national accounts, see Beutel (2017).

SUTs for 2010[2] have been constructed according to the rules of the European System of Accounts (ESA 2010).[3] The most detailed unpublished version (workformat) of the SUTs contains a breakdown into 133 industries and 350 product categories, which are respectively based on the European Union industry and product classifications NACE Rev.2 and CPA2008.[4] Manufacturing covers NACE Rev.2 industries 10 to 33, which amounts to 57 industries in the workformat classification. For disaggregating these industries, we rely on most of the firm-level data that are used in the construction of the SUTs. We make sure that our disaggregation is consistent with the official Belgian SUTs, i.e., values for output, intermediate inputs, and value added of the split manufacturing industries sum to the values for the total non-heterogeneous industry.

The stylized supply table and use table shown in tables 10.1 and 10.2 illustrate the SUTs with a disaggregation of manufacturing industries (columns) according to exporter status. Table 10.3 and table 10.4 add a split of the use table according to the origin of the used goods and services, i.e., whether they are imported or purchased from Belgian producers (table 10.3) and, among the latter, whether they are sourced from exporters or non-exporters (table 10.4).

In practice, we proceed in several steps to obtain export-heterogeneous Belgian SUTs for 2010. First, we identify exporters and disaggregate total output and intermediate inputs for the 57 manufacturing industries in the tables. Then, we split the columns of both the supply and the use table that contain the product distribution of output and intermediate inputs for each industry. We also specifically disaggregate the use table to identify the use of imported intermediate inputs and purchases of intermediate inputs from manufacturing exporters and non-exporters. Finally, we derive a symmetric heterogeneous industry-by-industry IOT, which we then integrate into a global multiregional input-output table (GMRIO).

10.2.1 Disaggregating Total Industry-Level Output and Intermediate Inputs

Identifying exporters among manufacturing firms allows us to disaggregate total industry-level output and intermediate consumption for the 57 manufacturing industries in the SUTs based on the exporters' share of turnover and purchases. The results correspond to the dark gray cells in the

2. We will also refer to these as standard SUTs.

3. The 2010 Belgian SUTs at purchasers' prices and at basic prices with a 64 industry and product breakdown (as well as the IOT) can be downloaded for free from the website of the Belgian Federal Planning Bureau (FPB): http://www.plan.be/databases/data-54-en-input+output+tables+2010+esa+2010+december+2015+. Further detail (in French or Dutch) on their construction can be found in FPB (2015).

4. NACE stands for Statistical Classification of Economic Activities in the European Community and CPA for Statistical Classification of Products by Activity in the European Economic Community.

Table 10.1 Supply table

		Agriculture	Mining	Manufacturing					Services			Total output by product	Imports	Total supply
				M1		M2		…	S1	S2	…			
				X	non X	X	non X	…						
Products of agriculture														
Mining products														
Manufactured Products	M1													
	M2													
	M3													
	⋮													
Services	S1													
	S2													
	S3													
	⋮													
Total output by industry														

Table 10.2 **Use table (column disaggregation only)**

		Agriculture	Mining	Manufacturing					Services			Total intermediate inputs	Final uses	Total use
				M1		M2		…	S1	S2	…			
				X	non X	X	non X	…						
Products of agriculture														
Mining products														
Manufactured Products	M1													
	M2													
	M3													
	⋮													
Services	S1													
	S2													
	S3													
	⋮													
Total use by industry														
Net taxes on products														
Value added														
Output														

Table 10.3 **Use table for domestic production and imports**

		Agriculture	Mining	Manufacturing					Services			Total intermediate inputs	Final uses	Total use
				M1		M2		…	S1	S2	…			
				X	non X	X	non X	…						
Domestic														
Products of agriculture														
Mining products														
Manufactured Products	M1													
	M2													
	⋮													
Services	S1													
	S2													
	⋮													
Imports														
Products of agriculture														
Mining products														
Manufactured Products	M1													
	M2													
	⋮													
Services	S1													
	S2													
	⋮													
Total use by industry														
Net taxes on products														
Value added														
Output														

Table 10.4 **Use table (full disaggregation)**

			Agriculture	Mining	Manufacturing					Services			Total intermediate inputs	Final uses	Total use
					M1		M2		…	S1	S2	…			
					X	non X	X	non X	…						
Domestic															
Products of agriculture															
Mining products															
Manufactured Products	X	M1													
		M2													
		⋮													
	non X	M1													
		M2													
		⋮													
Services		S1													
		S2													
		⋮													
Imports															
Products of agriculture															
Mining products															
Manufactured Products		M1													
		M2													
		⋮													
Services		S1													
		S2													
		⋮													
Total use by industry															
Net taxes on products															
Value added															
Output															

bottom row of tables 10.1 and 10.2 and the fourth row from the bottom in table 10.2. Disaggregated value added including net taxes on products is obtained as the difference between total output and intermediate inputs of the heterogeneous manufacturing industries (dark gray cells in the second and third rows from the bottom in table 10.2).

The general business register underlying the 2010 national accounts (NA) and SUTs contains 40 194 manufacturing firms[5] for which data on turnover and total purchases are available based on the following sources: balance sheet data, structural business survey data, and periodical value added tax (VAT) declarations.[6] These are the main data sources used to estimate industry-level NA aggregates for total output and intermediate inputs by industry. The 40 194 manufacturing firms with turnover and total purchases data constitute our *full sample*. Their total turnover sums to €229.7 billion. Merging in merchandise export data, we calculate export to turnover ratios for these firms and consider those with a ratio above 25 percent as export oriented. This yields a sample split for manufacturing firms into 2 430 export-oriented firms, and 37 764 firms that mainly serve the domestic market, which we refer to as domestic market firms. The share of export-oriented firms in turnover amounts to about 75 percent (€171.2 billion). Hence, export-oriented firms are bigger firms: their average turnover is €70.4 million compared to €5.7 million for the entire sample. Due to the 25 percent cut-off ratio for defining export-oriented firms, this category of firms does not account for all exports. Merchandise exports of export-oriented firms amount to €98.2 billion out of a total of €101.3 billion of exports by manufacturing firms (97 percent). All these sample characteristics are summarized in the upper part of table 10.5.

10.2.2 Disaggregating Manufacturing Industries in the Supply and Use Tables

As illustrated by the light gray cells in tables 10.1 and 10.2, the SUTs contain the distribution of industry-level output and use of intermediate inputs over product categories. For the column-wise split of manufacturing industries in the 2010 Belgian SUTs into export-oriented and domestic market firms, we use a *restricted sample* of firms for which we have information on turnover and purchases by product category.

In the Belgian SUTs, the product distribution of output and intermediate inputs is derived from several sources. The main source is two supplementary questionnaires annexed to the structural business survey (SBS): one on the product detail of turnover and the other on the product detail

5. Belgian national accounts (NA) are based on legal units, which we refer to as firms.

6. The order of this list of sources reflects the hierarchy in their use. Balance sheet data are the primary source. If balance sheet data are unavailable for a firm, then structural business survey data are used, and if those are not available either, then data from periodical VAT declarations are used.

Table 10.5 **Sample characteristics for manufacturing industries, 2010**

	Number of firms	Turnover (billion euros)	Average size (million euros)	Exports (billion euros)
Full sample				
All firms	40,194	229.7	5.7	101.3
Export-oriented firms	2,430	171.2	70.4	98.2
	(6.0%)	(74.5%)		(96.9%)
Domestic market firms	37,764	58.5	1.5	3.1
	(94.0%)	(25.5%)		(3.1%)
Restricted sample				
All firms	1,710	181.2	105.9	85.9
Export-oriented firms	980	149.9	153.0	83.9
	(57.3%)	(82.8%)		(97.6%)
Domestic market firms	730	31.2	42.8	2.0
	(42.7%)	(17.2%)		(2.4%)

Note: The *full sample* comprises all firms with data on turnover and total purchases. The *restricted sample* comprises firms with supplementary SBS questionnaires. Export-oriented firms are those with an export to turnover ratio above 25%.

of total purchases. These two questionnaires are sent out jointly every five years to a *restricted sample* of big firms (all firms with at least 50 employees plus smaller firms if necessary to reach a coverage of minimum 50 percent of turnover at the four-digit industry level). For the product detail on output in manufacturing industries, the data from the supplementary SBS questionnaire on turnover are complemented by data from the survey on industrial production (Prodcom). Moreover, the data are compared to firm-level exports by product category to correct inconsistencies. By the same token, the data from the supplementary SBS questionnaire on the product detail of total purchases are cross-checked and corrected for inconsistencies through a comparison with firm-level imports by product category and data on domestic purchases from the VAT transaction data set.[7] The latter comprises all transactions between domestic firms on which VAT is levied. In the construction of the SUTs, the resulting cross-checked data sets are used to distribute total industry-level output and intermediate inputs over product categories.

In 2010, 1 710 manufacturing firms completed the supplementary SBS questionnaires. They form the *restricted sample* for establishing the product distributions. Their turnover amounts to €181.2 billion, which is 79 percent of the total turnover of the 40 194 manufacturing firms in our *full sample*. Among these 1 710 firms, 980 are export oriented (export to turnover ratio above 25 percent). The turnover of these export-oriented firms sums to

7. In the construction of the SUTs, the aim of these corrections is to avoid that the underlying inconsistencies in the firm-level data resurface in the balancing process of the tables.

€149.9 billion (88 percent of the turnover of all 2 430 export-oriented firms in the *full sample*). Within the *restricted sample*, the average size of export-oriented firms also largely exceeds that of firms serving mainly the domestic market (€153.0 against €42.8 million). Finally, exports of export-oriented firms in the *restricted sample* amount to €83.9 billion compared to total exports of €85.9 billion by all firms in the *restricted sample* (98 percent). Again, table 10.5 provides an overview of these sample characteristics.

