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

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Abstract

In this paper, we introduce firm heterogeneity into Belgian supply-and-use and input-output tables by disaggregating manufacturing industries into exporters and non-exporters. As a further step, the resulting Belgian export heterogeneous input-output table is integrated into the global input-output table of the World Input-Output Database (WIOD). Based on these tables, we test for differences in input structures and import behaviour of exporters and non-exporters and analyse their integration into domestic and global value chains. According to our results, exporters and non-exporters in Belgian manufacturing industries are indeed different in terms of input structures and import behavior: the production processes of exporters are more fragmented, in particular internationally. This result confirms prior findings in the literature on firm heterogeneity in international trade. Regarding the roles of exporters and domestic firms in global value chains (GVCs), we find that Belgian manufacturing exporters participate in GVCs mainly through their purchases of imported intermediate inputs for producing exports (backward integration), while domestic producers participate in GVCs mostly through deliveries of intermediate inputs for export production (forward integration).

1. Introduction

Even in times of a slowdown in the pace of global trade growth, participation and optimal positioning in global value chains (GVCs) may yield substantial benefits for countries in terms of welfare gains and job creation. This holds true in particular for small open economies like Belgium. Therefore, in order to make informed economic policy choices, it is crucial to get a clear picture on how a country's firms participate and are positioned in GVCs. In this paper, we have strived to refine this picture for Belgium by producing data on GVC participation and trade in value-added separately for two groups of manufacturing firms: those that are export-oriented and those that mainly serve the domestic market.

Much of the analysis of globalisation over the past two decades has been shaped by two strands of the literature on international trade. On the one hand, there have been numerous contributions on the emergence of global value chains, which encompass all activities in different geographical locations that are required to bring a product to the market. Initially the analysis of global value chains was mainly based on case studies (e.g. Gereffy, 1994; Dedrick et al., 2008), but the development of global input-output databases has allowed to take a more macro-economic perspective on global value chains and determine how countries are positioned in these chains (Inomata, 2017; Los, 2017). On the other hand, analyses of the characteristics of exporters based on firm-level data have shown that exporters are different from domestic firms in terms of production technology. Exporters are not only more productive (Melitz, 2003), but they also import more of the intermediates they use (Bas, 2009).

The aim of our work is to bring together these two strands of the literature by constructing supply-and-use and input-output tables for Belgium in which a distinction is made between firms according to their exporter status. As globalisation 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 supply-and-use and input-output tables – can accommodate recent findings from the academic literature on international trade.

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 defined in terms of the traditional product similarity. The same point is made by Los (2017) arguing that “such differences can only be captured in value chain trade indicators if each industry is split in two subindustries (p.317)”. Given the openness of the Belgian economy, a disaggregation based on the exporter status of firms was a natural choice. We focus on the disaggregation of manufacturing industries and use the full set of individual firm-level data sources that serve for the construction of Belgium’s official supply-and-use and input-output tables. The resulting export heterogeneous tables allow to test for differences in input structures and import behaviour of exporters and non-exporters and to analyse their integration into domestic value chains. As observations on integration into global value chains are derived from global multiregional input-output tables, we integrate the export heterogeneous Belgian input-output tables into the global tables of the World Input-Output Database (WIOD). Based on this global table, we look at the roles of Belgian exporters and domestic firms in global value chains.

There are a few prior contributions on firm heterogeneity in supply-and-use and input-output tables. For China, have been disaggregated to isolate processing traders and foreign-owned firms (Ma et al., 2015). The disaggregation with respect to processing trade has also been integrated into the OECD’s global input-output tables. The same holds for Mexico. Most other initiatives have been gathered in the context of the OECD’s Expert Group on Extended Supply-and-Use Tables: they come, amongst others, from Austria (disaggregation by exporter status and ownership, see Lais and Kolleritsch, 2017), Costa Rica (separation of firms in free trade zones, see Saborio, 2015) and the Netherlands (disaggregation by size class, see Chong et al. 2017). The novelty of our approach is twofold: the estimation of the industry-level output, input and import structures in the exporter heterogeneous SUT and IOT are data-based rather than just proportional, and the integration of the Belgian tables into the global table is such that these Belgian data are not modified.

This article is organised as follows. We start off by providing details on constructing export heterogeneous supply-and-use and input-output tables for Belgium in section 2. This includes explanations on how we have disaggregated manufacturing industries in Belgian supply-and-use tables, derived national heterogeneous input-output tables and integrated them into the global input-output table of the WIOD project. In section 3, we analyse differences in input structures between manufacturing exporters and non-exporters and take a look at their integration into domestic value chains. The role of these firms in global value chains is investigated based on the global table in section 4. Finally, we draw conclusions in section 5.

2. Export heterogeneity in supply-and-use and input-output tables

Supply-and-use tables (SUT) 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 SUT are mainly a statistical tool, symmetric input-output tables (IOT) are an analytical tool derived from SUT based on assumptions about the relation between output and inputs.[1]

SUT are product-by-industry tables with domestic production and imports given in the supply table, and intermediate consumption (intermediate inputs), value-added and final uses (final consumption of households and government, gross fixed capital formation, changes in inventories and exports of goods and services) reported in the use table. Thus, the use table reveals the structure of production costs by

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

industry. Moreover, intermediate inputs and final use are split according to where they are purchased from: domestic or foreign producers.

The classification of industries in SUT is such that industries are made up of production units or firms that produce similar goods or services, e.g. 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 within the same industry may differ, for example, in terms of size and ownership, and they may be exporters or serve only the domestic market. Their production cost structure may then differ accordingly. This warrants looking at alternative disaggregations of industries within SUT and IOT.

The focus here is on heterogeneity in terms of export behaviour: 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 non-exporters in terms of technology. In particular, exporters are found to have higher productivity levels (and mark-ups) 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 SUT and IOT for the year 2010 by disaggregating manufacturing industries according to exporter status in the official tables at the most detailed industry-level breakdown. The official Belgian SUT for 2010 – the most recent input-output reference year – have been constructed according to the rules of European System of Accounts (ESA 2008).[2] The most detailed unpublished version (workformat) of the SUT 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 the CPA2008.[3] Manufacturing cover NACE Rev.2 2-digit industries 10 to 33, which amounts to 58 industries in the workformat of the Belgian SUT. For the purpose of disaggregating these industries, we rely on most of the firm-level data that have been used in the construction of the SUT. Note that we make sure that our disaggregation is consistent with the official Belgian SUT, i.e. values for output, intermediate inputs and value added of exporter and non-exporter manufacturing industries sum to the values for the total non-heterogeneous industry in the official table.

The stylized supply table and use table shown in the two panels of table 1 (a and b) illustrate the SUT with a disaggregation of manufacturing industries according to exporter status. The third panel of table 1 adds a split of the use table according to the origin of the used goods and services, i.e. whether they are purchased from exporters or non-exporters or imported.

