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Accounting for firm heterogeneity in global value chains:

The role of Small and Medium sized Enterprises

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Accounting for firm heterogeneity in Global Value Chains: the role of Small and Medium sized Enterprises

1. Introduction

Global value chains (GVCs), and more generally globalisation, have been a dominant feature of the global economy in recent decades. Fostered by significant technological change and the widespread adoption of policies aimed at reducing trade costs, coupled with investment liberalisation, economies today are more integrated than ever before.

To better inform the debate around GVCs and globalisation a number of statistical initiatives have been launched in recent years. Notable examples include the OECD-WTO database on Trade in Value Added (TiVA) and the World Input-Output database (WIOD), which have helped to shape the policy debate, highlighting for example the importance of imports for export success, the need for well-developed domestic services industries that support manufacturing exports, and the changing relative importance of trading partners when looking at the ultimate sources and destinations of trade, rather than the immediate counterpart. In addition, and to further reinforce these efforts, recent years have seen the initiation of complementary regional initiatives such as the Eurostat FIGARO project, APEC TiVA and North American TiVA.

However, whilst these initiatives have helped to significantly improve our views on economic interdependencies, they have until now been confined to viewing integration through the statistical prism of industries. However, even within narrowly defined industries, firms show marked variation in competitive advantages related to productivity, capital and skill intensity (Bernard et al., 2007), as well as - of particular relevance to the debate on inclusive globalisation - significant differences in their levels of integration in GVCs and the benefits that accrue from that (including to workers).

Self-evidently, illustrating these differences in core statistics on TiVA is important for effective policy making. But it also matters because a focus on industries alone introduces structural biases in current TiVA estimates. For example, the evidence shows that large and exporting firms are typically also more import intensive than small and non-exporting firms, which means that current TiVA estimates of, for example, the import content of exports, are typically downward biased.

Building on earlier work by Ahmad et al. (2011), who highlighted the potential scale of these biases using Turkish national statistics and microdata, several initiatives have already introduced firm heterogeneity in the analysis of global value chains, by breaking down national supply-and-use and input-output tables. Much of this has focused on countries where heterogeneity is likely to have a significant impact on results such as in China and for Mexico (see e.g Koopman *et al.* (2012), Yang *et al.* (2013) and De la Cruz *et al.* (2011)).

These have however been one-off country studies. It is only more recently that a core statistical response has been formulated to mainstream the development of these tables within national statistical production systems. The key mechanism to do so is through the development of what have become known as Extended Supply-Use Tables, work on which is led by an OECD Expert Group. However, while a number of countries such as

the US (Fetzer and Strassner, 2015), the Netherlands (Chung et al., 2017), Mexico (INEGI, 2017) and Costa Rica (Saborío, 2015) have made significant advances on this front, with plans to mainstream these activities in their regular statistical production systems, for many other countries it may be some time before they are able to produce such tables.

As such, and to fill this gap in the short to medium term, the OECD (see Piacentini and Fortanier, 2015) have worked to further develop this philosophy by producing breakdowns of national tables on the basis of firm size for several OECD countries (see also OECD-World Bank 2015). Lopez-Gonzalez (2017) applied the same approach to develop results for several Asian countries. More recently, the OECD Statistics Directorate and the Statistical Offices of the Nordic countries refined the methodology, and the level of detail of linked microdata, in their report on Nordic Countries in Global Value Chains (2017), which broke firms down on the basis of size, ownership and trading status.

Building on this work, this paper produces results for 20 OECD economies covering the years 2008 to 2014. The remainder of this paper is organised as follows. First, section 2 describes the conceptual approach, assumptions and methodologies, to break down national IO tables into more granular groupings of firms using complementary data produced and published by countries. The datasets that were used, including the various challenges they pose related to incompleteness and confidentiality (and approaches for tackling these) are discussed in section 3. Section 4 presents the results, and section 5 describes the various robustness checks performed to test the robustness of the various assumptions that are used. Section 6 concludes. The focus of this paper is on breakdowns between SMEs and larger enterprises, however, the conceptual methodology can easily be extended to account for other sources of firm heterogeneity such as firm ownership.

2. Methodology

The development of indicators on firm heterogeneity in GVCs necessitates the introduction of firm characteristics into the core component that underpins the analysis of GVCs, a national input-output table. The basic structure of a national IO table with three industries is illustrated below (Figure 2.1). The core of the matrix describes the intermediate use relationships between industries, and is supplemented with columns for final demand (consumption, capital formation, exports etc.), and rows that record value added, cif-fob adjustments, tax and subsidies, and output. The dark green cells specify the intermediate and final use of domestically produced products, while the lighter green cells indicate intermediate and final use of imported products.

Figure 2.1. Structure of a typical national Input-Output table

			Country A			
			Sector 1	Sector 2	Sector 3	Final Demand
Country A	Domestic	Sector 1				
		Sector 2				
		Sector 3				
	Imports	Sector 1				
		Sector 2				
		Sector 3				
Taxes less subsidies on products						
Cif-fob adjustments						
Value added		Labour compensation				
		Operating surplus				
		Taxes less subsidies on production				
Output						

Disaggregating a national IO table by firm characteristics requires breaking down the columns, and subsequently the rows, by firm type, using information derived from business and trade statistics. The resulting table is presented in Figure 2.2, showing an enlarged matrix of intermediate and final use relationships that indicates not only how industries, but also different types of firms within an industry, are interconnected.

Five core steps are involved in this transformation. Each is described in turn below, with numerical examples provided in Annex A.

As the focus in this paper is on the role of SMEs in GVCs, the main data sources used were the OECD Structural and Demographic Business Statistics (SDBS) database (for value added and gross output by industry and firm size) and the OECD Statistics on Trade by Enterprise Characterises (TEC) (merchandise exports and imports by industry and firm size), as described in more detail in section 3. However, the methodology is universal in the sense that it can be applied to develop other disaggregations, when similar data are available. In essence, whatever the focus of heterogeneity, it is important to split the following key variables by category of firm: value added; output, imports and exports.

Figure 2.2. Input-Output table with split by firm heterogeneity

			Country A						
			SMEs			Large firms			Final Demand
			Sector 1	Sector 2	Sector 3	Sector 1	Sector 2	Sector 3	
Country A	SMEs	Sector 1							
		Sector 2							
		Sector 3							
	Large firms	Sector 1							
		Sector 2							
		Sector 3							
	Import	Sector 1							
		Sector 2							
		Sector 3							
Taxes less subsidies on products									
Cif-fob adjustments									
Value added		Labour compensation							
		Operating surplus							
		Taxes less subsidies on production							
Output									

Step 1: Disaggregating IO columns: industry value added and gross output

The first step towards disaggregating the IO by firm characteristics is to break down the activity columns. In order to achieve this, value added and output by industry are split using the share of SMEs in total value added, and in total gross outputs derived from SDBS.

It's important to flag up a few assumptions that are implicit here and that will be further developed and refined in future years as the work progresses:

- Implicitly, the combination of SDBS and IO data presupposes consistency between two, which is not typically the case. Partly this reflects the coverage of non-observed activities, which are not usually included in SDBS data but which *are* estimated in the national accounts. While exhaustiveness adjustments may be larger for SMEs, as they may engage more in informal activities, in most sectors and most developed economies these are generally not particularly significant, and their impact on the results in this paper is likely to be minimal.
- A secondary source of difference reflects the units used in constructing the different data sets. Typically these align as SDBS data are among the key data-sources for constructing national IO tables, but there may be differences related to variation in statistical units (enterprises in SDBS and establishments in IO tables).
- Non-market activities are not typically covered in SDBS data. As such, in the analysis that follows, activities with significant non-market output (public administration services, health, education, and other social services) are excluded, i.e. they are not broken down and are treated separately. Similarly, estimates of owner-occupied dwelling services are removed from the category of real-estate activities and included in non-market activities. Finally, because SDBS data for this industry are not typically collected, no heterogeneity breakdowns are provided for the financial services sector.