We split the *restricted sample* into export-oriented and domestic market firms and use the cross-checked data from the supplementary SBS questionnaires on turnover and total purchases to estimate separate product distributions of output and intermediate inputs for both groups of firms in each manufacturing industry. We were able to do so for 47 out of the 57 manufacturing industries. The sample size was insufficient for domestic market firms in eight industries and for export-oriented firms in two industries. In those cases, we had to make a proportionality assumption. Given the aim to investigate differences in production cost structures, we have been striving to determine the product distributions of output and intermediate inputs of heterogeneous industries based on firm-level data rather than just assume proportionality to the non-heterogeneous industries in the official tables. A sample split based on lower export to turnover ratios increases the number of industries where the sample size for non-exporters is insufficient for a data-based estimation of the product distribution of output and inputs. Hence, we faced a trade-off between including exporters with a low export to turnover ratio in the exporter sample and avoiding proportionality in the estimation of the product distributions of the heterogeneous industries.

Finally, we apply a RAS procedure to ensure consistency with respect to the product distribution of output and intermediate inputs of the non-heterogeneous industries in the official SUTs. As a result, we obtain a heterogeneous supply table as shown in table 10.1 and a heterogeneous use table as shown in table 10.2. The heterogeneous use table is still at purchasers' prices. For transformation to basic prices, the valuation matrices for trade and transport margins and for taxes less subsidies on products must be subtracted. As we have no firm-level information that would allow us to disaggregate valuation tables by exporter status, we do so proportionally to values of intermediate inputs at purchasers' prices.

10.2.3 Disaggregating the Use Table according to the Origin of the Products

The disaggregation of the use table at basic prices according to the origin of the products is done in two steps: first a split into imported and domestic goods and services (table 10.3) and then a split of the latter into goods produced by export-oriented manufacturers and by domestic market manufacturers (upper part of table 10.4). The official Belgian use table at

Table 10.6 Heterogeneous supply table for Belgium, 2010, millions of euros

	Export-oriented manufacturers	Domestic market manufacturers	Other industries	Imports	Total supply
Manufactured goods	135,960	47,683	10,767	161,793	356,203
Other goods and services	13,344	4,783	538,571	100,952	657,651
Total output/imports	149,304	52,467	549,338	262,745	1,013,854

basic prices contains a split according to the origin of the goods and services, i.e., a use table for domestic output and a use table for imports. This is necessary for deriving an IOT. Hence, we need to split the heterogeneous use table into heterogeneous use tables for domestic output and imports. This requires specific data work for the columns of manufacturing industries (see table 10.3).[8] To estimate the use of imported intermediate inputs by export-oriented and domestic market manufacturers, we use product-level import data for these firms corrected for re-exports and excluding imports of capital goods. Again, a RAS procedure is applied so that the disaggregation respects the values of imported intermediate inputs in the official use table. The use of domestically produced intermediate inputs by export-oriented and domestic market manufacturers is calculated as the difference between total and imported intermediate inputs.

As shown shaded in light gray in table 10.4, the entire rows for domestically produced manufactured goods in the use table can be further disaggregated according to whether these goods are produced by domestic market manufacturers or by export-oriented manufacturers. To do this, we proceed in two steps. First, we disaggregate exports, which are part of final uses. As illustrated above, export-oriented firms do not account for all exports due to the 25 percent export to turnover cut-off ratio for identifying these firms. Based on the sample split (*full sample*) and firm-level export data by product category, we determine exports by export-oriented and domestic market firms for all categories of manufactured goods. Second, for all other final and intermediate use categories, we disaggregate the rows proportionally for each category of manufactured goods based on shares of export-oriented and domestic market firms in output of these goods that is not exported. These shares are calculated from the data in the heterogeneous supply table.

This completes the column-wise and row-wise disaggregation of Belgium's 2010 SUTs into export-oriented and domestic market firms in manufacturing industries as illustrated in tables 10.1 and 10.4. Tables 10.6 and 10.7 present the resulting heterogeneous SUTs in a very aggregated form.

8. For all other industries and all final demand categories, the split into goods and services of domestic origin and imports is the same as in the official use table.

Table 10.7 **Heterogeneous use table for Belgium, 2010, millions of euros**

	Export-oriented manufacturers	Domestic market manufacturers	Other industries	Domestic final demand	Commodity exports	Service exports	Total output / imports
Domestic							
Manufactured goods, export-oriented manufacturers	14,816	3,711	9,328	10,058	96,429	1,617	135,960
Manufactured goods, domestic market manufacturers and firms in other industries	8,153	6,650	16,815	13,163	10,891	2,778	58,450
Other goods and services	27,545	12,580	170,954	260,813	21,400	63,404	556,698
Imports							
Manufactured goods	39,416	9,839	15,879	35,285	61,374	0	161,793
Other goods and services	26,526	3,558	49,175	7,382	14,312	0	100,952
Total use	116,456	36,338	262,151	326,702	204,407	67,799	1,013,853
Value added	32,848	16,128	287,187				
Total output	149,304	52,467	549,338				

Table 10.8 **Heterogeneous input-output table for Belgium, 2010, millions of euros**

	Export-oriented manufacturers	Domestic market manufacturers	Other industries	Domestic final demand	Commodity exports	Service exports	Total output
Export-oriented manufacturers	15,335	3,866	11,482	12,446	101,566	4,609	149,304
Domestic market manufacturers	6,900	5,697	14,730	13,278	8,975	2,888	52,467
Other industries	28,279	13,379	170,886	258,311	18,180	60,303	549,337
Imports	65,941	13,397	65,053	42,667	75,686	0	
Value added	32,848	16,128	287,186				
Total output	149,304	52,467	549,337				

10.2.4 Deriving the Export-Heterogeneous Industry-by-Industry Input-Output Table

For the transformation of SUTs at basic prices into symmetric industry-by-industry IOT, we choose the commonly used fixed product sales structure assumption (Model D in Eurostat, 2008). According to this assumption, "each product has its own specific sales structure irrespective of the industry where it is produced" (Beutel 2017, 119). This comes down to assuming that an industry's output of a product is delivered to users in the same proportion as total economy-wide output of that product.[9]

The heterogeneous industry-by-industry IOT that we derive from the heterogeneous SUTs is given in very aggregated form in table 10.8. The rows of this industry-by-industry IOT show the values of deliveries of an industry's output to the different users. The columns for industries indicate where they purchase their inputs from, and their value added, i.e., they describe the industries' cost structures.

10.2.5 Integrating the Export-Heterogeneous IOT for Belgium into a Global Table

The last step of our statistical work is to integrate the 2010 heterogeneous IOT for Belgium into a global multiregional input-output table (GMRIO) for the same year. Among the available GMRIOs, we have chosen the global table from the 2016 release of the World Input-Output Database (WIOD).[10] This 2010 World Input-Output Table (WIOT) is consistent with the 2008 System of National Accounts (SNA 2008) and covers 43 countries (includ-

9. See Eurostat (2008) for the mathematical expressions of the derivation of industry-by-industry IOT from SUT under the fixed product sales structure assumption.

10. These tables can be downloaded for free from the website of the WIOD project: http://www.wiod.org/. Timmer et al. (2015) provides an introduction to WIOD data, and Timmer et al. (2016) contains a detailed description of the sources and methodology for constructing the world input-output tables (WIOT).

ing Belgium) and 56 industries in a classification that is compatible with NACE Rev.2.[11] All values are in current dollars.

In a nutshell, the construction of a WIOT starts from publicly available national SUTs, which are complemented with international trade data from COMTRADE and combined into world SUTs. The industry-by-industry WIOT is derived from these world SUTs based on the standard fixed product sales structure assumption. The WIOT respects countries' published national accounts aggregates (output and value added by industry as well as totals of final demand by category), but the inner structure of the tables is not consistent with published SUTs or IOTs of individual countries due to necessary transformations in the course of the construction process (Dietzenbacher et al. 2013). This is problematic for our analysis as we want to keep the structure of our export-heterogeneous Belgian table as it is when integrating it into the WIOT. Edens et al. (2015) have developed a methodology for introducing a national table for the Netherlands into the WIOT without changing these national data: they replace the input data for the Netherlands with more detailed national data, which are actually a firm-level-data-based extension of the most detailed official national SUTs, and they replicate the construction process of the WIOT keeping data for the Netherlands constant. A similar methodology has been applied for Belgium for the years 1995–2007 in Hambÿe, Hertveldt, and Michel (2018). Here, we have opted for a shortcut compared to this thorough method: we directly integrate the Belgian IOT into the 2010 WIOT. This is less cumbersome than the method of Edens et al. (2015). As shown in Hambÿe, Hertveldt, and Michel (2018) for the years 1995–2007, the main difference between official national data and WIOT data for Belgium is in re-exports. This also holds true for the year 2010.

We start off by converting our Belgian IOT into dollars based on the exchange rate used in WIOD (1.3257\$/€). As a second step, we use the Belgian firm-level data on exports and imports by partner country to distribute imports and exports in our national tables over countries of origin and destination. This includes determining the specific country distribution of exports and imports of export-oriented manufacturers. For the distribution of Belgian exports over use categories in the destination countries, we rely on data from WIOD on the use of imports from Belgium in these countries. In a third step, we replace all domestic transactions, imports and exports for Belgium in the WIOT by data based on our heterogeneous national IOT (including imports and exports distributed over countries and country-user pairs obtained in the previous step). Then, we adjust the data for all other countries in the WIOT with a RAS procedure. This yields a 2010 WIOT

11. There are 19 manufacturing industries among those 56 industries, which are identical to the 19 manufacturing industries in the A64 breakdown of the NACE Rev.2 of our national tables (see list in the appendix).