[Introduce tables 1a, 1b and 1c here]

In practice, we proceed in several steps to obtain export heterogeneous Belgian SUT for 2010. First, we identify exporters and disaggregate total output and intermediate inputs for the 58 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 tables row-wise to identify the use of imported intermediate inputs and purchases of intermediate

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2 The 2010 Belgian SUT 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) at the following address: 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).

3 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.

inputs from manufacturing exporters and non-exporters. Finally, we derive symmetric heterogeneous industry-by-industry IOT, which we then integrate into a global multi-regional input-output table (GMRIO).

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 58 manufacturing industries in the SUT based on the exporters' share of turnover and purchases. The results correspond to the diagonally shaded cells in the bottom row of table 1a and the 4th row from the bottom in table 1b. Disaggregated value-added including net taxes on products is obtained as the difference between total output and intermediate inputs of the heterogeneous manufacturing industries (diagonally shaded cells in the 2nd and 3rd rows from the bottom in table 1b).

The general business register underlying the 2010 national accounts (NA) and SUT contains 46876 manufacturing firms.[4] Data on turnover and total purchases is available for 40194 of these firms based on the following sources: balance sheet data, periodical value added tax (VAT) declarations and structural business survey data.[5] These are the main data sources used to estimate industry-level NA aggregates for total output and intermediate inputs by industry. This is done through extrapolation of the data on turnover and purchases and the application of a number of corrections so as to respect ESA-concepts. The 40194 manufacturing firms with turnover and total purchases data constitute our *full sample*. Their total turnover sums to 229.7 billion euros. Merging in merchandise export data, we calculate export to turnover ratios for these firms and consider those with a ratio above 25% as export-oriented.[6] This yields a sample split for manufacturing firms into 2428 export-oriented firms, which we will also call exporters,

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

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

6 We provide further explanations on this choice below.

and 37766 firms that mainly serve the domestic market, which we also refer to as non-exporters. The exporters' share of turnover amounts to about 54% (124.8 billion euros). Hence, exporters are bigger firms: their average turnover is 51.4 million euros compared to 5.7 million euros for the entire sample. Due to the 25% cut-off ratio for defining export-oriented firms, not all exports are made by this category of firms. Merchandise exports of export-oriented firms amount to 88,3 billion euros out of a total of 101.3 billion euros of exports by manufacturing firms (87%). All these sample characteristics are summarised in the upper part of table 2.

Disaggregating the columns of the supply-and-use tables for manufacturing industries

As illustrated by the narrowly-gridlined cells in tables 1a and 1b, the SUT show the distribution of industry-level output and use of intermediate inputs over product categories. Output by product category is reported in the columns of the supply table and intermediate input use by product category is reported in the columns of the use table (part on intermediate inputs). For the column-wise disaggregation of manufacturing industries in the 2010 Belgian SUT into exporters and non-exporters, we use a restricted sample of firms for which we have information on turnover and purchases by product category.

In the Belgian SUT, the product distribution of output and intermediate inputs is derived from several sources. The main source are two supplementary questionnaires annexed to the structural business survey (SBS): one on the product detail of turnover and the other on the product detail of total purchases as reported in the firms' balance sheets. 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% of turnover at the 4-digit industry-level). For the product detail on output in manufacturing industries, the data from the supplementary SBS questionnaire on turnover is complemented by data from the survey on industrial production (Prodcom). Moreover, the data is 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 dataset.[7] The latter comprises all transactions between domestic firms on which VAT is levied. In the construction of the SUT, the resulting corrected datasets are used to distribute total industry-level output and intermediate inputs over product categories. In 2010, 1710 manufacturing firms completed the supplementary SBS questionnaires. They form the *restricted sample* for establishing the product distributions. Their turnover amounts to 181.2 billion euros, which is 79% of the total turnover of the 40194 manufacturing firms in our full sample. Among these 1710 firms, 978 are export-oriented (export to turnover ratio above 25%). The turnover of these export-oriented firms sums to 103.5 billion euros (83% of the turnover of all 2428 export-oriented firms in the full sample). Within the restricted sample, the average size of export-oriented firms and firms serving mainly the domestic market is almost identical (105.8 and 106.1 million euros respectively). Finally, exports of export-oriented firms in the restricted sample amount to 74.0 billion euros compared to total exports of 85.9 billion euros by all firms in the restricted sample (86%). Again, table 2 provides an overview of these sample characteristics.

Table 2 Sample characteristics for manufacturing industries

	Number of firms	Turnover (billion euros)	Average size (million euros)	Exports (billion euros)
Full sample[1]				
All firms	40194	229.7	5.7	101.3
Export-oriented firms[3]	2428 (6.0%)	124.8 (54.3%)	51.4	88.3 (87.2%)
Restricted sample[2]				
All firms	1710	181.2	105.9	85.9
Export-oriented firms[3]	978 (57.2%)	103.5 (57.2%)	105.8	74.0 (86.1%)

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

[7] In the construction of the SUT, 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.

At this point, we are able to provide some discussion on why we have defined exporters based on the exports to turnover ratio of 25%. Our aim is to investigate differences in the production cost structure between exporters and non-exporters. Therefore, when determining the product distributions of output and intermediate inputs of heterogeneous industries (columns of the SUT), we have been striving to produce results based on firm-level data rather than just assume proportionality with respect to the non-heterogeneous industries in the official tables. This would not have been possible for too many of the 58 manufacturing industries if we had defined exporters as all firms with non-zero exports rather than on the basis of the 25% export to turnover ratio. In that case, sample sizes for non-exporters would have been insufficient for a significant number of industries in the restricted sample that we use for determining the product distributions. All in all, we are facing 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.[8]

Thus, we split the restricted sample into export-oriented firms and firms serving mainly the domestic market and use the corrected data from the supplementary SBS questionnaires on turnover and total purchases to estimate separate product distributions of output and intermediate inputs for exporters and non-exporters by industry. We were able to do so for 50 out of the 58 manufacturing industries. The sample size was insufficient for non-exporters in six industries and for exporters in two industries. In those cases, we had to make a proportionality assumption. 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 SUT. As a result, we obtain a heterogeneous supply table as shown in table 1a and a heterogeneous use table as shown in table 1b.

8 Regarding the cut-off percentage, we are aware that our choice of 25% is arbitrary. For future work, it would be of interest to test other cut-off percentages.

At this stage, 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 do not have any firm-level information that would allow us to disaggregate valuation tables according to exporter status, we do so proportionally to values of intermediate inputs at purchasers' prices.