Step 2: Disaggregating IO columns: imports

The next step is to split the columns in the import matrix (imports of products by using industries) by firm type. This is achieved using information available in the TEC database. The starting point is information on the value of total 'direct' imports by SMEs and large enterprises. However, many enterprises import 'indirectly' via wholesale intermediaries. Therefore, estimates of 'direct' imports for non-wholesale goods traders are complemented with estimates of 'indirect' imports to derive the overall shares of imports in each industry by SMEs and large enterprises (see Box 1).

Box 1. Wholesale adjustment for imports

In Input-Output tables, following the SNA, imports by firms are included as direct imports even if they pass through resident wholesale and retail industries first. In other words, imports of goods by wholesalers and retailers for subsequent sale without any further processing are not recorded as their imports in the SNA. The same holds for exports of goods that have not been the subject of any further processing by wholesalers and retailers.

In contrast, in TEC statistics, trade is matched to those enterprises that are immediately responsible for imports and exports – including by wholesale and retail firms themselves. Compared to the National Accounts data, this results in a strong overestimation of trade by this industry and a strong underestimation of trade by all others. To align with national accounts concepts, the TEC export and import values for the wholesale and retail industry were therefore constrained to the levels reported in national IO tables.

The additional trade was subsequently distributed to other sectors in a two-stage procedure by first identifying the products involved (using TEC statistics on trade by product for the wholesale industry, converting the CPC classifications to the ISIC classification used in the symmetric IOs) and then proportionately allocating these products to using (importing) or exporting industries and firm types on the basis of information included in TEC and national IOs.

Since no further information is available on the types of products that are imported by SMEs or by large firms, this ratio is applied across all imported products within an industry, in other words it assumes that within an industry, SMEs import the exact same product basket as large firms.

An important caveat is that TEC statistics only reflect merchandise trade, and not services trade. For manufacturing industries, this will likely not generate major biases, but it is more problematic for enterprises in the services industry. Therefore, a slightly different and more aggregate treatment was used for the services industries, as explained in more detail in section 3. However, this by necessity still assuming that the share of SMEs in total exports of these industries is the same as observed as their share in goods. The emerging availability of STEC statistics (Services Trade by Enterprise Characteristics) will be able to mitigate this going forward.

As before, an important assumption made here concerns consistency between TEC statistics and national IO tables. In reality, differences may exist because the statistical unit used in TEC is nearly always the enterprise, whereas in many countries the unit for

IO tables is the establishment. As was the case for SDBS, exhaustiveness adjustments for the non-observed economy are not included in TEC. These are however not expected to form a significant source of difference as trade data is generally less affected by the non-observed economy (in most countries).

Step 3: Disaggregating IO columns: domestic intermediate use

Domestic purchases were calculated, by firm type, as the remainder of gross output –/– value added –/– imports. This replicates the proportionality assumption introduced for imports: i.e. the domestically purchased product basket between SMEs and large firms is the same.

Step 4: Disaggregating IO Rows: exports

The export column of national IO tables is split using exports by firm type (within industries) available from TEC with adjustments for exports by wholesalers/retailers (see Box 1).

Step 5: Disaggregating IO Rows: intermediate and domestic final demand

The final step in the transformation of the national IO table into splits by firm category concerns the rows. From Step 4, the exports by firm type have already been calculated and so Step 5 allocates the remainder of output (from Step 1) and (step 4) to intermediate use and final consumption by firm type. This is perhaps the most important of the assumptions used in creating the split IO table, as by design, it generates relationships between categories of firms (for example intermediate consumption of parts by large firms from smaller firms). The approach used here takes a neutral position on these relationships by assuming that the share of residual output (output minus exports) for a given category of firm that is allocated to final demand (excluding exports) follows that seen for the industry as a whole. In practice this may generate a downward bias in the degree of upstream integration of SMEs as in many sectors these provide intermediate parts for larger firms. Future work will look to capitalise on more detailed 4-digit information in SDBS (and in trade statistics) to refine the nature of these assumptions. For example, if SDBS point to a disproportionate production of intermediate products by SMEs, then these results will be incorporated in the subsequent breakdowns.

Another area for future work (for the next updates) will be through the incorporation of national supply-use, as opposed to national input-output tables, to account for possible differences in the degree of secondary production by categories of firms.

In summary, while this methodology introduces data by firm size class with respect to their value added, output, imports and exports, several important assumptions have also been used:

- No product heterogeneity in imports or domestic purchases. Within an industry, small firms use the same products, and in the same proportions, as large firms.
- No preferences by users for purchasing from small or large enterprises. Excluding exports, within an industry, both SMEs and large firms are assumed to provide products to (and purchase products from) other industries (intermediate use) and final consumers in the exact same proportion.

These assumptions can be quite strong – but can also be tested. Section 5 reports on these tests and the robustness of the findings.

3. Data: sources and preparation

The main data sources used to develop the splits in the national IO tables were the OECD Structural and Demographic Business Statistics (SDBS) database (for value added and gross output by industry and firm size) and the OECD Statistics on Trade by Enterprise Characterises (TEC). However, and as noted above, several practical challenges needed to be addressed in preparing these data for use, including for example aligning differences in industry classifications, estimating missing data (e.g. due to confidentiality), and correcting for inconsistencies (e.g. exports in TEC larger than output in SDBS).

In addition, combining primary statistics (trade, business) with national accounts highlights inconsistencies requiring adjustments to the primary statistics in order to develop plausible estimates of extended IO tables, even after carefully considering and correcting for the main conceptual differences. This can be explained for example by the differences in statistical units (for example enterprises in primary data versus establishments in IO tables) and the subsequent consequences for the industry attribution of output and value added (e.g. in the case of secondary production).

This section describes these steps in more detail, providing brief descriptions of the main data sources (3.1), the estimation and imputation methods used to ensure their completeness (3.2) and the approach used to adapt the primary data when inconsistencies with IO tables occurred (3.3).

3.1. Data sources

3.1.1. National Input-Output tables

National Input-Output tables were created by aggregating the ICIO tables that underpin the OECD-WTO TiVA and Nowcast TiVA databases, for the years 2009-2014. The tables cover 34 industries, aggregations of the ISIC Rev 3 classification.

3.1.2. OECD TEC database

The TEC database contains annual international trade in goods data broken down by industry (ISIC Rev 4) and enterprise characteristics, including firm size class (number of employees) and ownership (foreign and domestic), for 26 OECD and 6 non-OECD countries. TEC is estimated by attributing trade flows to enterprises by merging international trade (usually customs data) with business registers via common business identifiers.

For a variety of methodological reasons, certain parts of international trade may not be attributable to an individual enterprise. In TEC, these are classified with characteristics ‘unknown’. When calculating the shares of SMEs and Large enterprises in trade, this category is excluded, as it may cause biases.

To ensure alignment with the IO tables in ISIC 3, the data were converted to this classification using the concordance table provided in Annex B.1.

3.1.3. OECD SDBS Database

The SDBS database provides harmonised information on structural business statistics (and business demography) by industry (ISIC Rev 4) and enterprise characteristics. To ensure alignment with the IO tables in ISIC 3, the data were converted to this classification using the concordance table provided in Annex B.2. Subsequently, the shares of large (and per derivation, smaller) enterprises, defined as those with more than 250 persons employed, in value added and output were directly calculated from the database.