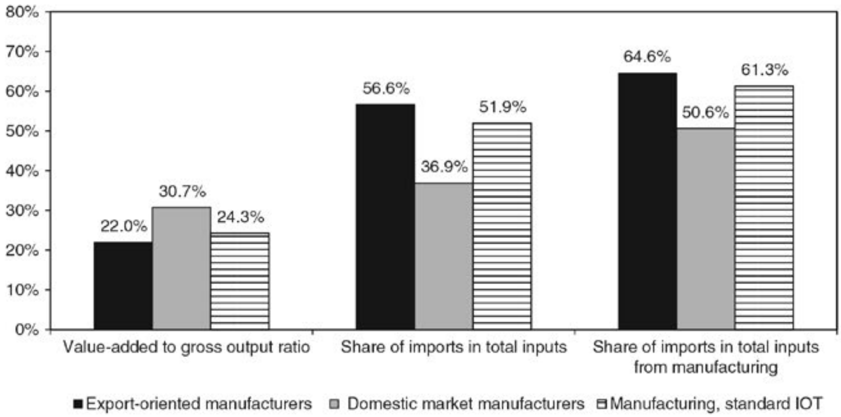

Figure 10.1 Direct production cost structures in manufacturing, heterogenous and standard IOT, 2010, percentages

entirely consistent with national data for Belgium—we also refer to this as the adapted WIOT—with a disaggregation of Belgian manufacturing industries into export-oriented firms and domestic market firms.

10.3 Export Heterogeneity in Input-Output Tables: Analysis

Input-output tables enable the analysis of production structures and value chains. With heterogeneous tables, this analysis can be specifically focused on certain types of firms. In this section, we first compare the direct cost structures of export-oriented and domestic market firms in Belgian manufacturing industries. Then, we proceed to the analysis of their integration into domestic value chains based on the national heterogeneous IOT and standard input-output models taking into account the full indirect cost structures. Finally, we use the GMRIO tables with export heterogeneity for Belgian manufacturing to look at the integration of export-oriented and domestic market firms into global value chains (GVC).

10.3.1 Differences in Direct Production Cost Structures

The IOT with exporter heterogeneity in table 10.8 reveals that export-oriented firms account for almost three-quarters of total output of manufacturing industries but only two-thirds of total manufacturing value added. In other words, export-oriented manufacturers have a lower value added to gross output ratio than manufacturing firms that mainly serve the domestic market (figure 10.1). Moreover, export-oriented manufacturing firms do not only purchase more intermediate inputs compared to their gross output, they also purchase proportionally more of their intermediate inputs from abroad.

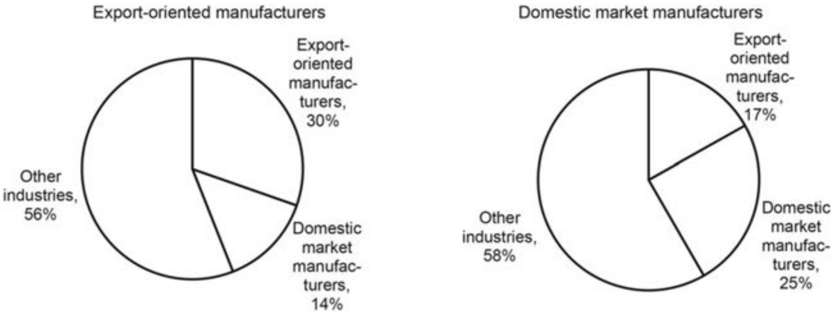

Figure 10.2 Origin of domestically sourced intermediate inputs of export-oriented and domestic market manufacturers, 2010, percentages

Indeed, as illustrated in figure 10.1, imports make for almost 57 percent of total intermediate inputs of export-oriented firms, while this share is just below 37 percent for firms mainly serving the domestic market. Hence, in line with prior findings in the literature on firm heterogeneity and international trade, export-oriented manufacturing firms in Belgium tend to rely more on imported intermediate inputs. Narrowing things down to inputs from manufacturing, this import share becomes 65 percent for export-oriented firms and 51 percent for firms that mainly serve the domestic market (figure 10.1). This corresponds to offshoring of manufactured goods as originally defined in Feenstra and Hanson (1996). Export-oriented manufacturing firms engage more into offshoring, which reflects the greater cross-border fragmentation of their production processes. Figure 10.1 also reports values for these three indicators (value added to gross output ratio, share of imports in total inputs and share of imports in total inputs from manufacturing) for the whole of manufacturing based on the standard IOT for 2010. They turn out to be closer to the values for export-oriented manufacturing firms due to the higher shares of this group of firms in the industry totals.

Based on the heterogeneous IOT and looking at intermediate input structures, figure 10.2 illustrates differences between export-oriented and domestic market manufacturers in terms of their purchases from domestic suppliers. More than half comes from other (service) industries for both groups. But domestic market firms purchase relatively more of their intermediate inputs from other domestic market firms, while export-oriented firms purchase relatively more from other export-oriented firms.

Finally, we also test for similarity of intermediate input structures at a more detailed level by calculating the correlation between technical coefficients of export-oriented and domestic market firms in each manufacturing industry. Technical coefficients are the result of a normalization of an industry's input structure by its output, i.e., they indicate the amount of the dif-

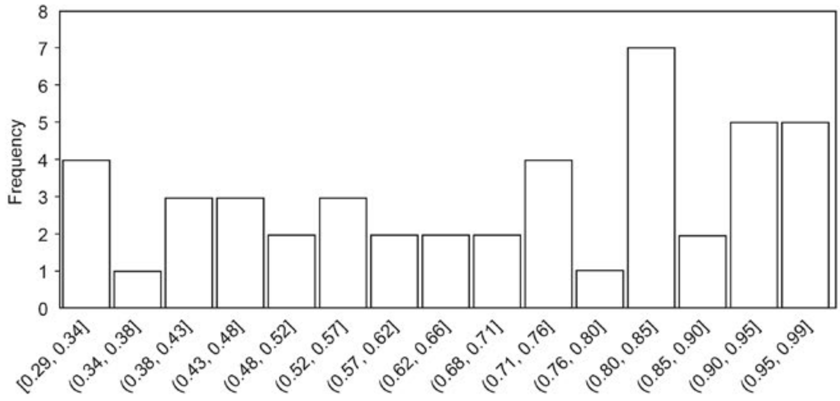

Figure 10.3 Distribution of the industry-level correlation between technical coefficients of export-oriented and domestic market manufacturers

ferent types of intermediate inputs required per unit of output. The average correlation between intermediate input structures of export-oriented and domestic market firms in the same industry is 0.707. This excludes industries for which we had to rely on proportionality when determining the respective product distributions of inputs for export-oriented and domestic market firms. The histogram in figure 10.3 shows the distribution of the correlation coefficients. Among industries for which the input structure is not split proportionally, Printing and Manufacture of motor vehicles have the highest correlation coefficients (0.99) and Manufacture of air and spacecraft and parts thereof and Manufacture of leather and related products the lowest (0.29), i.e., export-oriented and domestic market firms have very similar intermediate input structures in the former and relatively different ones in the latter.

10.3.2 Integration into Domestic Value Chains

Input-output analysis goes one step further by taking into account the (indirect) intermediate input requirements of suppliers. The underlying idea is to determine the effect of a final demand shock (domestic final demand or exports) on economy-wide output or value added. The final demand shock prompts a firm to expand the scale of its production process. The firm purchases more inputs from its suppliers, and, as a consequence, the firm's suppliers also produce more output, for which they purchase additional inputs from their suppliers. In turn, the suppliers' suppliers produce more output and purchase extra inputs, and so on. This gives rise to an upstream effect on output, i.e., through the increase in purchases of intermediate inputs. Standard input-output analysis models the effect of such a demand shock on the entire domestic production chain in terms of output, value added, and employment generated in the chain. Here, we focus on output and value added of export-oriented and domestic market firms.

In the input-output model, the total effect on output is measured by multiplying the shock by the Leontief inverse matrix. This accounts for the magnitude of the shock and all extra output generated in domestic supplying (upstream) industries. In a national IOT framework, the Leontief inverse matrix L^d, which is also called total domestic requirements matrix, is calculated as follows:

$$L^d = (I - A^d)^{-1} \quad (1)$$

where A^d is an industry-by-industry matrix of domestic technical coefficients and I is an identity matrix of the same dimensions as A^d. For any industry, domestic technical coefficients represent the shares of inputs purchased from domestic supplying industries in its total output. The matrix A^d is calculated as $Z^d * \hat{y}^{-1}$ where Z^d is the matrix of domestically produced intermediate inputs and $\hat{y}$ a diagonalized vector of output by industry. Any element l_{ij}^d of the L^d-matrix represents domestic output by industry i generated (directly or indirectly) by a one-euro final demand shock for output of industry j. The sum over all i (producing industries) is called the output multiplier for industry j ($\sum_i l_{dj}^d$). It indicates how many extra euros of domestic output are generated (in all industries) through domestic intermediate input purchases by a one-euro increase in final demand for output of industry j. The output multiplier is an indicator of an industry's backward integration into a country's economy.[12]

Effects can also be calculated in terms of value added. Multiplying l_{ij}^d by industry i's value added in output share v_i yields the amount of value added generated in industry i by this shock to industry j's final demand. The value added multiplier corresponds to the sum over the producing industries ($\sum_i v_i l_{ij}^d$). It indicates how many extra euros of domestic value added are generated (in all industries) through intermediate input purchases by a one-euro increase in final demand for output of industry j.

Based on the 2010 heterogeneous national IOT for Belgium, we calculate output and value added multipliers for export-oriented and domestic market firms in manufacturing industries. Overall results are reported in figure 10.4, including those for total manufacturing based on the standard IOT. The average output multiplier is substantially higher for domestic market firms than for export-oriented firms, i.e., export-oriented manufacturers are less backward integrated into the Belgian economy. This finding reflects the international fragmentation of their production process. They use more intermediate inputs than domestic market manufacturers, but most of these

12. Note that, in this national framework, imported intermediate inputs are not taken into account, as they do not generate domestic output. Thus, industries that use relatively more domestically produced intermediate inputs tend to have higher output multipliers.