Disaggregating the rows of the supply-and-use tables

In view of deriving an IOT, the official Belgian use table at basic prices is split according to the origin of the used goods and services: domestic output or imports. This split can be seen in table 1c, which contains separate rows for the product distribution of domestic and imported intermediate inputs (and final uses). To obtain a heterogeneous use table with such a split, we disaggregate total industry-level imported intermediate inputs and their distribution over product categories according to exporter status. For this purpose, we use firm-level import data, which is corrected for re-exports and excludes imports of capital goods. Again, a RAS-procedure is applied so that the disaggregation respects the values of imported intermediate inputs by product category of the non-heterogeneous manufacturing industries in the official use table. For each product category, the use of domestically-produced intermediate inputs by exporters and non-exporters in manufacturing industries is obtained as the difference between total and imported intermediate inputs.

As shown in table 1c, the rows for domestically-produced manufactured goods in the use table can be further disaggregated according to whether these goods are produced by exporters or non-exporters. 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% export to turnover cut-off ratio for identifying export-oriented firms. Based on the sample split (for the full sample) and firm-level export data by product category, we determine exports by export-oriented firms and by firms mainly serving the domestic market 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 exporters and non-exporters 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 SUT into exporters and non-exporters in manufacturing industries as illustrated in tables 1a and 1c. Tables 3a and 3b present the resulting heterogeneous SUT in a very aggregated form.

Table 3a Heterogeneous supply table for Belgium in 2010
Millions of euros

	Manufacturing exporters	Manufacturing non-exporters	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

Table 3b Heterogeneous use table for Belgium in 2010
Millions of euros

	Manufacturing exporters	Manufacturing non-exporters	Other industries	Final demand	Commodity exports	Service exports	Total output / imports
Domestic							
Manufactured goods exporters	14,816	3,711	9,328	10,058	96,429	1,617	135,960
Manufactured goods non-exporters	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				

Deriving export heterogeneous industry-by-industry IOT

The transformation of SUT at basic prices into symmetric industry-by-industry IOT implies making an assumption for the treatment of secondary products, i.e. off-diagonal elements in the supply table. We choose the fixed product sales structure assumption (Model D in Eurostat, 2008), which is the most commonly used. According to this assumption, "each product has its own specific sales structure irrespective of the industry where it is produced" (Beutel, 2017, p.119). This comes down to assuming that an industry's output of a certain product is delivered to users in the same proportion as total economy-wide output of that product.[9]

Table 4 Heterogeneous input-output table for Belgium in 2010
Millions of euros

	Manufacturing exporters	Manufacturing non-exporters	Other industries	Final demand	Commodity exports	Service exports	Total output
Manufacturing exporters	15,335	3,866	11,482	12,446	101,566	4,609	149,304
Manufacturing non-exporters	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				

The heterogeneous industry-by-industry IOT that we derive from the heterogeneous SUT is given in very aggregated form in table 4. 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.

Integrating the export heterogeneous IOT for Belgium into a global table

The last step of our statistical work on export heterogeneity in Belgian SUT and IOT is to integrate the 2010 heterogeneous national tables for Belgium into a global multi-regional 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] The 2010 WIOT is consistent with the 2008 System of National Accounts (SNA 2008) and covers 43 countries (including Belgium) and 56 industries in a classification that is compatible with NACE Rev.2. All values are in current dollars.

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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 of the world input-output tables (WIOT).

In a nutshell, the construction of the WIOTs starts from national SUT, which are complemented with international trade data from COMTRADE and combined into world SUT. The industry-by-industry WIOT is derived from these world SUT based on the standard fixed product sales structure assumption. The WIOT respects countries' published national accounts aggregates (output and value-added by industry, totals of final demand by category) but the inner structure of the tables is not consistent with published SUT or IOT of individual countries due to necessary transformations in the course of the construction process. This is problematic for our analysis as we want to keep the structure of our export heterogeneous Belgian table as it is when integrating the table into the WIOT. Edens et al. (2015) have developed a methodology for introducing national tables for the Netherlands into the WIOTs without changing these national data[11]: they replace the SUT for the Netherlands by their national data, which are firm-level-data-based extension of the most detailed official national SUT, and replicate the construction process of the WIOTs keeping data for the Netherlands constant. A similar methodology has been applied for Belgium for the years 1995-2007 in Hambÿe et al. (2017). 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). Given that industry-level value-added and the trade balance for Belgium in the 2010 WIOT are almost identical to those in the official national IOT, differences between our shortcut method and the thorough SUT-based method are likely to be small. As shown in Hambÿe et al. (2017) 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.

For our method, we start off by converting our Belgian IOT from euros into dollars based on the exchange rate used in WIOD (1.3257$/€). As a second step, we use the shares of Belgian imports by country and of Belgian exports by country-user pair to distribute imports and exports in our national tables over respectively countries of origin and destination country-user combinations. In the third step, we replace

[11] Edens et al. (2015) apply their methodology for the years 2003 and 2009.

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 apply a RAS procedure to adjust the data for all other countries in the WIOT. This yields a 2010 WIOT which is entirely consistent with national data for Belgium and which contains a disaggregation of Belgian manufacturing industries into exporters and non-exporters.

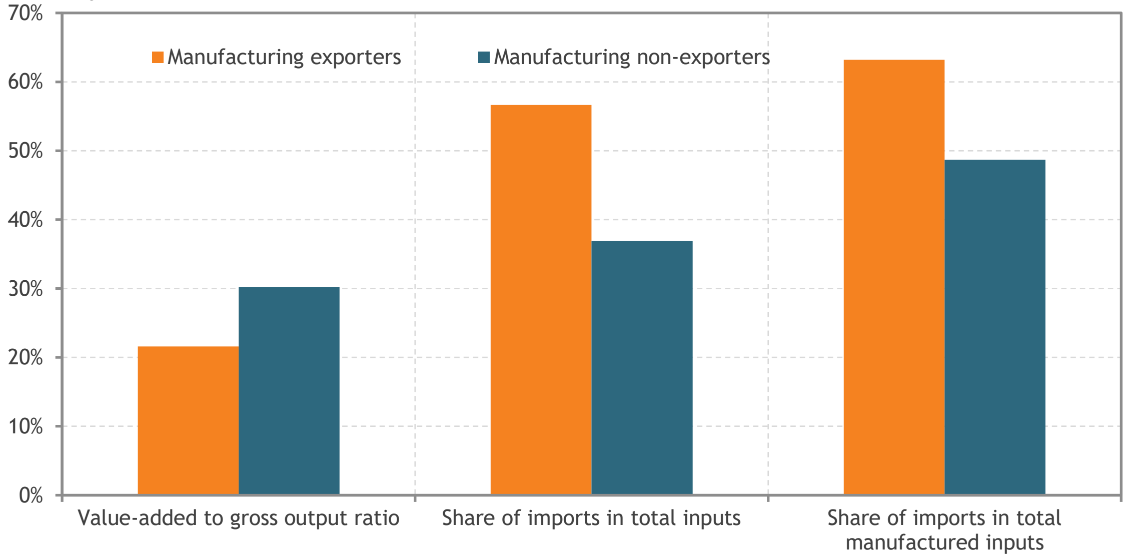
3. Analyses based on national supply-and-use and input-output tables

Differences in direct production cost structures

The SUT with exporter heterogeneity in tables 3a and 3b allow to determine that export-oriented firms account for almost three-quarters of total manufacturing output but only for two-thirds of total manufacturing value-added. In other words, manufacturing exporters have a lower value-added to gross output ratio than firms that mainly serve the domestic market. This is illustrated in graph 1 and it is in line with the widely-held intuition that production processes of exporters are more fragmented.