Among the variables in SDBS, the production value and value added most resemble the National Accounts definitions for output and value added respectively. If the production value was not reported, turnover was used. If value added was not reported, the value added at factor costs was used. If no information on value added at all was available, the relative share of small and large firms in gross operating surplus was used.

For the US, data availability in SBDS is limited, and as such additional data on output and value added by industry and firm size were sourced from the economic census data published by the US Census Bureau.

3.2. Data imputations

Given the degree of granularity that is required, countries often have to resort to confidentialising data points in SDBS and TEC statistics. Likewise, given the effort involved to produce (in particular TEC) statistics, timeliness of the information is an issue for certain countries. However, a full set of information is required to disaggregate IO tables according to the method outlined above. Several steps and imputation methods were therefore used in the preparation of the data.

First, only those countries with reasonable SDBS and TEC data coverage at the industry level were selected. However, the reported data still often contained missing values. These missing values were estimated, where possible, using either the aggregate growth rate (e.g. if data for SMEs in one industry were missing in one year but not the next, they were estimated using the total growth of SMEs in that period), or by using the structure of previous years (e.g. if in one year are detailed breakdown was reported but not in the next, the shares from an earlier year were applied to the recent year totals). Data for those detailed ISIC Rev 4 industries that could be aggregated without affecting the ability to map them to the 34 TiVA industries were combined.

Subsequently, the shares of both large and small firms in total industry value added, gross outputs, imports and exports were then calculated based on this data. While relatively straightforward for most industries, this involved several additional steps for business services, due to the fact that TEC data only cover merchandise trade and are therefore not a good approximation to develop a detailed breakdown of trade by firm size class for individual services industries.

To address this issue, the imports and exports by firm size for Construction (41T43), Transportation & storage (49T53), Accommodation & food services (55T56), Information Services & Communication (58T63), Real estate activates (68), Professional, scientific & technical activities (69T75), and Administrative & support (77T82) were combined to calculate a single value of the share of large and small enterprises in the trade for these industries combined. By pooling the data, this estimate of the role of SMEs

in trade is less sensitive to idiosyncratic variations between services industries or over time.

However, information on the role of SMEs in the value added and output of individual services industries *is* available in SDBS, and a simple combination of this information with the broad estimate developed above proved to be sometimes inconsistent. For example, the estimate of the role of SMEs in overall services exports could be 50%, whereas the share of SMEs in output of one particular individual services industry could be as small as 10%. Or vice versa, where the share of SMEs in output and value added is much higher.

Therefore, the aggregate estimate of the share of SMEs in the exports and imports of services industries was then further adjusted for each individual services by aligning it more with the share of small and large enterprises in output. The adjustment followed the intuitive reasoning that if the output of small firms compared to large firms in one particular services industry is much larger than in services industry overall, it can be expected that its role in trade for that industry is also larger than the calculated average. In mathematic notion:

$$X_i^L = \frac{O_i^L X_S^L}{O_S^L}$$

Where X_i^L = the share of large firms in exports of individual services industry *i*,

O_i^L = the share of large firms in output of individual services industry *i*,

A similar calculation was made for imports using output –/– value added instead of output.

In addition to this Services imputation, six other imputation methods were used to complete the dataset of shares of large firms (and as a consequence, small firms) in value added, output, exports and imports, in the following order:

- Simple linear interpolations (labelled as T in Annex C)
- Using TEC export shares as a proxy for value added and gross outputs for agriculture sector (01T03), as data in SDBS for agriculture sector is missing in general (labelled as X in Annex C)
- Mean imputation using country average share*industry average share/world average share for a specific variable (labelled as M in Annex C)
- Correction applied if any imputed shares are greater than 1, then set to the nearest acceptable time series value (labelled as C in Annex C)
- Logic checks: if the share of large or small firms in output is zero, then value added, imports and exports are also set to zero to avoid data conflicts (labelled as L in Annex C)
- And if the entire series is still missing, then large firms' shares in gross output was used to impute all other variables (labelled as O in Annex C).

Annex table C provides a detailed overview of the frequency of all imputations used.

Finally, to remove any idiosyncratic fluctuations in time series, three year moving averages were calculated for all series.

3.3. Treatment of data inconsistencies between primary statistics and National Accounts

As noted above, primary statistics as available in TEC and SDBS are not fully consistent with comparable National Accounts aggregates. As a consequence, an initial application of the methodology can introduce negative values (which with the exception of changes in inventories) should not occur). Three different types of negatives occurred, which were treated in the following ways:

- If a given firm-type's share in value added is relatively high but in gross output relatively low, this may result, when combined with ICIO data that it may not be consistent with, in gross output being lower than value added, which in turn results in the sum of domestic and imported use being e negative. This happened mostly when a particular firm type was not very relevant in an industry, for example, if SMEs were responsible for 4% of output but 8% of value added. In these cases, the distribution of value added is adjusted by lowering the share of the group where negatives occur up to the point where these disappear. To prevent this from happening in the first place, value added-to-output ratios were constrained to not be more than 15 percentage points away from those in the original IO.
- If a given firm-type's share in value added and in imports is relatively high as compared to its share in output, negative values may occur for domestic use of intermediates. In these cases, the distribution of imports is adjusted in a similar way as above for the firm type concerned, again making the other category absorb any differences.
- Finally, if a type of firms' share in gross output is relatively low compared to its share in exports, similar adjustments are made for the export shares.

Among the various other options that were explored, this method ensured that the primary data were only minimally adjusted to ensure that the IO broken down by firm heterogeneity continues to contain only positive figures.

4. Results

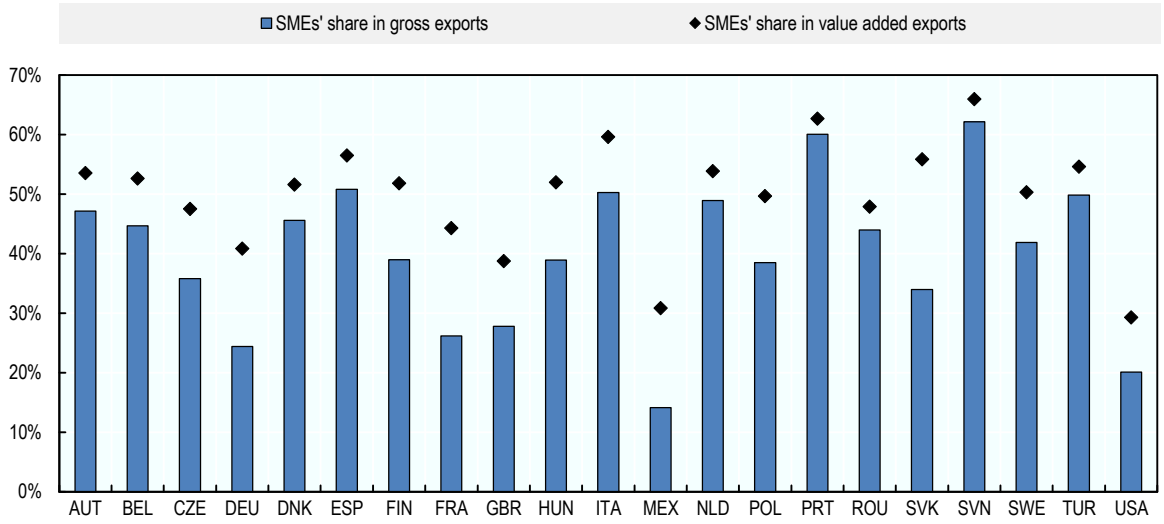
The IO tables extended with firm characteristics that have been created using the methodology and data outlined above can be used to calculate a variety of TiVA indicators for small and large enterprises, including for example the import content of exports, the role of SMEs and large firms in value added exports, all of which are able on shed new light on how different types of firms are engaged in global value chains. This section presents these indicators, comparing the role of SMEs across countries and in different industries.