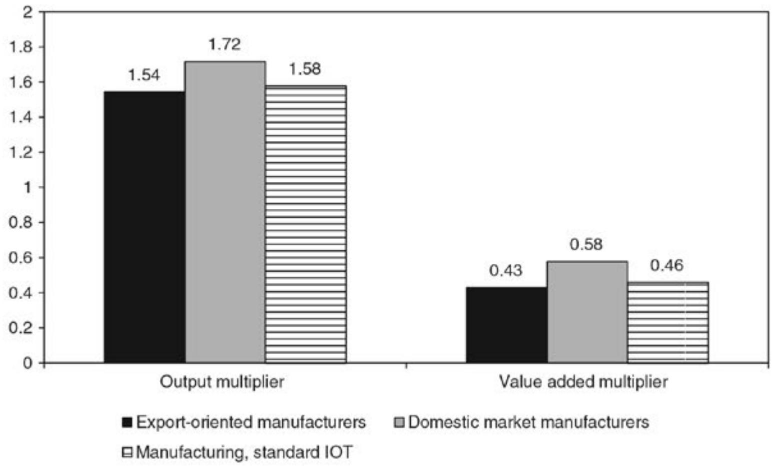

Figure 10.4 Output and value added multipliers in manufacturing, heterogenous and standard IOT, 2010. Millions of euros (per €1 million final demand shock)

inputs are imported, which implies that their (domestic) output multiplier is lower. The value added multiplier for domestic market manufacturers is also higher (0.58 against 0.43 for export-oriented manufacturers). Two underlying differences between export-oriented and domestic market manufacturers drive this result. First, a one-euro final demand shock to the output of export-oriented manufacturers generates less direct value added than an equivalent shock to the output of domestic market manufacturers since the value added in output share is lower for export-oriented manufacturers. Second, it also generates proportionally less output in domestic upstream industries and hence also less value added. The output and value added multipliers for manufacturing overall shown in figure 10.4 are closer to the multipliers for export-oriented firms. This is again due to the higher weight of export-oriented firms in manufacturing industries.

Figures 10.5 and 10.6 report output and value added multipliers by NACE Rev.2 A64 industry for export-oriented and domestic market manufacturers (see list in the appendix). The output multiplier of export-oriented manufacturers is lower for all but five manufacturing industries. Moreover, there is a large spread in the values of output multipliers: between 1.32 and 1.91 for domestic market firms, and between 1.26 and 1.83 for export-oriented firms. The value added multiplier is lower for export-oriented firms than for domestic market firms in all industries except for the pharmaceutical and the other transport equipment industries (codes 21 and 30).

Finally, in input-output analysis, an industry's integration into the domestic economy is considered not only in terms of its purchases of domestically produced intermediate inputs (upstream) but also in terms of its deliveries

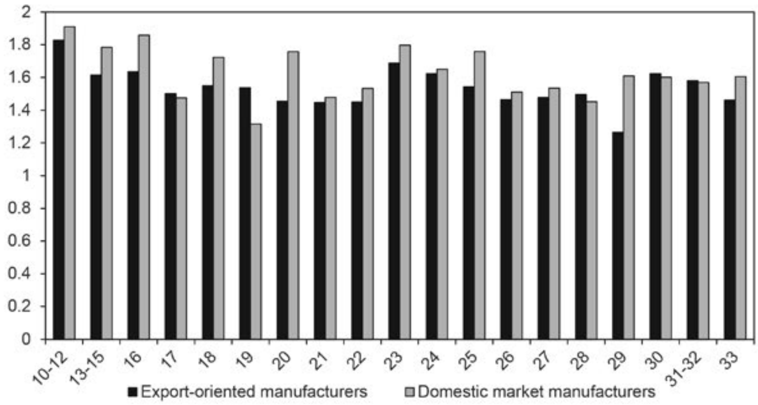

Figure 10.5 Output multipliers of export-oriented and domestic market manufacturers, by industry, 2010. Millions of euros (per €1 million final demand shock)

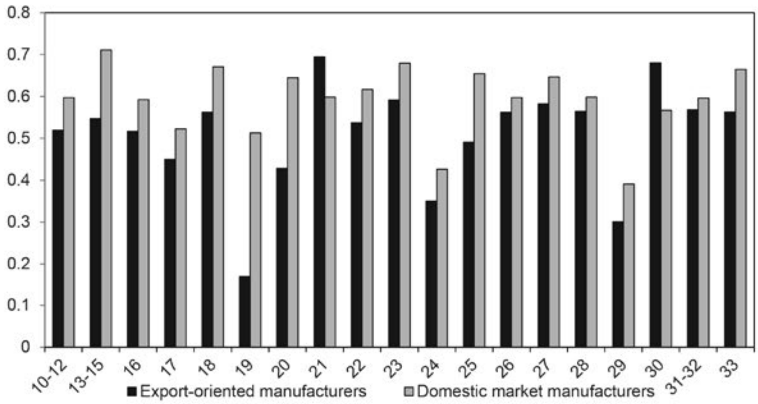

Figure 10.6 Value added multipliers of export-oriented and domestic market manufacturers, by industry, 2010. Millions of euros (per €1 million final demand shock)

of goods and services to other domestic (downstream) industries that use them as intermediates. The former is referred to as backward integration or backward linkages of an industry and, as mentioned above, can be measured by the output multiplier. The latter is referred to as forward integration or forward linkages of an industry. Their calculation is based on the Ghosh inverse matrix:

$$G^d = (I - B^d)^{-1} \tag{2}$$

where $B^d = \hat{y}^{-1} * Z^d$ is a matrix containing the shares of the (domestic) purchasing industries in the output of the producing industry. Total forward linkages of industry i correspond to the sum of its row in the Ghosh inverse

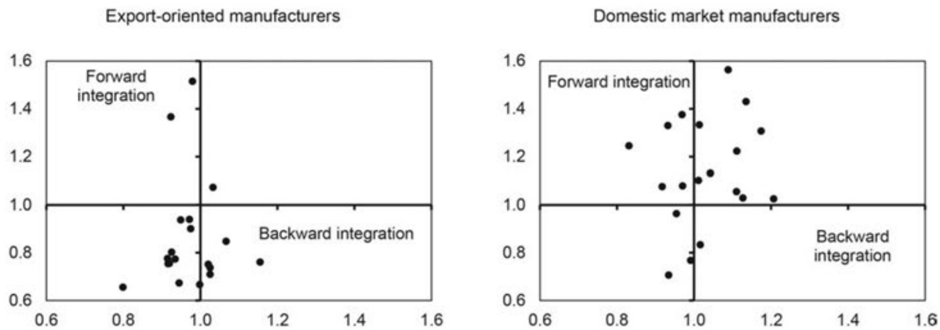

Figure 10.7 Forward and backward integration into the domestic economy, export-oriented and domestic market manufacturers, 2010

matrix ($\sum_j g_{ij}^d$) and measure how a value added shock to industry *i* (directly and indirectly) affects economy-wide output through the sales of industry *i*'s output as intermediate inputs to other domestic industries. Hence, an industry with high total forward linkages "supplies a significant part of its output as intermediate inputs to other industries" (Miller and Temurshoev 2013, 9).

Our calculations of this forward linkage indicator show that it is generally much lower for export-oriented manufacturers than for domestic market manufacturers, i.e., forward integration into the domestic economy is higher for domestic market firms. Export-oriented firms deliver relatively less of their output to other domestic industries. However, exports may be used as intermediate inputs abroad. Hence, export-oriented firms are likely to be integrated forward into global value chains rather than domestic value chains. This cannot be identified based on a national IOT, which does not provide information on how exports are used in destination countries, but requires a GMRIO.

Integration of export-oriented and domestic market manufacturers into Belgian domestic value chains is summarized in the scatterplots of figure 10.7. Backward integration is shown on the horizontal axis and forward integration on the vertical axis. Both are normalized with respect to the average for all manufacturing industries. The scatterplot for manufacturing firms serving mainly the domestic market is skewed more toward the top and right, indicating a stronger integration into domestic value chains.

10.3.3 Foreign and Domestic Value Added in Exports

As production processes have become increasingly fragmented at the international level, a growing share of international trade is trade in intermediate goods and services (Miroudot, Lanz, and Ragoussis 2009). Moreover, greater fragmentation implies that many goods are shipped back and forth in the course of the production process before being delivered to final consumers. Due to multiple border crossings, gross export flows have increased faster than the underlying value added. These trends in international trade and production have prompted researchers to look at the domestic and foreign value added shares in a countries' exports (Hummels, Ishii, and Yi 2001; Koopman, Wang, and Wei 2014). The vertical specialization in trade (VS) share measure defined by Hummels, Ishii, and Yi represents "the value of imported inputs embodied in goods that are exported" (2001, 76–77) as a share of gross exports. It is a widely used indicator of the extent of the international fragmentation of production processes and reveals how much foreign value added is contained in a country's exports. The VS share is calculated as $i'A^m L^d e / i'e$ where A^m is the matrix of imported intermediate input coefficients, e the vector of gross exports and i a summation vector. Its complement is the domestic value added in exports (DVAX) share (Koopman, Wang, and Wei 2014), calculated as $v'L^d e / i'e$ where v is a vector of industry-level value added in output shares.[13] Belgium's VS share of exports computed with the standard 2010 IOT amounts to 43.7 percent. In manufacturing, Belgium's VS share stands at the much higher level of 55.2 percent.