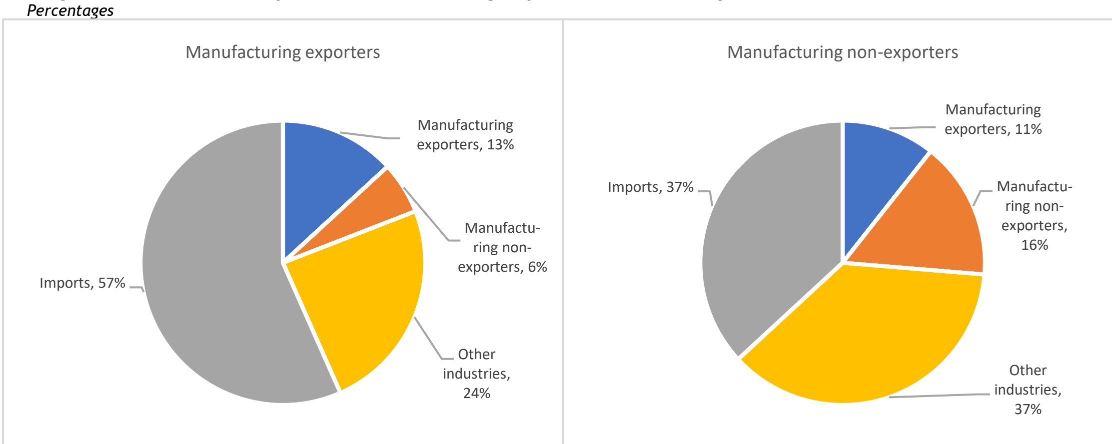
Furthermore, export-oriented manufacturing firms do not only purchase more intermediate inputs compared to their gross output, they also purchase proportionally more of their intermediate inputs from abroad. Indeed, as illustrated in graph 1, imports make for almost 57% of total intermediate inputs of export-oriented firms, while this share is just below 37% for firms mainly serving the domestic market. Hence, in line with prior finding in the literature on firm heterogeneity and international trade, manufacturing exporters in Belgium tend to rely more on imported intermediate inputs. Narrowing things down to manufactured goods, this share becomes 63% for export-oriented firms and 49% for firms that mainly serve the domestic market (see again graph 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.

Graph 1 **Aggregate differences in production processes of exporters and non-exporters**
Percentages



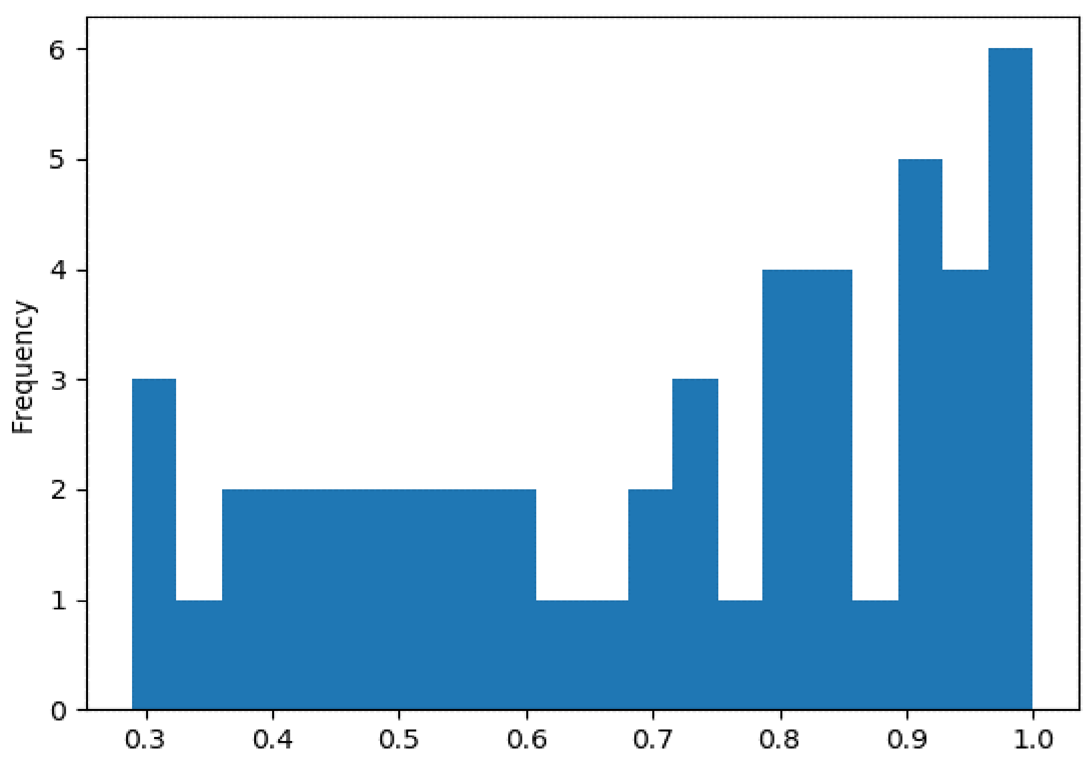
Based on the heterogeneous IOT, we take another look at intermediate input structures. Graph 2 illustrates differences between manufacturing exporters and non-exporters. As we have already shown with the data from the SUT, manufacturing exporters import more than half of the intermediate inputs they use. The import share is substantially lower for non-exporters. For both exporters and non-exporters, most of the domestically-produced intermediate inputs they purchase are produced by the group of other industries. But this share is much higher for non-exporters. Moreover, manufacturing exporters purchase only 6% of their intermediate inputs from non-exporters, whereas the purchases of intermediate inputs from exporters amount to 11% of the total for non-exporters.

Graph 2 **Origin of intermediate inputs of manufacturing exporters and non-exporters**
Percentages



Finally, we also test for similarity of input structures at a more detailed level by calculating the correlation between technical coefficients of exporters and non-exporters 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 different types of inputs required per unit of output. The average correlation between the input structures of exporters and non-exporters 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 intermediate inputs for exporters and non-exporters. The histogram in graph 3 provides a picture of the distribution of the correlation coefficients. Among industries for which the input structure is not split proportionally, 'printing' has the highest correlation coefficient and 'manufacture of air and spacecraft and parts thereof' the lowest, i.e. exporters and non-exporters have a very similar input structure in the former and relatively different ones in the latter.