4.1. SMEs indirectly participate in GVCs

Across OECD countries, smaller firms are generally less directly involved in international trade. This can be explained by a number of factors including economies of scale (which may be exacerbated by more limited access to financing), but also by the disproportionate fixed costs of exporting (e.g. in relation to market research, conforming to foreign regulatory standards, overcoming language barriers etc.). However, comparing the role of SMEs in gross exports and in value added exports, Figure 4.1 shows that the contribution of SMEs to exports is much larger than suggested by traditional statistics.

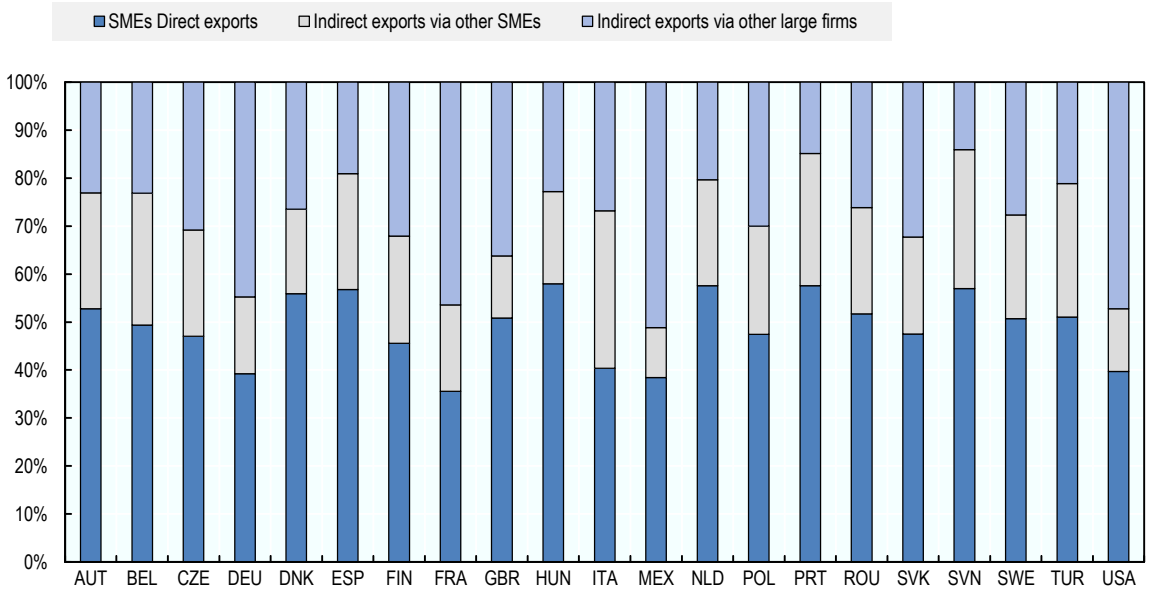
This indicates that while SMEs may indeed have difficulties accessing foreign markets directly, they have important integration channels as suppliers to other, often larger enterprises that subsequently export. This indirect role of SMEs is particularly important in larger economies such as Germany, France, Mexico, the UK and the United States, where the export shares of SMEs in gross terms are much lower in comparison (see Figure 4.1). In contrast, in smaller economies or countries with fewer (very) large enterprises, such as Denmark, Sweden, or Portugal, the differences between the role of SMEs in gross and value added exports is smaller.

Figure 4.1. SME's share in gross exports and value added exports, 2014



Across OECD countries, around half of SMEs exports in value added reaches foreign markets indirectly, implying that the role of exports for SMEs' growth and performance is twice as important as normally considered. Two-thirds of SMEs' indirect exports are channelled to foreign markets via large enterprises, the remaining one third via other SMEs. Again, important differences exist across countries: in Portugal, Italy, Spain and Turkey, but also in Belgium and Austria, more than half of SMEs' indirect exports are channelled through other SMEs.

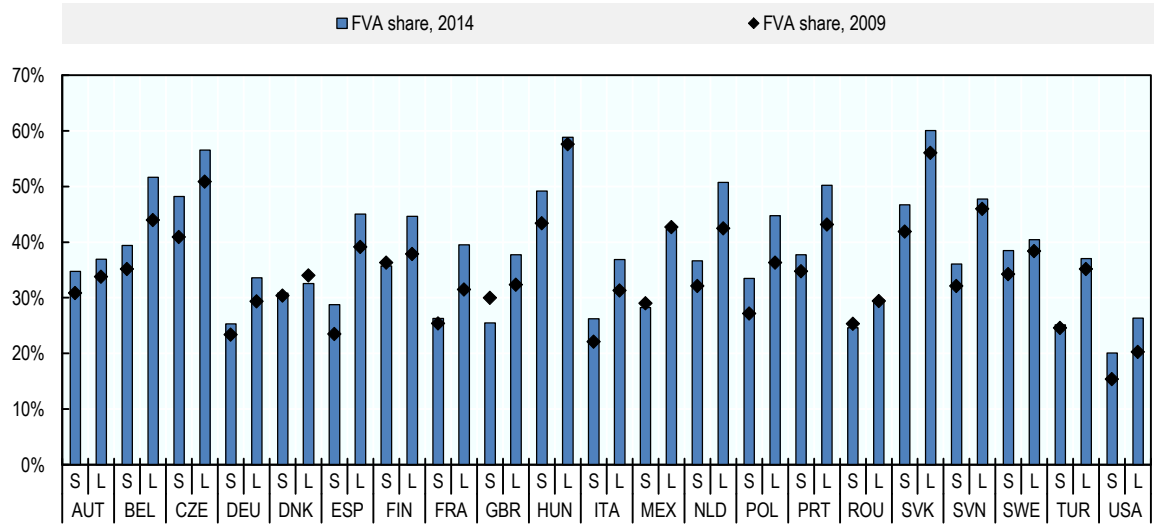
Figure 4.2. SMEs' value added export channels, 2014



4.2. Growing integration in GVCs for both SMEs and large firms since Crisis

Large firms are more directly involved in international trade – exports and imports – compared to their smaller counterparts. Equally, the import content of exports of large firms is also larger than that of SMEs, as indicated in figure 4.3. In nearly all countries and across all industries, the import content of exports was higher in 2014 compared to the low of 2009. Interestingly little difference between the change in engagement in GVCs between large and small firms can be observed.

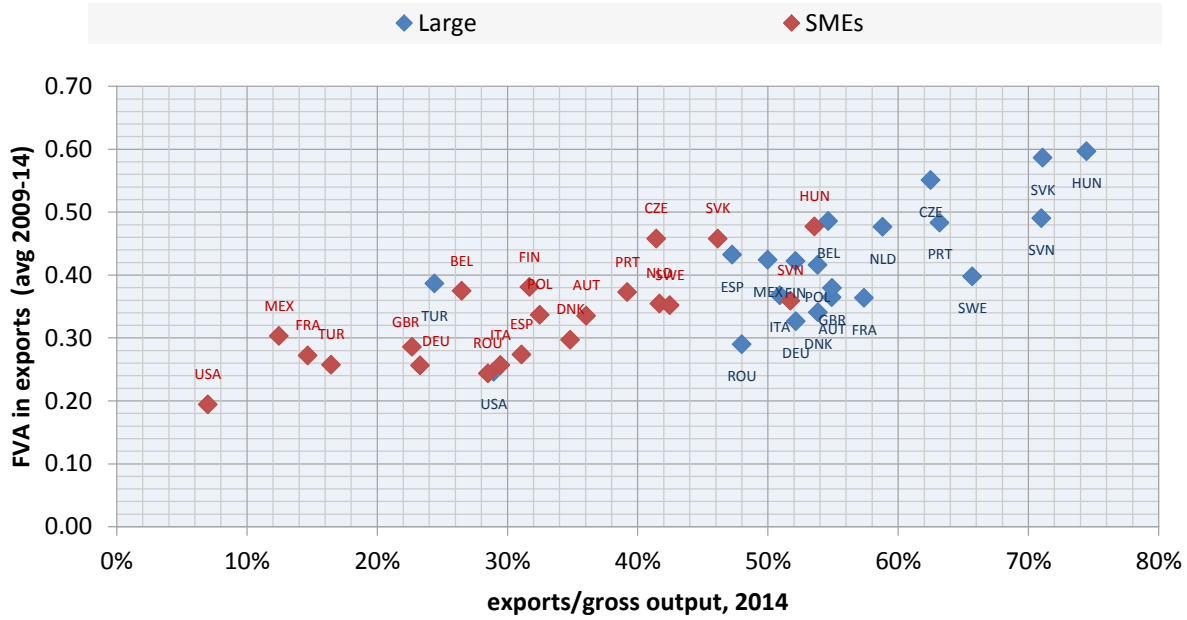
Figure 4.3. Foreign value added content as a share of exports, manufacturing, 2009 and 2014