As emphasized in Piacentini and Fortanier, "the use of homogeneous input-output tables . . . assumes that imported inputs are used evenly in production for domestic sales and exports. If domestic production is different from production for exports, i.e., the input-output structure of exporters is different from the one of non-exporters, then the measure based on standard (IOT) is biased. The direction of the bias is clear: as exporters make a more intensive use of intermediate imports than non-exporters, the standard measure under-estimates vertical specialization" (2015, 16). Based on our export heterogeneous IOT the overall VS share for Belgium amounts to 44.1 percent and for manufacturing to 56.0 percent.[14] Hence, the downward bias of computing the VS share with the standard table is rather small. Nonetheless, computing separate VS shares for export-oriented and domestic market firms reveals a large difference, which is indeed driven by the difference in the intensity in the use of imported intermediates. The VS share is 57.2 percent for export-oriented manufacturers and 45.1 percent for domestic market manufacturers.[15]

Three main factors have an influence on the VS share: (a) the share of exports in total output; (b) the value added to output ratio; and (c) the share of imports in total use of intermediate inputs (Piacentini and Fortanier 2015). By definition, export-oriented manufacturers have a higher share of exports in total output. But the other two factors also play a role. Export-oriented manufacturers have lower value added to output ratios, i.e., use

13. The term $i'A^m$ measures the foreign share of output. In the context of calculations with a national IOT, it is taken to measure foreign value added in output. This ignores potential feedback effects that can only be taken into account with a global table (see section 10.3.4).

14. Tables 10.10 and 10.11 give an overview of the VS shares that we have calculated.

15. Appendix figure 10A.1 reports industry-level VS shares for export-oriented and domestic market manufacturers.

Table 10.9 Domestic value added in exports for Belgium, 2010, millions of euros

Value added\exports	Export-oriented manufacturers	Domestic market manufacturers	Other industries	Total
Export-oriented manufacturers	25,992	248	603	26,843
Domestic market manufacturers	2,364	3,900	981	7,245
Other industries	17,069	2,368	56,340	75,776
Total	45,425	6,515	57,923	109,863
Gross exports	106,175	11,862	78,483	196,520

proportionally more intermediates in their production process, and they rely to a larger extent on imports when sourcing these intermediates.[16]

As mentioned above, the complement of the VS share is the domestic value added in exports (DVAX) share. Total domestic value added generated in Belgium in 2010 by exports amounts to €109.9 billion, which corresponds to 55.9 percent of Belgium's total gross exports (€196.5 billion). We use the heterogenous IOT to specifically decompose the domestic (Belgian) value added embodied in exports by industry and firm types. Results are reported in table 10.9 with value added by types of firms in the rows and exports by types of firms in the columns. As an example of how to read this table, take the cell corresponding to the second row in the first column: it contains the value added of domestic market manufacturers generated by exports of export-oriented manufacturers. The table reveals several interesting results. First, the exports of export-oriented manufacturers generate a total domestic value added of €45.4 billion, of which more than half is value added of this group of firms. But their exports also generate a substantial amount of value added in the rest of the Belgian economy: €17.1 billion in other industries, which are mainly service industries, and €2.4 billion for domestic market firms in manufacturing industries. Hence, Belgian service industries do actually participate in GVCs through their deliveries to export-oriented manufacturers. Second, the exports of domestic market manufacturers and firms in the other industries generate only very little value added for export-oriented manufacturers. Again, this is related to the lesser integration of export-oriented manufacturers into the domestic economy. Third, the exports of the other industries, mostly service exports, generate comparatively less value added in manufacturing (for both export-oriented and domestic market firms). Two characteristics of service industries contribute to this finding: they have a higher value added to output ratio, and services make for a larger share of the intermediates they purchase. The comparison of column and row totals of table 10.9 shows, for export-oriented manufacturers, that the value added generated in Belgium by their exports (45.4) is much higher than their value added due to total Belgian exports (26.8).

16. See figures 10A.2 and 10A.3 in the appendix.

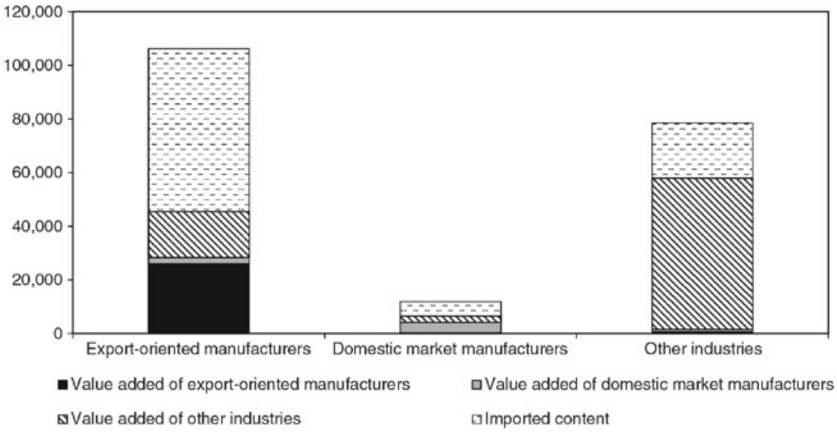

Figure 10.8 Source of content in gross exports by industry and firm type, 2010 (millions of euros)

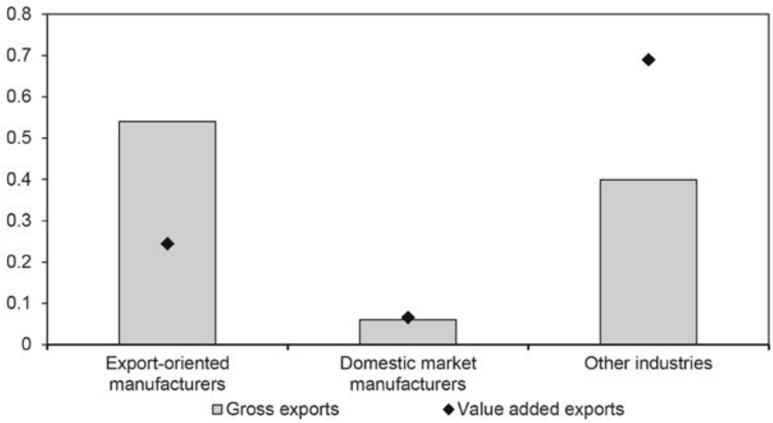

Figure 10.9 Shares in domestic value added in exports and in gross exports by firm type, 2010, percentages

The opposite holds for domestic market manufacturers and firms in other industries. Adding the imported content of exports, figure 10.8 sums up the sources of content in gross exports by types of firms.

Figure 10.9 provides a comparison of shares in gross exports and in domestic value added in exports and reveals striking differences between groups of firms. Export-oriented manufacturers account for more than half of Belgium's total gross exports (54 percent) but only for a quarter of domestic value added generated by exports (24 percent). Most of domestic value added in exports is generated in other industries, i.e., service industries (69 percent), while the share of these industries in gross exports is only 40 percent. For domestic market manufacturers, shares in gross exports and domestic value added in exports are similar and low.[17]

10.3.4 Integration into Global Value Chains

Incorporating the Belgian export-heterogeneous IOT into the 2010 WIOT allows us to look at how Belgian export-oriented and domestic market manufacturers are integrated into and positioned within global value chains. Such an analysis relies on a multiregional input-output model. In essence, the multiregional model works the same way as the national model, but the scope of the effects is extended: the multiregional model takes into account not only purchases and sales of domestically produced intermediates but also purchases of intermediate inputs from abroad as well as deliveries to foreign intermediate and final demand. In the standard Leontief model, all upstream effects are captured by the elements of the multiregional Leontief inverse matrix L_{MRIO}, which is calculated based on the multiregional matrix of technical coefficients A_{MRIO}:

(3) $$L_{MRIO} = (I - A_{MRIO})^{-1}$$

Any element in this matrix represents the output of a country-industry pair that is generated by a one-dollar[18] final demand shock to output of another country-industry pair. In this multiregional setup, a final demand shock to the output of an industry in a country gives rise to domestic effects and effects in other countries through imports of intermediates (spillover effects). Moreover, it may lead to feedback effects for the country when the industry purchases intermediate inputs from foreign suppliers and these foreign suppliers, in turn, purchase intermediate inputs from the country where the shock has occurred.

10.3.4.1 Vertical Specialization

In a multiregional setting, the VS share is a measure of backward integration into GVCs. Its computation is based on the *VBE* industry-country by industry-country matrix of value added embodied in exports.

(4) $$VBE = \hat{v}_{MRIO} * L_{MRIO} * \hat{e}_{MRIO}$$

Here, $\hat{v}_{MRIO}$ is a diagonalized vector of value added in output shares and $\hat{e}_{MRIO}$ a diagonalized vector of gross exports for all country-industry pairs con-

17. Figure 10A.4 in the appendix also shows where the upstream effects of a shock to exports of export-oriented or domestic market manufacturers actually occur (in terms of output and value added). In line with the results reported above, the biggest part of the upstream effects occurs in Other industries, which mainly comprise service industries. Note that the composition of exports is different for the two groups of firms.

18. While national tables for Belgium are labelled in euros, the WIOT is labelled in dollars. We decided to keep the original currency of the latter table.