Graph 3 Distribution of the industry-level correlation between technical coefficients of exporters and non-exporters



Indirectly generated output and value-added

Input-output analysis is all about taking into account not only direct intermediate inputs in the production process as analysed above but also indirect intermediate inputs requirements of suppliers. The underlying idea can be described as follows: take a final demand shock (domestic final demand or exports) and determine its effect on economy-wide output or value-added. The final demand shock prompts a firm to expand the scale of its production process. This increase in output is the direct effect. When expanding its production, 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. The reasoning can be extended to as many upstream production stages as necessary. This is the indirect effect on output, which comes through the increase in purchased intermediate inputs. Standard input-output analysis models the effect of such a demand shock on the entire production chain in terms of output, value-added and employment that is generated in the chain.[12] Here, we focus on output and value-added of manufacturing exporters and non-exporters. An export demand shock may not only increase the output of exporters but also lead to substantial extra output and value-added of non-exporters due to local intermediate input purchases by exporters.

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

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

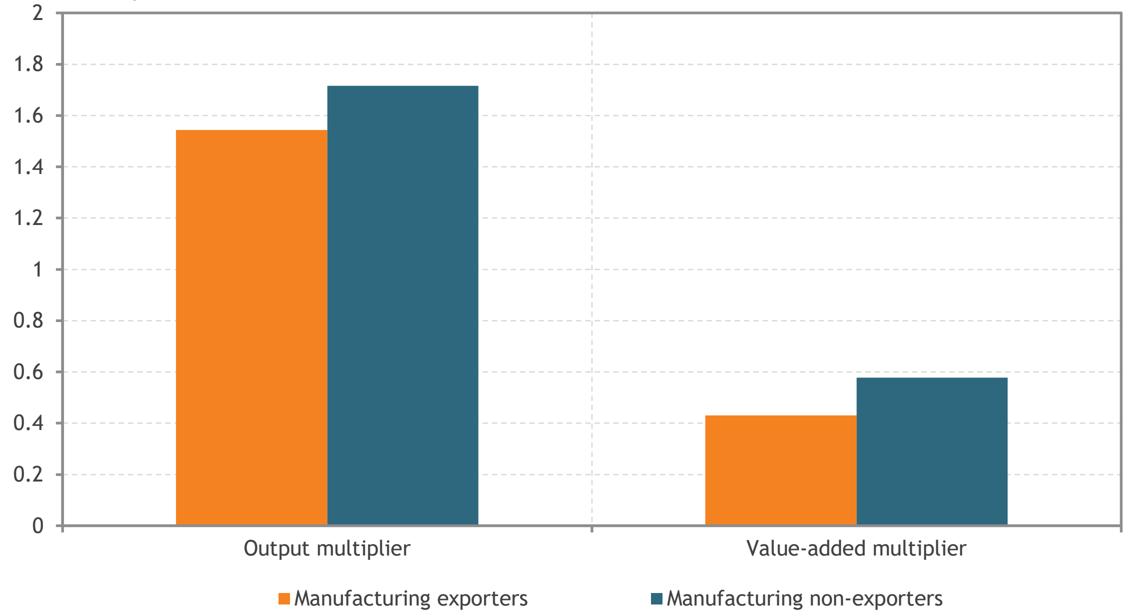
[12] Environmental input-output analysis combines the model with environmental variables such as emissions of pollutants or use of water or materials.

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 diagonalised vector of output by industry. Any element l_{ij} of the L-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 ($\sum_i l_{ij}$). It indicates how many extra euros of domestic output are generated (in all industries) directly and indirectly 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. Note that, in this national framework, imported intermediate inputs are not taken into account: they do not generate domestic output. Thus, industries that use relatively more domestically-produced intermediate inputs tend to have higher output multipliers.

Effects can also be calculated in terms of value-added. Multiplying l_{ij} by industry i's value-added in output share v_i yields the amount of value-added of industry i generated by this shock to industry j's final demand. The value-added multiplier corresponds to the sum over the producing industries ($\sum_i v_i l_{ij}$). It indicates how many extra euros of domestic value-added are generated (in all industries) directly and indirectly 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 exporters and non-exporters in manufacturing industries. Overall results are reported in graph 4. The average output multiplier is substantially higher for non-exporters than for exporters. This also holds for all but five of the manufacturing industries. Thus, as expected, manufacturing exporters are less (backward) integrated into the Belgian economy. This finding reflects the international fragmentation of their production process. They use more intermediate inputs than non-exporters, but most of these inputs are imported, which implies that their output multiplier is lower.

Graph 4 Output and value-added multipliers of manufacturing exporters and non-exporters
Percentages

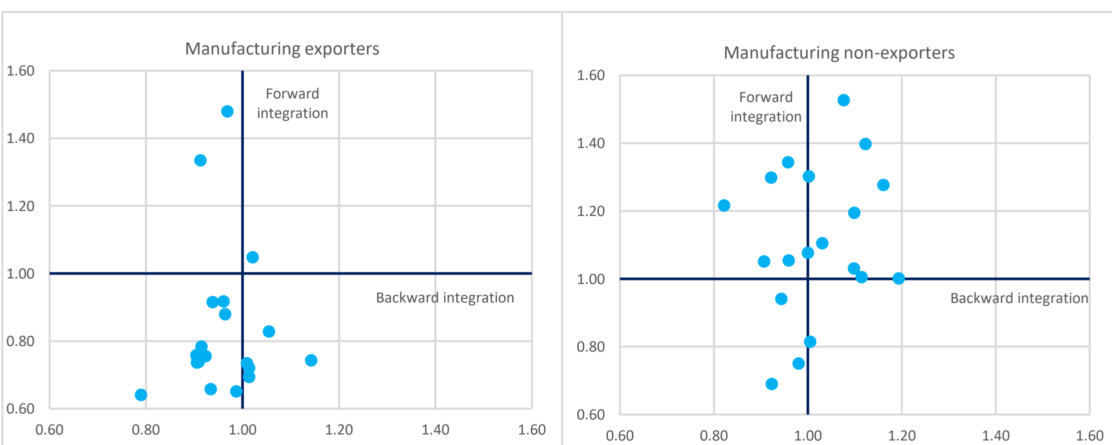


As shown in graph 4, the value-added multiplier for non-exporters is also higher. It stands at 0.58 against 0.43 for exporters. Two underlying differences between manufacturing exporters and non-exporter drive this result. First, a one-euro final demand shock to manufacturing exporters' output generates less direct value-added than an equivalent shock to non-exporters' output since the value-added in output share is lower for exporters. Second, it also generates proportionally less output in upstream industries and hence also less value-added.