4.3. Imports and export success: differences between SMEs and large enterprise

One of the main contributions of the OECD-WTO TiVA initiative has been to highlight the importance of imports for export success. Figure 4.5 illustrates that this relationship holds for both small and large enterprises across OECD countries: export intensive firms typically also have a higher import content of exports. Large firms score higher on both dimensions than smaller firms, a sign of their capabilities to reach overseas markets and source inputs efficiently from abroad. This also illustrates that SMEs, in addition to facing larger barriers to export, have difficulties in overcoming some of the costs associated with importing – and integrating in GVCs more generally - such as finding reliable suppliers and ensuring that the imported products have the right specifications.

Figure 4.5. foreign value added content of exports and export intensity



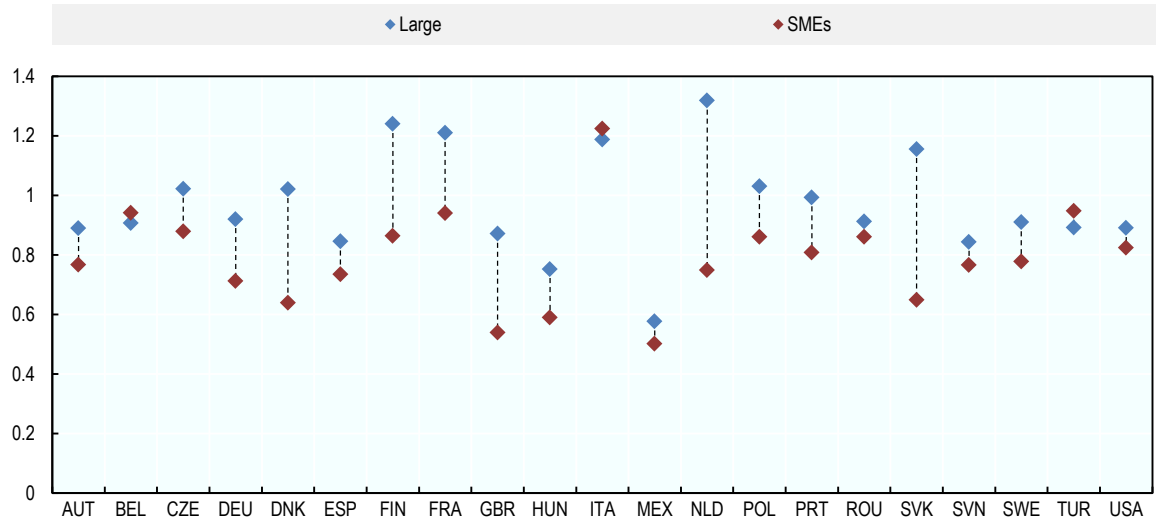
4.4. Greater upstream spillovers from large enterprises

Large enterprises have significant upstream supplier chains. Across OECD countries, each unit of value added by large firms generates roughly the same amount of value-added in upstream suppliers (Figure 4.6). This partly reflects the stronger focus of large firms on their core business functions but also in part their position in value chains, which is typically downstream, at least compared to other firms in the economy. Smaller firms have smaller multipliers and generate on average 0.8 units of additional upstream value added for each unit of value added produced, as they are less likely to outsource parts of production or auxiliary business processes.

The finding that large firms generate relatively more upstream value added is particularly interesting in combination with the results in 4.3, that larger firms also have a higher import content of export, since these two are typically considered to be mutually exclusive. In contrast, the findings presented here suggest that higher import content of exports can go hand in hand with strong domestic supply chains.

Figure 4.6. Backward linkage of firms' production, 2014

By firm size



5. Robustness checks

While the findings presented in section 4 provide interesting insights on the role of SMEs and large firms in global value chains, the fact that these have been derived from extended IO tables that were partially generated using assumptions, raises questions regarding their robustness Three main assumptions have been used that will be tested here:

- *no substitution effects* between imports and domestically purchased products by large and small firms (i.e. while the share of imports in purchases differs across firms, the product baskets in imports and in domestic purchases do not);
- *no use preference* in the sense that the production of small and large firms is proportionally attributed to intermediate and final demand (excluding exports); and
- *no supplier preference* in that firms have no preference to purchase from either smaller or large enterprises.

This section aims to test the sensitivity of the results to these assumptions[1]. Instead of using proportionality assumptions, extremes are explored. Combinations of maximum and minimum assumptions result in several alternative extended IO tables by firm size; and consequently different estimates for TiVA indicators. Comparing the results for all possible scenarios for key TIVA indicators by firm characteristics, such as import content of exports and the direct and indirect exports of Value Added gives insights into how sensitive the findings presented in section 4 are to changes in assumptions by providing broad upper and lower bounds.

The first assumption modified, and simulated below, relates to the distribution of output across intermediate and final use categories. The proportionality assumption implies that large firms have the exact same sales structure as smaller ones. However, it may be that within the same industry, larger firms are more successful at supplying final consumers and SMEs are mainly involved as upstream suppliers to other firms, or vice versa. In the robustness tests below, values for each scenario were determined by either maximising large firms' sales for intermediate use (and minimising the share for final use), and vice versa.

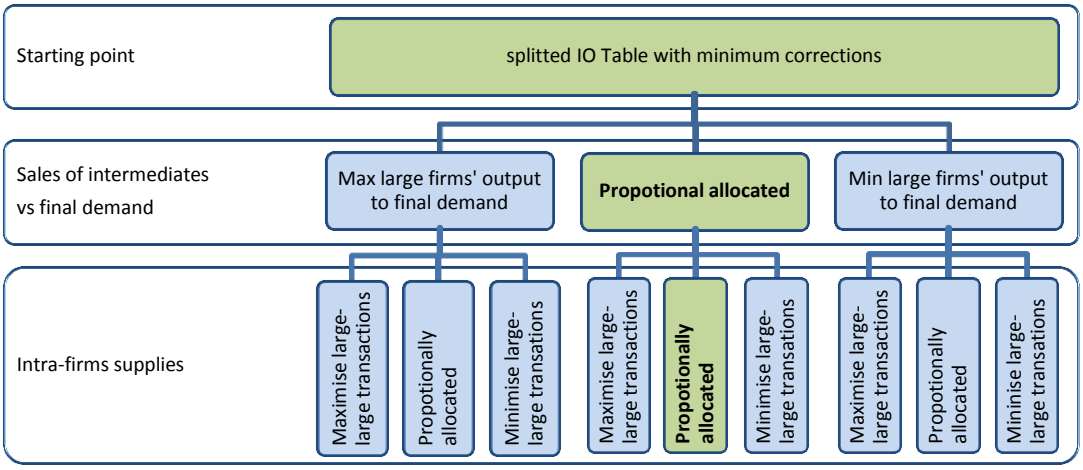
The second assumption that was modified introduced variation in the *supplier bias*. The proportionality assumption implies that neither SMEs nor large firms have a preference

[1]*No substitute effect* assumption will not impact key indicators listed above, as this doesn't alter the import constraints in IO. Therefore we design the experiments to only target the latter two proportionality assumptions, namely no use preference and no supplier bias.

for purchasing from other small or large enterprises. While quality statistical information about these relationships would represent a 'holy grail' in the creation of (heterogeneous) IO tables, this would typically only be possible to obtain via detailed surveys, or for example VAT declarations that included VAT counterpart information. In the two extreme cases that were tested, large firms' purchases from other large firms were either maximised or minimised (again within the constraints provided by the row and column totals of the extended IO tables), which in parallel minimises or maximises SMEs inputs from large firms.