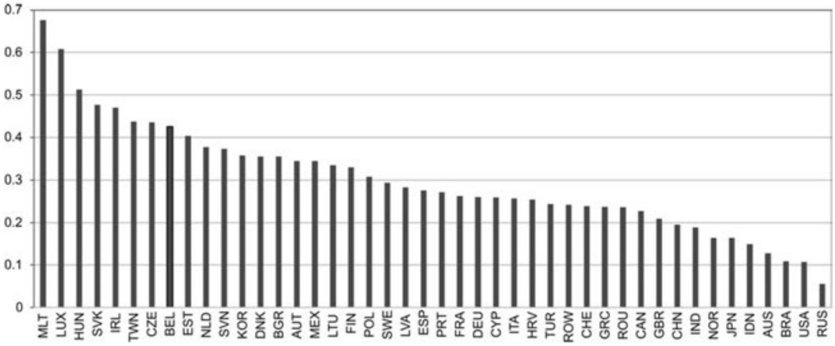

Figure 10.10 Vertical specialization shares (imported content of exports as a share of gross exports), 2010

tained in the GMRIO table. The *VBE* matrix can be divided into a domestic part VBE^d (on the block diagonal) and a foreign part VBE^{nd} (off the block diagonal). The column sum of the domestic part yields domestic value added in exports by country-industry pair ($i' * VBE^d$) and the column sum of the foreign part yields foreign value added in exports by country-industry pair ($i' * VBE^{nd}$). By summing over industries for each country and dividing by country-level gross exports, we obtain country-level DVAX and VS shares.

A comparison of VS shares for all 43 countries in the adapted WIOT reveals that Belgium is among the countries with the highest shares, i.e., it is highly backward integrated into GVCs. This is illustrated in figure 10.10. As reported earlier, Belgium's VS share stands at 43.7 percent based on the standard (homogeneous) national IOT and at 44.1 percent based on the heterogeneous national IOT. When recalculating VS shares with the adapted 2010 WIOT, i.e., into which we have integrated our national IOT for Belgium, we obtain a VS share of 43.2 percent without export heterogeneity and of 43.7 percent with export heterogeneity.[19] Table 10.10 summarizes VS share results from different types of tables. In our setting where data for Belgium in the GMRIO tables are entirely consistent with the national IOT, VS shares based on multiregional tables are by definition lower than VS shares based on national tables. This is due to the feedback effects in the multiregional model, which increase the domestic value added in exports and hence reduce the VS share.[20] In practice, the difference between VS shares based on multiregional tables and VS shares based on national tables

19. Belgium's VS share calculated with the original 2010 WIOT amounts to 42.7 percent. Note also that Los (2017) reports a VS share of 46 percent for Belgium based on the 2011 WIOT.

20. The consistency of Belgian data in the adapted WIOT with data from the national IOT for Belgium implies that industry-level value added coefficients and gross exports for Belgium are identical in both tables. Hence, differences in national IOT-based and WIOT-based DVAX shares (and also VS shares) originate from differences between L^d and the Belgian domestic part of L_{MRIO}. As the national setting cannot account for feedback effects, the elements of L^d are always smaller than the elements of the Belgian domestic part of L_{MRIO} (see Round 2001, and

Table 10.10 **Differences in vertical specialization shares for Belgium between national tables and WIOT, 2010, percentages**

	Total economy		Manufacturing industries	
	National IOT	WIOT	National IOT	WIOT
Heterogeneous tables	44.1	43.7	56.0	55.5
Homogeneous tables	43.7	43.2	55.2	54.7

Table 10.11 **Differences in vertical specialization shares for Belgium between national tables and WIOT by firm type, 2010, percentages**

	National IOT	WIOT
Export-oriented firms	57.2	56.7
Domestic market firms	45.1	44.6

is small because feedback effects are small. Table 10.10 also highlights again that the downward bias due to the use of standard rather than heterogeneous tables is rather small. But export-oriented and domestic market manufacturers have very different VS shares as illustrated in table 10.11.

10.3.4.2 Global Value Chain Participation

The VS share indicates how a country's firms participate backward in GVCs, i.e., through purchases of intermediates from abroad for producing exports. But they may also participate in GVCs by exporting intermediate inputs that are then used (directly and indirectly) in the production of third country exports. This alternative way of participating in GVCs was already identified in Hummels, Ishii, and Yi (2001). These authors suggested measuring such forward integration into GVCs by the VS1 share. In their definition, it is calculated as the value of a country's exports embodied in foreign countries' exports divided by the country's gross exports.[21] In our setup, a country-industry pair's exports embodied in third country exports corresponds to the row sum of the foreign part (off the block diagonal) of the *VBE* matrix ($VBE^{nd} * i$). A country's VS1 share is then obtained by summing over all industries for that country and dividing by the country's gross exports.[22]

Both VS and VS1 shares for a country depend on its average position

Koopman et al., 2010). Therefore, Belgium's national IOT-based DVAX share is smaller than its WIOT-based DVAX share, and the opposite holds for Belgium's VS share (see table 10.10).

21. Computing this VS1 share requires information about the use of exports in the destination country, which is only available in GMRIO tables. Hence, it cannot be done with national IOT. This is why Hummels, Ishii, and Yi (2001) were not able to compute the VS1 share they had defined.

22. There is a slight methodological difference between the forward linkages that we have calculated with the national IOT and the forward integration into GVCs that we calculate with

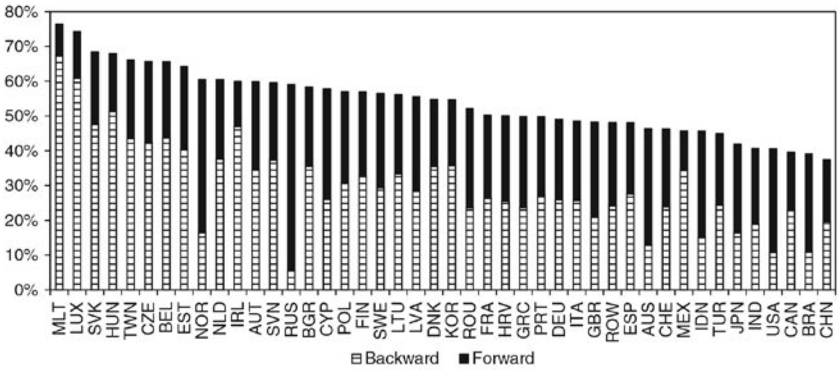

Figure 10.11 Global value chain participation index, 2010, shares in gross exports

in GVCs: countries with a greater share of downstream activities tend to have higher VS shares and lower VS1 shares, and vice-versa for countries with more upstream activities. For a more comprehensive assessment of countries' participation in GVCs, Koopman et al. (2010) define the *GVC participation index* that sums the VS and VS1 measures and is normalized by total country-level exports.[23]

Figure 10.11 shows a comparison of the GVC participation index for all countries in the 2010 WIOT with a split into the contributions of backward and forward integration. Again, Belgium is among the countries with the highest values for this index, i.e., Belgium is highly integrated into global value chains, both backward and forward. This result is in line with the results reported by De Backer and Miroudot (2014) based on data from the OECD's 2009 intercountry input-output (ICIO) table. Forward participation is especially high for countries producing raw materials such as Australia, Norway, and Russia. As a consequence, these countries are higher ranked in terms of GVC participation than in terms of the VS share. Overall, country size does seem to matter for these indicators, with smaller countries having a higher GVC participation index on average.

The integration of the export-heterogeneous IOT for Belgium into the 2010 WIOT allows us to determine contributions of export-oriented manufacturers, domestic market manufacturers, and other industries to Belgium's participation in global value chains as shown in figure 10.12. The third

the adapted WIOT: the former is based on a Ghosh inverse matrix, while the latter is based on a (multiregional) Leontief inverse matrix.

23. De Backer and Miroudot highlight an issue of double counting for the GVC participation index: "[a]s domestically produced inputs can incorporate some of the foreign inputs, there is an overlap and potentially some double counting. . . . Likewise, some foreign inputs can incorporate domestic value added exported in an earlier stage of the value chain" (2014, 10).

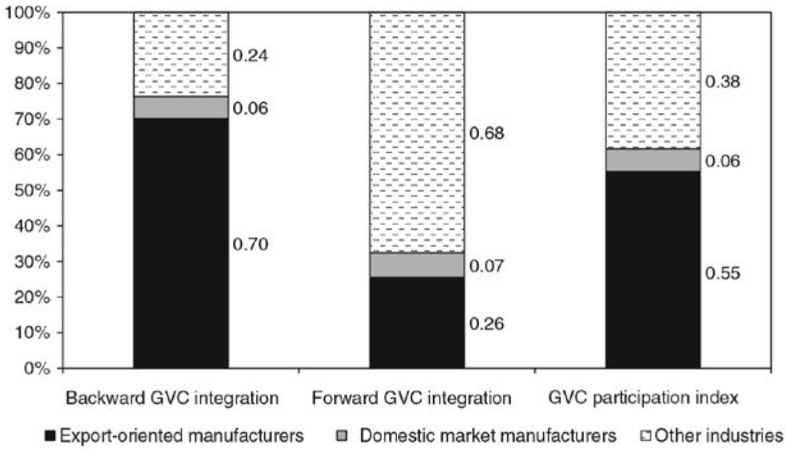

Figure 10.12 Contributions to Belgium's global value chain participation, 2010, shares in total

stacked bar in the figure indicates that Belgium's participation in GVCs is due for 55 percent to export-oriented manufacturing firms, for 38 percent to the firms in other industries and for the remaining 6 percent to domestic market manufacturing firms. The first and second stacked bars illustrate the difference in how export-oriented manufacturers and firms in other industries participate in GVCs. There is a clear distribution of the roles: export-oriented manufacturers essentially participate in GVCs through their purchases of imported intermediate inputs for producing exports (backward integration), while firms in other industries participate in GVCs mainly through exports of intermediates for export production abroad (forward integration).