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 but also in terms of its deliveries of goods and services to other domestic industries that use them as intermediates. The former is referred to as backward integration or backward linkages of an industry and, as mentioned above, measured by the output multiplier. The latter is referred to as forward integration or forward linkages of an industry. It is measured as the sum of the industry's row in the Ghosh inverse matrix, which is calculated based on the shares of the industry's output used as intermediate inputs by other industries. Our calculations of this forward linkage indicator show that it is generally much lower for manufacturing exporters than for manufacturing non-exporters. The reason is very simple: exporters deliver relatively less of their output to other domestic industries than non-exporters. Thus, the forward integration into the domestic economy is higher for non-exporters. However, exports may be used as intermediate inputs abroad. Hence, exporters 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 manufacturing exporters and non-exporters into Belgian domestic value chains is summarized in the scatterplots of graph 5. 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 non-exporters is skewed more towards the top and right indicating a stronger integration into domestic value chains.

Graph 5 Forward and backward integration into the domestic economy



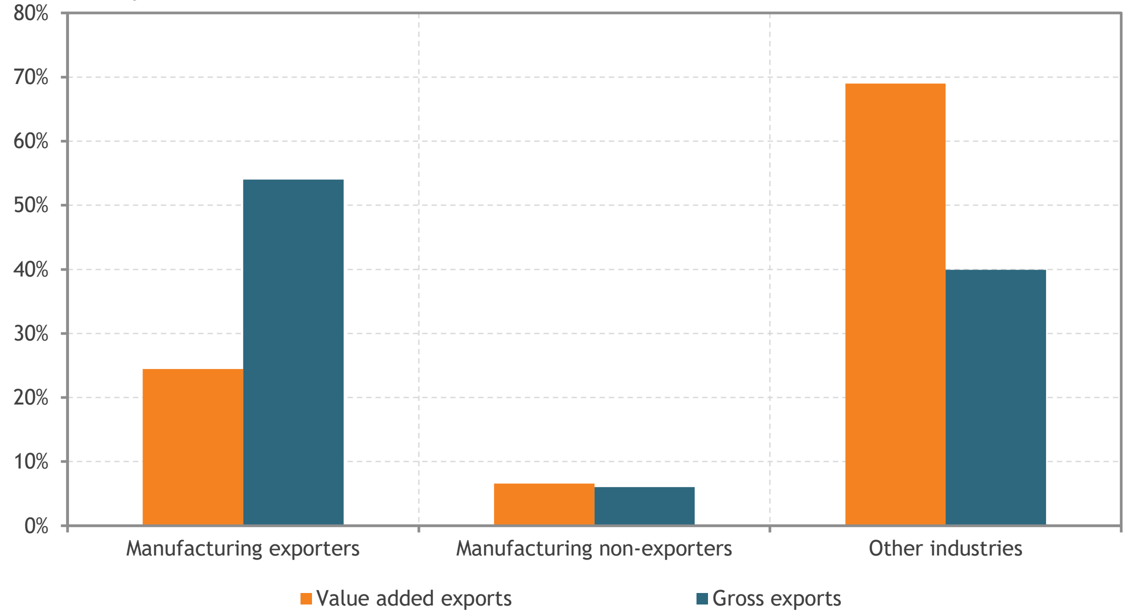
As a further step, we specifically look at domestic (Belgian) value-added generated directly and indirectly by exports. In this context, we also include 'other industries', which are mainly service industries. Results are reported in table 5 with value-added by types of firms in the rows and exports by types of firms in the columns. So, for example, the cell corresponding to the second row in the first column reports the value-added of manufacturing non-exporters generated directly and indirectly by exports of manufacturing exporters. The table highlights several interesting results. First, the exports of manufacturing exporters generate a total domestic value-added of 45.4 billion euros, most of which is value-added of manufacturing exporters. But these exports also generate a substantial amount of value-added in the rest of the Belgian economy: 17.1 billion euros for other industries and 2.4 billion euros for non-exporters in manufacturing industries. This is consistent with findings reported in OECD (2015) that Belgian service industries participate in global value chains through their deliveries to exporting manufacturing industries. Second, the exports of manufacturing non-exporters and of the other industries generate only very little value-added for manufacturing exporters. Again, this is related to the lesser integration of manufacturing exporters into the domestic economy. Third, the exports of the other industries, mostly service exports, generate comparatively less value-added in manufacturing (for both exporters and non-exporters). The comparison of column and row totals of table 5 shows that, for manufacturing exporters, the value-added generated in Belgium by their exports is much higher than their value-added due to total Belgian exports. The opposite holds for both manufacturing non-exporters and other industries.

Table 5 Domestic value-added in exports, million euros

Value-added \ exports	Manufacturing exporters	Manufacturing non-exporters	Other industries	Total
Manufacturing exporters	25,992	248	603	26,843
Manufacturing non-exporters	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

In graph 5, we compare shares in gross exports and in domestic value-added in exports. Manufacturing exporters account for more than half of Belgium's total gross exports (54%) but only for a quarter of the domestic value-added generated by these exports (24%). Most of the domestic value-added in exports is generated in other industries, i.e. service industries (69%), although the share of these industries in gross exports is only 40%. For manufacturing non-exporters, the shares in gross exports and domestic value-added in exports are similar.

Graph 5 **Shares in domestic value-added in exports and in gross exports**
Percentages



Total domestic value-added generated directly and indirectly by exports amounts to 109.9 billion euros (see table 5), which corresponds to 56% of Belgium's total gross exports. This domestic value-added in exports (DVAX) share as defined by Koopman et al. (2010) is the complement of the vertical specialization (VS) measure defined by Hummels et al. (2001), which in turn represents "the value of imported inputs embodied in goods that are exported" (p.76-77). Thus, the VS share is 44% for Belgium in 2010. It is a widely-used indicator of the extent of the international fragmentation of production processes. The results shown above clearly indicate that for Belgium the international fragmentation measured by the VS share is largely driven by manufacturing exporters.

4. Analyses based on global multi-regional input-output tables

Given that we have integrated our export heterogeneous IOT for Belgium into the 2010 GMRIO table from WIOD, i.e. the WIOT, we can push the analysis regarding the integration of Belgian manufacturing exporters and non-exporters into global value chains one step further. The global table allows us not only to recalculate DVAX and VS shares for Belgium, but also to look at other indicators such as GVC participation or distance to final demand.