Combining the two modifications above with the proportionality assumption results in 9 different scenarios to generate an extended IO table, as depicted in Figure 5.1. The results presented in section 4 form the 'middle' scenario highlighted in green.

Figure 5.1. Robustness tests: overview of the 9 scenarios

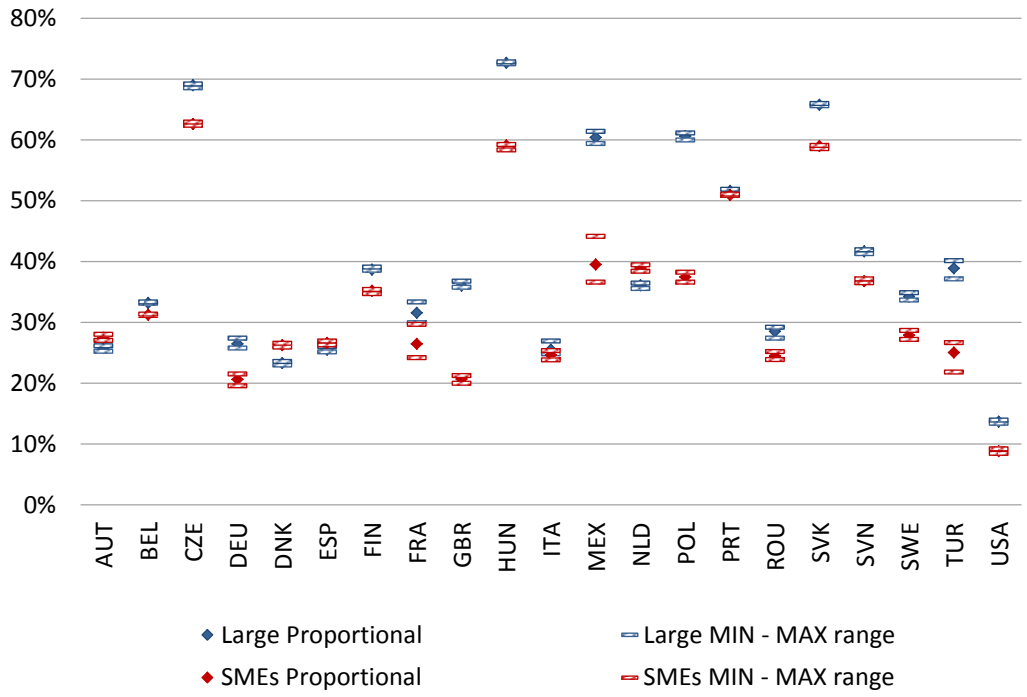


Note: Results in section 4 follow the middle, green-shaded option

Calculating the import content of exports under each of these scenarios, Figure 5.2 highlights the 'mid-point' estimates as presented in section 4, as well as minimum and maximum values calculated based on the simulations for the other eight scenarios for total economy. At this level of aggregation, the result are not very sensitive to the proportionality assumptions used, and certainly not for the main conclusion that large firms have a higher foreign value added content of exports compared to small firms. The largest differences occurred for France, Turkey, and Mexico, with up to 5 percentage points variation in the estimates.

Figure 5.2. Mid-point estimate and possible range for foreign value added content of exports in exports

2014, by firm size



The estimates are also relatively stable at the industry level and over time between 2008 and 2014. Figure 5.3 illustrates this with examples for France and Mexico, for *Food, beverages and tobacco* (C15T16), *Chemicals and chemical products* (C24), and *Computers, electronics and optical products* (C30T33X). These two countries are the ones with largest variations in foreign value added content of exports, as highlighted above. But also at the industry level, the range between the minimum and maximum import content of exports remains relatively small. The largest range is found for Mexico's SMEs in Computer and electronics industry (around 9 percentage points). For France, the differences between maximum and minimum estimates typically do not exceed the 5 percentage points.

Figure 5.3. Foreign value added content of exports as a share of total exports, with simulated boundaries