10.3.4.3 Position in Global Value Chains

The set of GVC indicators is completed by two measures of the position of an industry or country in global value chains: the *number of embodied production stages* and the *distance to final demand*. For any industry in a country, the former indicates the average number of production stages up to the point where the industry's production activity takes place, while the latter indicates the average number of production stages until its output becomes embodied in a good or service delivered to final demand. These indicators of position are complementary with respect to vertical specialization and GVC participation, which measure how value chains are fragmented in terms of value added contributions. Our main aim is to compare Belgian export-oriented and domestic market manufacturers in terms of value chain position based on these two indicators. Accounting for export heterogeneity in manufacturing does not significantly alter overall results for Belgium for these position indicators.[24]

The number of embodied production stages indicator was initially proposed in Fally (2012). Its original definition is recursive based on a weighted count of the number of embodied intermediates, i.e., it is a measure of the length of the input chain of an industry's production.[25] It can be shown that the calculation boils down to computing the industry's total backward linkages (Miller and Temurshoev 2013).[26] Thus, with a GMRIO table, it is computed as $(i' * L_{MRIO})$. If the production of an industry does not require intermediate inputs, then the indicator is equal to one. Its value then increases with the number of intermediate inputs used in an industry's production process and their importance in that process (share of intermediates in output). The use of GMRIO tables for calculating the measure allows us to distinguish between the domestic and foreign embodied production stages. In terms of interpretation, De Backer and Miroudot (2014) emphasize that with plant-level information the indicator would represent the actual number of production stages. Given the relatively high level of aggregation of industries in GMRIO tables, and in the WIOT in particular, the indicator calculated with such tables should rather be interpreted as an ordinal measure for comparing countries or industries.

Averaging over industries with output weights, we find a slightly higher number of embodied production stages for export-oriented manufacturers (2.89) than for domestic market manufacturers (2.72) as shown in table 10.12. This also holds for most individual manufacturing industries (figure 10.13) and is consistent with our earlier finding that export-oriented manufacturers purchase more intermediates per unit of output, i.e., outsource more. Moreover, export-oriented manufacturers have, on average, more foreign embodied production stages than domestic market manufacturers (1.33 against 0.99) and less domestic embodied production stages (1.56 against 1.73) as could be expected based on their respective import shares. Figure 10.13 shows that this is also the case for almost all individual manufacturing industries. Finally, the number of embodied production stages of the other industries (mostly services) is lower (2.07), and most of their embodied pro-

24. Computing the number of embodied production stages and the distance to final demand for Belgium with the homogeneous or heterogeneous adapted WIOT makes for a difference of 0.1 percent or less. Values for these position indicators based on the original WIOT differ by approximately 2 percent from values based on the adapted WIOT.

25. The measure is sometimes also referred to as "value chain length" (De Backer and Miroudot 2014), but it should be kept in mind that it is a purely backward-looking indicator, i.e., of the length of the input chain up to the industry's production, and not of the entire value chain up to final demand. Miller and Temurshoev (2013) have independently developed the equivalent measure of "input downstreamness." In an earlier contribution, Dietzenbacher and Romero (2007) proposed the more complex "average propagation length" measure.

26. This is true because "the distance between any two stages of production is assumed to be one" (Miller and Temurshoev 2013, 10).

Table 10.12 **Embodied production stages and distance to final demand for Belgium by industry and firm type, 2010**

	Embodied production stages			Distance to final demand		
	Total	Domestic	Foreign	Total	Domestic	Foreign
Export-oriented manufacturers	2.89	1.56	1.33	2.66	1.33	1.33
Domestic market manufacturers	2.72	1.73	0.99	2.50	1.85	0.65
Other firms	2.07	1.60	0.47	2.12	1.65	0.47
Belgium	2.28	1.60	0.68	2.25	1.60	0.65

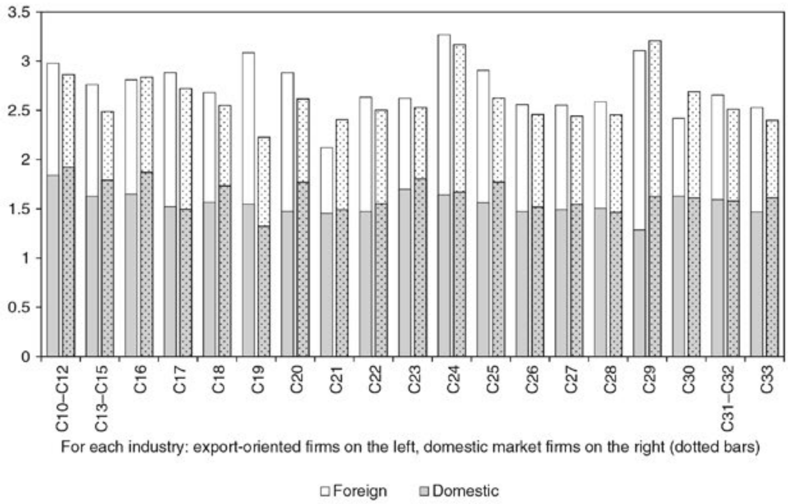

Figure 10.13 Number of embodied production stages of export-oriented and domestic market manufacturers, by industry, 2010

duction stages are domestic (1.60 against 0.47 for the foreign ones). In terms of country ranking, figure 10.14 shows that, in international comparison, Belgium has an above average number of embodied production stages.

The distance to final demand indicator was originally suggested by Fally (2012) and Antràs et al. (2012).[27] It is the forward-looking complement of the number of embodied production stages indicator. Its calculation is a weighted count of the number of production stages until an industry's output (initially often sold for intermediate consumption) becomes embodied in a good or service delivered to final demand. It turns out that it is equivalent to an industry's total forward linkages (Miller and Temurshoev 2013).

27. Note that it has also been referred to as an indicator of "upstreamness" by these authors and as "output upstreamness" by Miller and Temurshoev (2013).

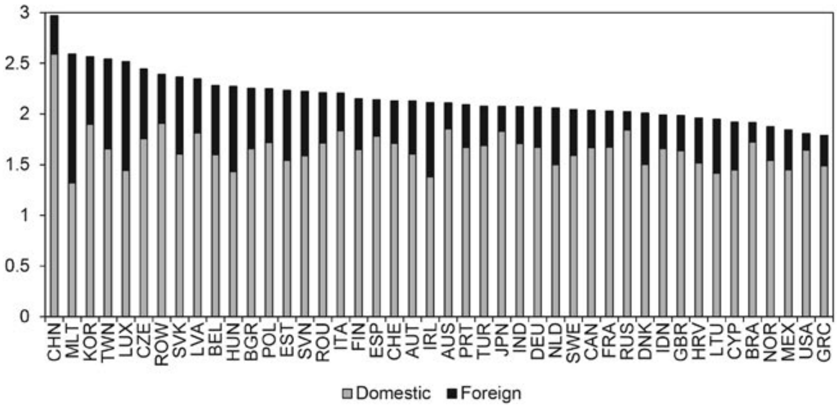

Figure 10.14 Average number of embodied production stages, 2010

In a GMRIO setup, it is thus calculated for any industry by taking the row sum of the multiregional Ghosh inverse matrix ($G_{MRIO} * i$ where $G_{MRIO} = (I - B_{MRIO})^{-1}$). The indicator takes a value of 1 if all of an industry's output is delivered to final demand, and it increases with the share of the industry's output that is delivered to other industries (i.e., intermediate demand) and with the number of production stages (i.e., industries) involved until the output becomes embodied in a good or service delivered to final demand. Industries with a higher distance value are also said to be more upstream and industries with a lower value are said to be more downstream.[28] Again, values should be interpreted as ordinal, i.e., for comparing countries or industries. Moreover, the use of GMRIO tables allows for a distinction between a domestic distance to final demand and a foreign distance to final demand.

According to our results with industry distance values aggregated with output weights, manufacturing industries in Belgium are on average more upstream with a distance value of 2.62 against 2.12 for the other—mainly service—industries. This is consistent with the idea that, for example, basic metal products are transformed in a greater number of production stages before reaching final customers than personal services. Within manufacturing, export-oriented firms have a slightly higher distance to final demand than domestic market firms (2.66 against 2.50, see table 10.12). For the former, the domestic and foreign distance are identical (1.33), while for the

28. As a caveat, Los (2017) points out that "the upstreamness of an industry (defined at a relatively aggregated level as in most global IO databases) can vary substantially across countries, due to the fact that an industry in a country can be specialized in the production of components, while the same industry in a different country can be specialized in assembly activities (which are downstream). . . . The apparently rather different activities carried out in these industries show that international fragmentation of production processes makes comparisons of industries with identical labels or codes increasingly difficult" (307).

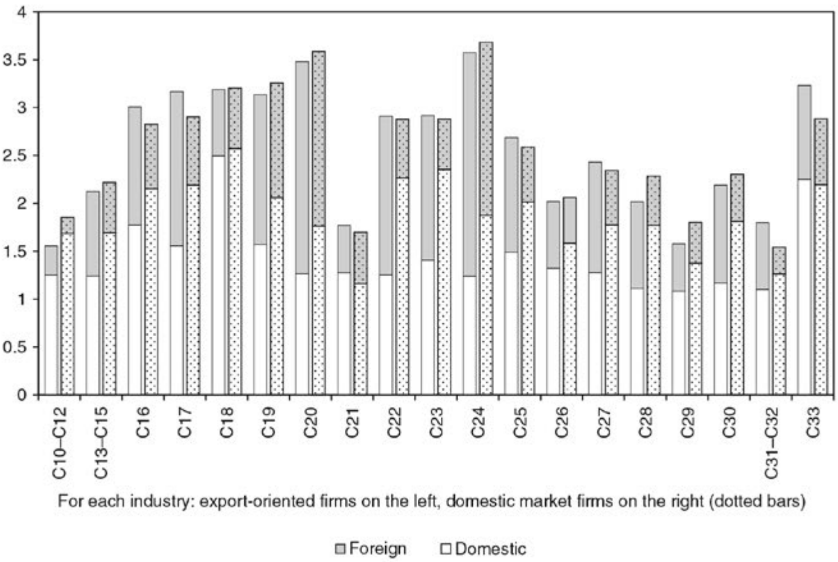

Figure 10.15 Distance to final demand of export-oriented and domestic market manufacturers, by industry, 2010