In this context, calculations are based on a multi-regional input-output model rather than the purely national one that we have used so far. The scope of the effect of a final demand shock is extended as the multi-regional input-output model takes into account not only purchases of domestically-produced intermediates but also purchases of intermediate inputs from abroad. All indirect effects are captured by the elements of the multi-regional Leontief inverse matrix L_{MRIO}, which is calculated based on the multi-regional matrix of technical coefficients A_{MRIO}:

$$L_{MRIO} = (I - A_{MRIO})^{-1} \quad (2)$$

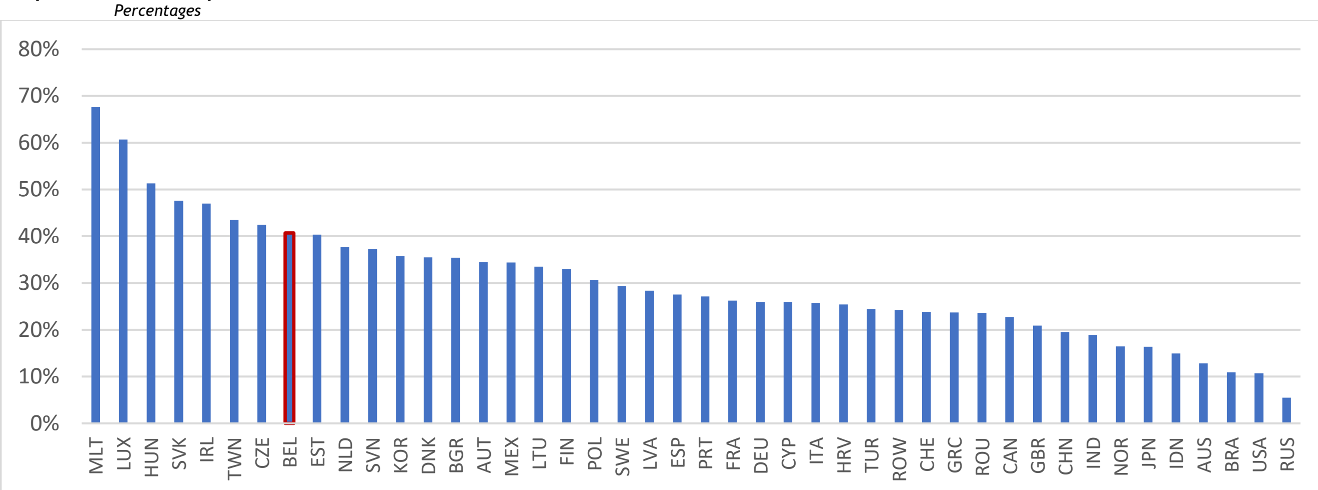
Any element in this matrix represents the output of a country-industry pair that is generated (directly or indirectly) by a one-dollar[13] final demand shock to output of another country-industry pair. In this multi-regional model, a final demand shock in one country may lead to feedback effects for that country, e.g. when the final demand shock gives rise to purchases of intermediate inputs from foreign suppliers and when these foreign suppliers, in turn, purchase intermediate inputs from the country where the shock has occurred. In essence, the multi-regional model works the same way as the national model, but the analysis can be extended to cross-country or even global value chains, i.e. it is not restricted to domestic value chains.

The VS share measures to what extent a country's industries rely (directly and indirectly) on imports of intermediate inputs to produce the goods and services they export. Hence, it is an indicator of backward integration into global value chains. The VS share reported in the previous section is based on a national IOT for Belgium. It is similar to the one reported in Los (2017) for Belgium for 2011 (DVAX share of 54%, i.e. a VS share of 46%), although the latter is based on the WIOT and therefore accounts for

[13] The WIOT is labelled in dollars.

feedback effects. When recalculating VS shares with the 2010 WIOT into which we have integrated the export heterogeneous IOT for Belgium, we obtain a DVAX-share of 59% and a VS share of 41% for Belgium. A comparison of VS shares for all 43 countries in the WIOT reveals that Belgium is among the countries with the highest shares, i.e. it is highly backward integrated into global value chains. This is illustrated on graph 6.

Graph 6 Vertical specialisation shares for all countries in the 2010 WIOT
Percentages



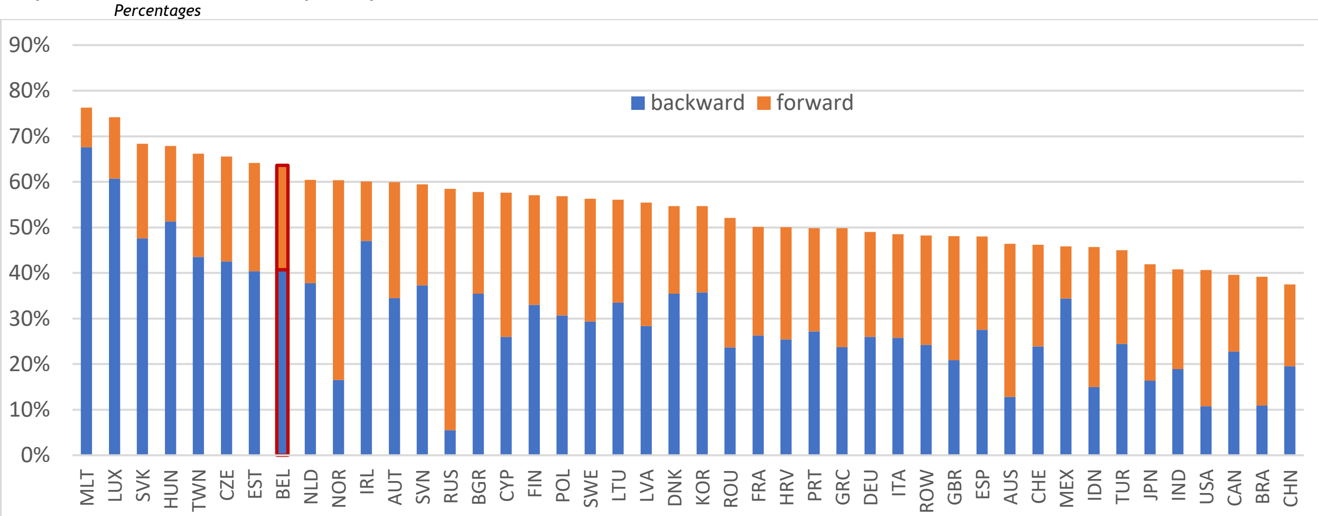
However, countries do not only participate in global value chains through imports of intermediate inputs (backward integration) but also through deliveries of intermediates to those who export (forward integration). Moreover, the measure of participation in global value chains should not depend on the position in the chain as is the case if only backward integration, i.e. the VS share, is considered. The idea that forward integration should also be taken into account was already formulated by Hummels et al. (2001), but these authors lacked the data needed to compute a measure of forward integration. This can only be done with MRIO data because it requires information about the use of exports. De Backer and Miroudot (2014) fill this gap: they define a global value chain (GVC) participation index that sums the VS measure as an indicator of backward integration with a measure of forward integration and they compute this indicator with data from the OECD's 2009 GMRIO (called inter-country input-output (ICIO) table). In practice, the GVC participation index is based on an industry-country by industry-country matrix of value-added embodied in exports. Following the notation in De Backer and Miroudot (2014), this matrix can be written as:

$$VBE = V * L_{MRIO} * E \quad (3)$$

Where V is a diagionalised vector of value-added in output shares and E a diagonalised vector gross exports. After eliminating the domestic parts of this matrix, its column sums yield the VS measure by industry-country pair and its row sums yield a measure of industry-country pairs' forward integration in global value chains, i.e. through deliveries of intermediates to foreign exporters. The GVC participation index is obtained by summing the two measures and normalizing by total country-level exports.