Selected industries for France and Mexico, by firm size

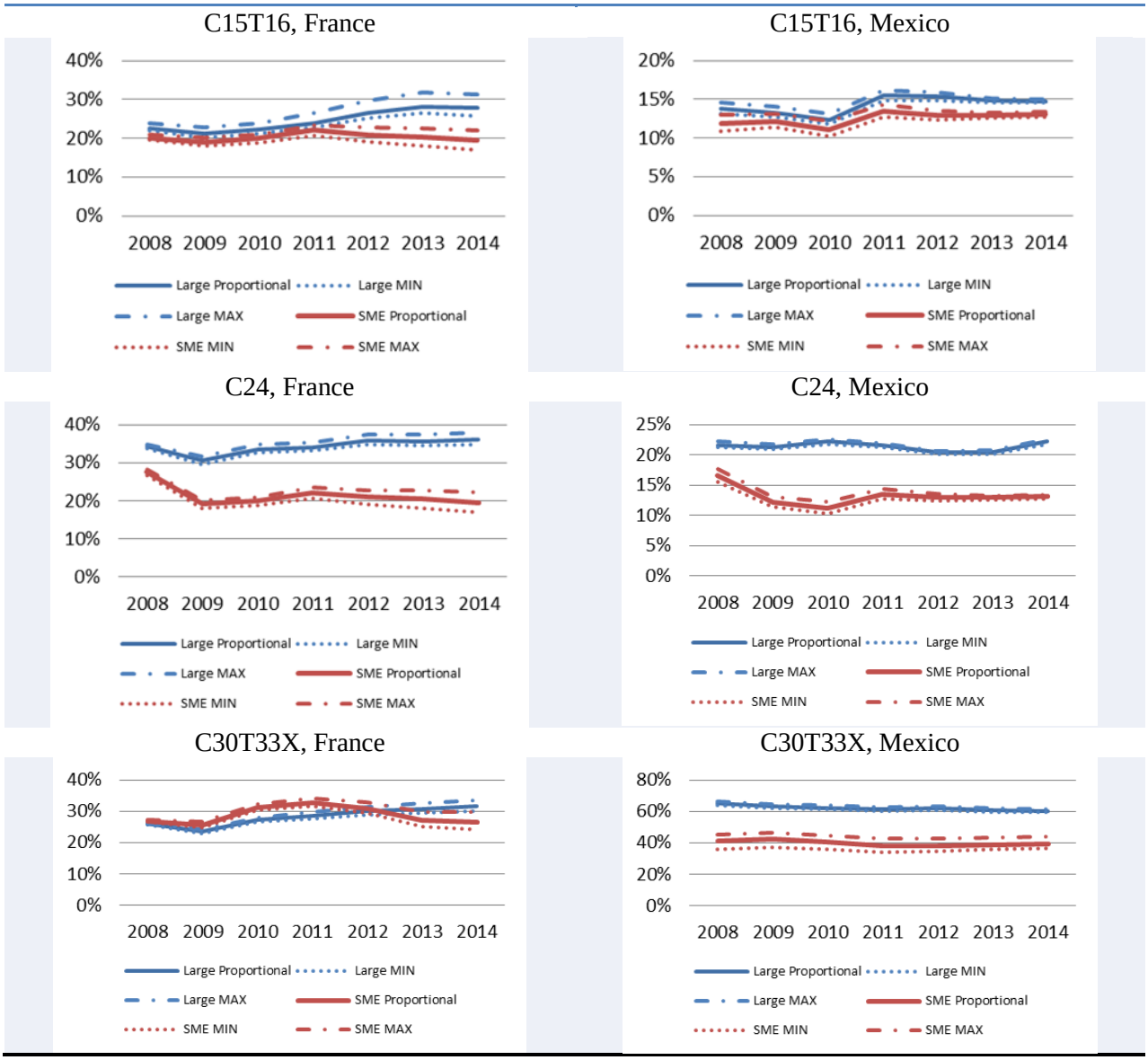
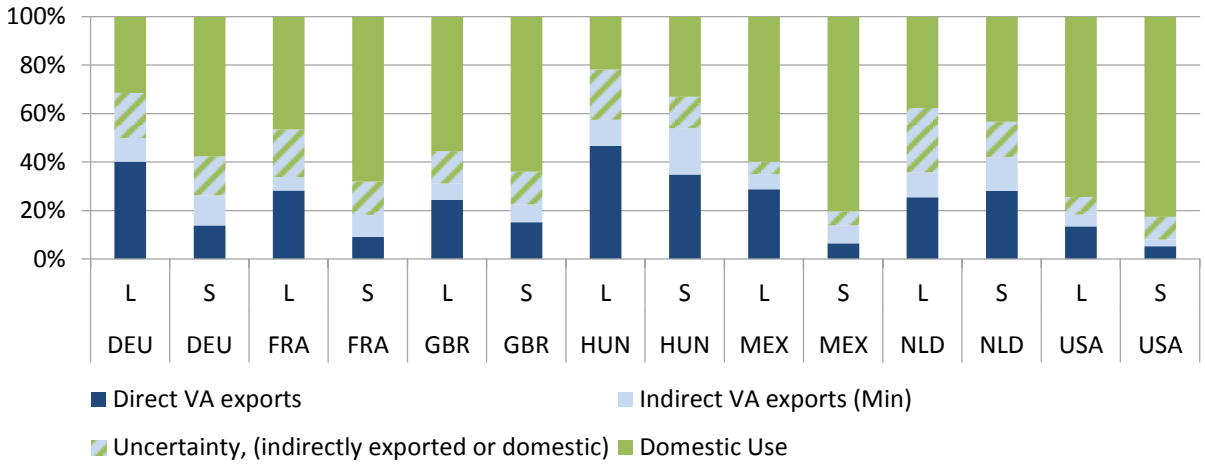


Figure 5.4 illustrates the impact of the different scenarios on the channels through which the exported value added of SMEs and of large enterprises reaches their final markets. Not surprisingly the directly exported value added is not susceptible to variation across the different scenarios however, indirect estimates are affected. The shaded area in the graph indicates the range of uncertainty as to the importance of each of these channels. For example, for small firms in Germany, the figure illustrates that 14% of SMEs' value added is exported directly, 12% *at least* is exported indirectly, 58% *at least* is used domestically, and that there is uncertainty for 16% of value added as to whether it is exported indirectly or used domestically. The variation in these estimates is as expected

larger than for the import content of exports, but not to the extent that they change the overall messaging, and it should be recalled that the ranges reflect extreme upper and lower bounds.

Figure 5.4. Export channels robustness test: uncertainty range for indirect exports and domestic sales

2014, for selected countries, by firm size



6. Conclusion

The development of statistics and analyses of Global Value Chains have so far predominantly focused on the role of countries and industries. However, it is well-established that within industries, firms may have very heterogeneous production functions depending on for example their size or ownership, and may differ therefore strongly with respect to their engagement in GVCs.

This paper presented a simple methodology to develop measures on the roles of different types of firms in GVCs, by disaggregating Input-Output tables using established official data sources on linked trade and business statistics, in a transparent manner – i.e. without having to resort to mathematical rebalancing of the Input-Output tables. While illustrating its use and robustness by examining the role of SMEs in GVCs, this methodology can equally be applied to other types of firm characteristics, such as ownership, and to Supply and Use tables as much as to IO tables.

The results in this paper show that SMEs and large firms engage differently in global value chains – not only in terms of their trade patterns, but also in their impact on upstream activities within the host country. The results indicate for example that while SMEs are less frequently *directly* involved in international trade, in value added terms, their contribution to exports is much larger than suggested by traditional statistics, as they supply other, often larger enterprises that subsequently export. This effect is greater in countries with larger domestic markets, where large firms dominate international trade.

On average around two-thirds of the *indirect* exports of SMEs are channelled to foreign markets via large enterprises – although in some (smaller) countries, the share of indirect exports of SMEs via *other SMEs* may be more than half of the total indirect exports.

Finally, the data illustrate how large firms, while more export intensive *and* with a higher import content of exports, *simultaneously* also have relatively larger upstream consequences as compared to smaller firms, likely as a consequence of their focus on core business activities and the comparatively lower likelihood of SMEs to outsource parts of production or auxiliary business processes. A higher import content of exports can therefore go hand in hand with strong domestic supply chains.

In addition to providing insights on the role of SMEs in GVCs across OECD countries for the 2008-2014 period, an additional important contribution of this paper involves the explicit tests for the robustness of the findings. Disaggregating SUTs *post hoc* always involves the use of assumptions, in the absence of more detailed information on for example how output of different types of firms within an industry is consumed by different end-use categories, with respect to differences in the product composition of imports and domestic purchases, and on the intermediate use relationships between different types of firms. This paper has stretched these assumptions to their extremes, and illustrated their impact on the key TiVA indicators by firm size.

While – as to be expected – the variation in assumptions had a negligible effect on the overall import content of exports for SMEs and large firms, greater variation was observed for the domestic intermediate use relationships between different types of firms – even if the overall conclusions were not affected.

The challenge of moving *beyond* assumptions, i.e. to develop statistics on these inter-firm supply relationships, is recognised as well by the CSSP Expert Group on Extended Supply and Use tables, and indeed information on how businesses provide intermediate inputs to other firms provides the foundation for a more precise intermediate use matrix, also for SUT and IO tables that do *not* include extensions by firm characteristics. Work is therefore ongoing by the CSSP Expert Group to develop the techniques at the national level to refine such estimates, taking advantage of both being able to use more granular SUTs as well as the internally available linked microdatasets (without confidentiality constraints).

A further step would be to also include more detailed partner dimensions in these extended tables, to allow for an (improved) integration of extended SUTs and IOs into global Supply and Use tables, and examine the differences in the geographical spread of GVCs engagement by different types of enterprises.

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Annex A. Numerical examples

This Annex provides a 3-sector numerical example for each of the 5 methodological steps outlined in section 2.