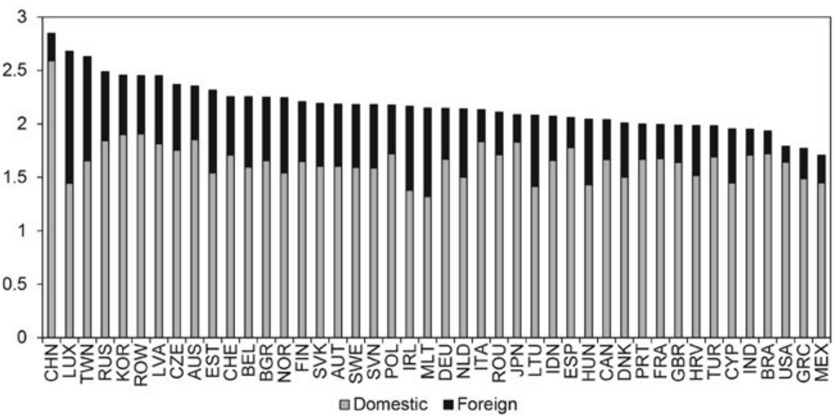

Figure 10.16 Average distance to final demand, 2010

latter domestic distance dominates (1.85 against 0.65). Figure 10.15 shows a large spread in distance to final demand across manufacturing industries in Belgium but only small differences between export-oriented and domestic market firms. Finally, in terms of the country ranking for distance to final demand, Belgium is slightly more specialized in upstream activities than the world average (distance value of 2.25 against 2.20, see figure 10.16).

10.4. Conclusions

The disaggregation of industries in SUTs and IOTs according to exporter status is considered as highly desirable, since it may actually reveal technological differences between firms within an industry defined in terms of product similarity (OECD 2015; Los 2017). In this chapter, we describe the statistical methodology for obtaining export-heterogeneous SUTs and IOT for Belgium for 2010 and their integration into a GMRIO table, and we present results from analyses based on these tables.

From a statistical point of view, our data-based split of manufacturing industries into export-oriented and domestic market firms represents a clear improvement with respect to the proportionality assumptions that most prior contributions in this field have relied on. This is true in particular for the product structures of output and intermediate inputs of these two types of firms. Our work also illustrates a statistical limitation in this respect: for a small country like Belgium, sample sizes may prove insufficient at the most detailed industry level for such a data-based split of output and input structures. In our case, we faced a trade-off between including minor exporters in the category of export-oriented firms and avoiding proportionality in the estimation of product distributions for heterogeneous industries. Although this may be less of an issue for larger countries, it represents a serious constraint for combined disaggregations of SUTs and IOTs, e.g., for firm size and ownership.

The analyses based on the resulting national export-heterogeneous IOT reveal differences between export-oriented and domestic market firms in manufacturing industries in terms of input structures and import patterns. Export-oriented manufacturers have lower value added in output shares, and they import proportionally more of the intermediates they use, i.e., their production processes are more fragmented, in particular internationally. These results, obtained in a setting that is consistent with the national accounts, confirm findings in prior analyses on firm heterogeneity in international trade (Melitz 2003; Bas 2009). Furthermore, our input-output analyses show that export-oriented manufacturing firms are less integrated upstream and downstream into the Belgian economy than domestic market firms, and that the exports of export-oriented manufacturers generate a substantial amount of value added in other Belgian firms, in particular providers of services.

With the heterogeneous Belgian table incorporated into the WIOT, we obtain further insights on the roles of the different types of firms in Belgium's integration into global value chains. Export-oriented manufacturers are the drivers of Belgium's backward GVC participation, i.e., through imports of intermediates for export-production, while the other firms push Belgium's forward GVC participation, i.e., by producing intermediates for other countries' exports. Moreover, export-oriented manufacturers participate in value chains that comprise, on average, a greater number of upstream and downstream production stages and of which a greater share is located abroad.

The value chain analysis based on the heterogeneous IOT highlights that the external competitiveness of Belgian manufacturing depends not only on export-oriented manufacturing firms but also on manufacturing firms that mainly serve the domestic market and supplier firms in service industries. Export-oriented manufacturers need to be competitive on foreign markets and domestic suppliers have to be competitive in the production of the inputs delivered to those export-oriented firms (internal competitiveness). Hence, it is not sufficient to focus only on export-oriented firms. They are the spearhead of participation in GVCs, but domestic upstream suppliers must also be taken into account. Overall, for Belgium to reap the full benefits from exports, the entire value chains must be considered.

Appendix

Table 10A.1 **Manufacturing industries in the A64 breakdown of the NACE Rev.2 classification**

10–12	Manufacture of food products, beverages and tobacco products
13–15	Manufacture of textiles, wearing apparel and leather products
16	Manufacture of wood and of products of wood and cork, except furniture
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Chemical industry
21	Manufacture of pharmaceutical products
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31–32	Manufacture of furniture; Other manufacturing
33	Repair and installation of machinery and equipment

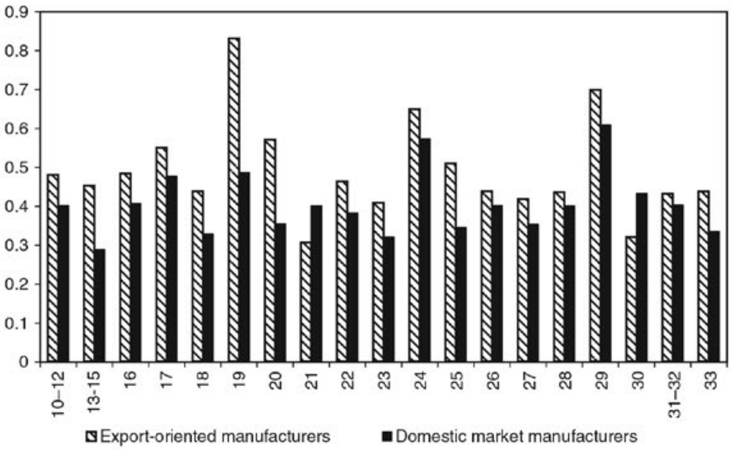

Figure 10A.1 Imported content of exports as a share of gross exports (VS share), export-oriented and domestic market manufacturers, by industry, 2010

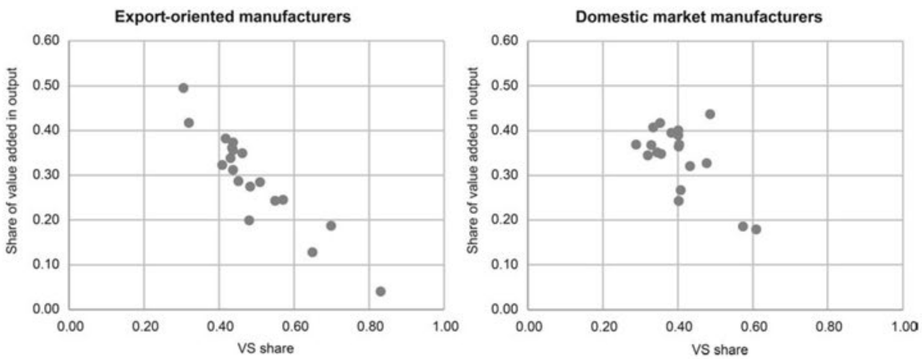

Figure 10A.2 VS share and value added to output ratio, export-oriented and domestic market manufacturers, 2010

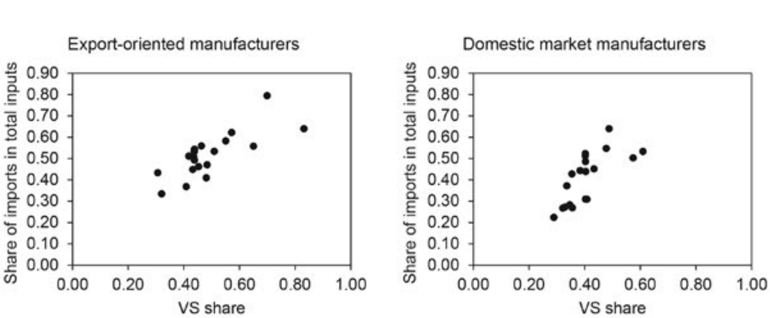

Figure 10A.3 VS share and share of imports in total inputs, export-oriented and domestic market manufacturers, 2010

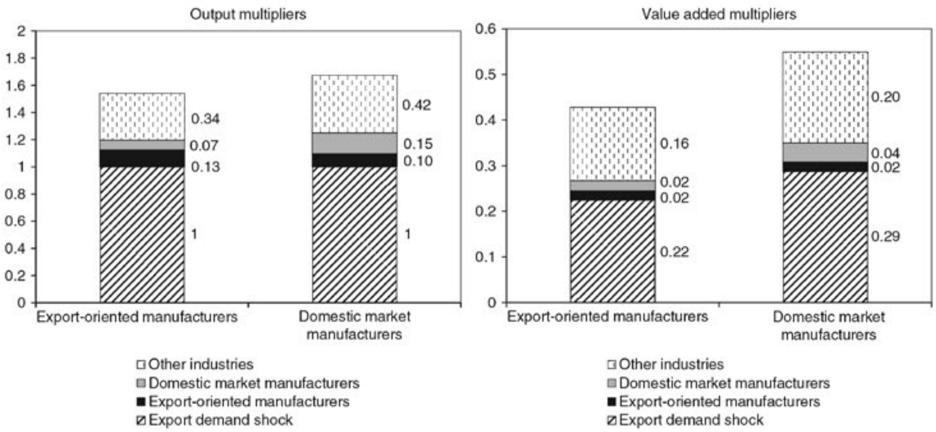

Figure 10A.4 Output and value added multipliers of a €1 million export shock, 2010 (millions of euros)

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