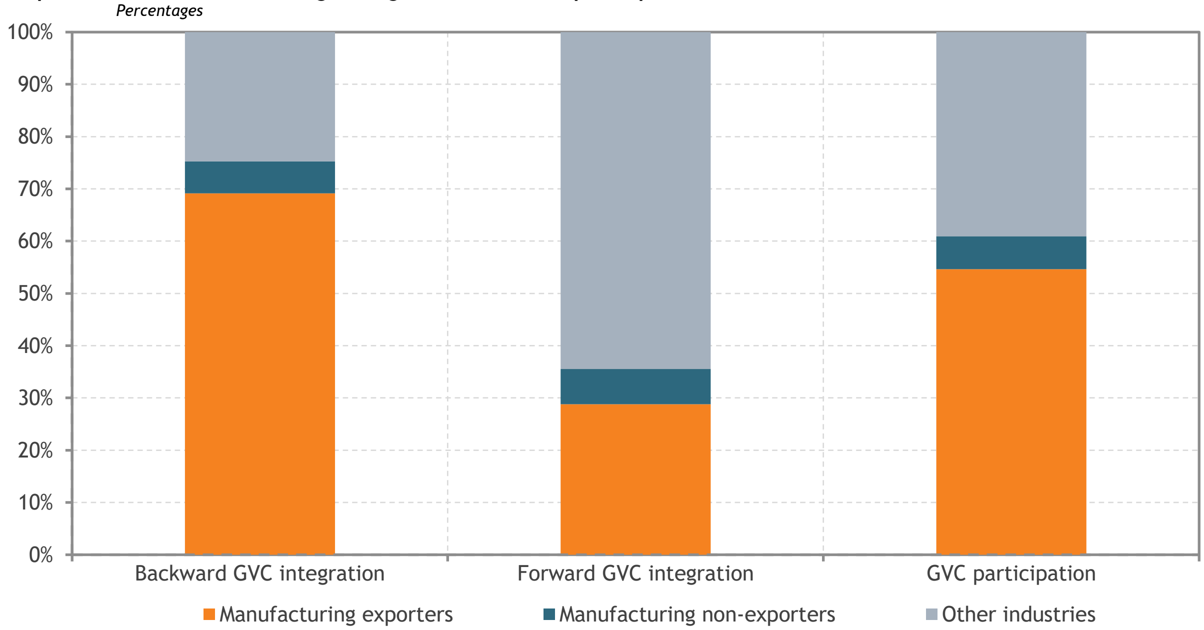
Graph 7 shows a comparison of the GVC participation index for all countries in the 2010 WIOT with a split into the contributions of backward and forward integration. Again, Belgium is among the countries with the highest values for this index, i.e. Belgium is highly integrated into global value chains, both backward through imports of intermediate inputs and forward through deliveries of intermediates for third country exports. This result is in line with the results reported by De Backer and Miroudot (2014).

Graph 7 Global value chain participation index for all countries in the 2010 WIOT
Percentages



The integration of the export heterogeneous IOT for Belgium into the 2010 WIOT allows to determine contributions of manufacturing exporters, manufacturing non-exporters and other industries to Belgium's participation in global value chains.[14] Results are given in graph 8. The third stacked bar in the graph indicates that Belgium's participation in GVCs is due for 55% to manufacturing exporters, for 39% to the firms in other industries, which are mainly service industries, and for the remaining 6% to non-exporters in manufacturing industries. The first and second stacked bars illustrate the difference in how manufacturing exporters and firms in other industries participate in GVCs. There is a clear distribution of the roles. The contribution of manufacturing exporters is essentially through their purchases of imported intermediate inputs for producing exports (backward integration), while firms in other industries participate in GVCs mostly through deliveries of intermediate inputs for export production (forward integration).

Graph 8 Contributions to Belgium's global value chain participation
Percentages



TBA: distance to final demand of manufacturing exporters and others

[14] Note that there is a slight methodological difference between the forward linkages that we have calculated with the national heterogeneous IOT and the forward integration into global value chains that we have calculated with the 2010 WIOT into which the Belgian heterogeneous IOT has been integrated: the former is based on a Ghosh inverse matrix, while the latter is based on a (multi-regional) Leontief inverse matrix.

5. Conclusions

The work presented in this paper consisted in the construction of export heterogeneous SUT and IOT for Belgium and their integration into a GMRIO as well as analyses based on these tables. We draw three main conclusions from this statistical and analytical work.

a) It is highly desirable to disaggregate industries in SUT and IOT according to firm characteristics such as size, ownership or exporter status. As suggested by OECD (2015) and Los (2017), these characteristics may actually be at the origin of technological differences between firms within an industry defined in terms of product similarity. However, our work on export heterogeneity for Belgium illustrates that there are limits to what can be done in this respect from a statistical point of view. For analyses to be of interest, it is not sufficient to restrict the disaggregation to national accounts aggregates. Detailed output and input structures by product must also be disaggregated based on data rather than proportionality assumptions. Our work shows that, especially for a small country like Belgium, a sample size problem may arise in this context. Sample sizes may prove insufficient for data-based disaggregation at the most detailed industry level. In our case, we faced a trade-off between including minor exporters into the category of exporters and avoiding proportionality in the estimation of product distributions for heterogeneous industries in the most detailed breakdown of the SUT. We are aware that this may be less of an issue for larger countries. Nonetheless, this problem related to sample size represents a serious constraint for combined disaggregations, e.g. firm size and ownership.

b) Exporters and non-exporters in Belgian manufacturing industries are indeed different in terms of input structures (production technology) and import behavior. We find that exporters have lower value-added in output shares and import proportionally more of the intermediates they use. This means that production processes of exporters are more fragmented, in particular internationally. Our results confirm prior findings in the literature on firm heterogeneity in international trade.

We believe that it is an important step to have confirmed these findings in a setting that is consistent with the national accounts.

c) Regarding the role of the different types of firms in global value chains, our results show that exporters are the spearhead of Belgium's participation in global value chains. But non-exporters in manufacturing industries and especially service industries also largely contribute to Belgium's GVC participation. Their contribution is an indirect one as they are integrated into global value chains mainly through their deliveries of intermediate inputs to exporters.

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Table 1a - Supply table

		Agri-culture	Mining	Manufacturing					Services			Output	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 1b – Use table (column disaggregation only)

		Agriculture	Mining	Manufacturing					Services			Intermediate use	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 1c - Use table (full disaggregation)

			Agri-cul-ture	Mining	Manufacturing					Services			Interme-diate use	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	X	M1													
		M2													
		⋮													
Services		S1													
		S2													
		⋮													
Total use by industry															
Net taxes on products															
Value added															
Output															