A.1. Step 1: Value added and gross outputs by firm size

Label		Industry 1	Industry 2	Industry 3
Observed data	Value added (from IO table)	100	50	200
	Output (from IO table)	500	80	400
	Large firm's shares of value added (from SDBS)	55%	30%	40%
	Large firm's shares of output (from SDBS)	60%	40%	50%
Derived	Value added by SMEs	45	35	120
	Output by SMEs	200	48	200
	Value added by large firms	55	15	80
	Output by large firms	300	32	200

A.2. Step 2: Import matrix by firm size

Label			Industry 1	Industry 2	Industry 3
Observed	Import matrix (from IO)	Source Industry 1	10	0	0
		Source Industry 2	40	20	0
		Source Industry 3	15	0	90
	Large firms' share in imports*		80%	50%	70%
Derived	Import matrix, SMEs	Source Industry 1	2	0	0
		Source Industry 2	8	10	0
		Source Industry 3	3	0	27
	Import matrix, Large firms	Source Industry 1	8	0	0
		Source Industry 2	32	10	0
		Source Industry 3	12	0	63

* After wholesale adjustment

A.3. Step 3: Intermediate use matrix by firm ownership

Label			Industry 1	Industry 2	Industry 3
Derived data from step 1&2	Output by SMEs		200	48	200
	less value added by SMES		45	35	120
	less imports by SMEs		13	10	27
	= Intermediate use by SMEs (1)		142	3	53
	Output by large firms		300	32	200
	less value added by large firms		55	15	80
	less imports by large firms		52	10	63
	= Intermediate use by large firms (2)		193	7	57
	Calculated: large firms' share of intermediate use (2)/(1)+(2)		58%	70%	52%
Observed data	Intermediates use matrix (from IO table)	Source Industry 1	300	1	15
		Source Industry 2	10	9	5
		Source Industry 3	25	0	90
Derived	Of which, SMEs	Source Industry 1	127.2	0.3	7.2
		Source Industry 2	4.2	2.7	2.4
		Source Industry 3	10.6	0.0	43.4
	Of which, large firms	Source Industry 1	172.8	0.7	7.8
		Source Industry 2	5.8	6.3	2.6
		Source Industry 3	14.4	0.0	46.6

A.4. Step 4: Exports by firm ownership

Label		Source Industry 1	Source Industry 2	Source Industry 3
Observed data	Exports (from IO table)	100	30	150
	Large firm shares of exports*	20%	30%	40%
Derived	Exports by SMEs	80	21	90
	Exports by large firms	20	9	60

*After wholesale adjustment

A.5. Step 5: Final demand by source of origin

			Source Industry 1	Source Industry 2	Source Industry 3
Derived data from step 1&4	Output by SMEs		200	48	200
	less exports of SMEs		80	21	90
	= Intermediate and final demand use, SMEs (1)		120	27	110
	Output by large firms		300	32	200
	less exports of large firms		20	9	60
	= Intermediate and final demand use, large firms (2)		280	23	140
	Calculated: Intermediate and final demand use, share of large firms (2)/(1)+(2)		70%	46%	56%
Observed data	Final demand (from IO table)		89	21	135
Derived	Final demand	from SMEs	26.7	11.3	59.4
		from large firms	62.3	9.7	75.6

Annex B. Concordance tables

B.1. Conversion table from ISIC rev. 4 to 3

ISIC4	Description in ISIC4	ISIC3	Description in ISIC3
D01T03	Agriculture, forestry and fishing	C01T05	Agriculture, hunting, forestry and fishing
D05T09	Mining and quarrying	C10T14	Mining and quarrying
D10T12	Food, beverages and tobacco	C15T16	Food products, beverages and tobacco
D13T15	Textiles, wearing apparel, leather and related products	C17T19	Textiles, textile products, leather and footwear
D16	Wood and products of wood and cork, except furniture; articles of straw and plaiting materials	C20	Wood and products of wood and cork
D17T18	Paper and printing	C21T22	Pulp, paper, paper products, printing and publishing
D19	Coke and refined petroleum products	C23	Coke, refined petroleum products and nuclear fuel
D20T21	Chemical and pharmaceutical products	C24	Chemicals and pharmaceutical products
D22	Rubber and plastics products	C25	Rubber and plastics products
D23	Other non-metallic mineral products	C26	Other non-metallic mineral products
D24	Basic metals	C27	Basic metals
D25	Fabricated metal products except machinery and equipment	C28	Fabricated metal products except machinery and equipment
D26	Computer, electronic and optical products	C30T33X	Computer, electronic and optical products
D27	Electrical equipment	C31	Electrical machinery and apparatus n.e.c
D28	Machinery and equipment n.e.c.	C29	Machinery and equipment n.e.c
D29	Motor vehicles, trailers and semi-trailers	C34	Motor vehicles, trailers and semi-trailers
D30	Other transport equipment	C35	Other transport equipment
D31T33	Other manufacturing; repair and installation of machinery and equipment	C36T37	Manufacturing n.e.c; recycling
D35T39	Electricity, gas, steam and air conditioning supply, water supply	C40T41	Electricity, gas and water supply
D41T43	Construction	C45	Construction
D45T47	Wholesale, retail trade and repair	C50T52	Wholesale and retail trade; repairs
D55T56	Accommodation and food service activities	C55	Hotels and restaurants
D49T53	Transportation and storage	C60T63	Transport and storage
D58T61	Telecommunication	C64	Post and telecommunications
D64T66	Financial and insurance activities	C65T67	Finance and insurance
D68	Real estate activities	C70	Real estate activities
D77T82	Administrative and support service activities	C71	Renting of machinery and equipment
D62T63	Information and services	C72	Computer and related activities
D69T75	Professional, scientific and technical activities	C73T74	Research and development & Other

			Business Activities
D84	Public admin., defence; social security	C75	Public admin. and defence; compulsory social security
D85	Education	C80	Education
D86T88	Human health and social work activities	C85	Health and social work
D90T93	Arts, entertainment and recreation	C90T93	Other community, social and personal services
D94T96	Other service activities	C95	Private households with employed persons

B.2. CPA to ISIC rev. 3

CPC	Commodity Group	Industry
01_04	Agriculture, forestry and fishery products	C01T05
11_16	Mining and quarrying	C10T14
17	Electricity, town gas, steam and hot water	C40T41
21_23	Food products	C15T16
24	Beverages	C15T16
25	Tobacco products	C15T16
26_27	Textiles	C17T19
26	Yarn and thread; woven and tufted textile fabrics	C17T19
28	Knitted or crocheted fabrics; wearing apparel	C17T19
29	Leather and leather products; footwear	C17T19
31	Products of wood, cork, straw and plaiting materials	C20
32	Pulp, paper and paper products; printed matter	C21T22
33	Coke oven products; petroleum products; nuclear fuel	C23
34_35	Chemicals	C24
34	Basic chemicals	C24
35	Other chemical products; man-made fibres	C24
36	Rubber and plastics products	C25
37	Glass and glass products, other non-metallic n.e.c.	C26
38	Furniture; other transportable goods n.e.c.	C36T37
39	Wastes or scraps	C40T41
41	Basic metals	C27
42	Fabricated metal products	C28
43-44-46	Machinery and equipment	C29
46	Electrical machinery and apparatus	C29
45-47-48	Computer, electronic and optical products	C30T33X
45	Office, accounting and computing machinery	C30T33X
48	Medical appliances, precision and optical instruments	C30T33X
49	Transport equipment	C34
TOTAL	Total	TOTAL
UNSPE	Not elsewhere specified	Unknown

Annex C. Imputed TEC and SDBS data

Table A C.1. Imputations methods used, by variable, country and firm size, 2008-2014

Variable	Country	C	L	M	O	S	T	X	% of data imputed
large firms' share in value added	AUT			14					7%
	BEL			14			2	7	11%
	CZE			7			1	7	7%
	DEU			7			2	7	8%
	DNK			14			5		9%
	ESP						1	7	4%
	FIN			21			2		11%
	FRA							7	3%
	GBR							7	3%
	HUN			14				7	10%
	ITA			7			7		7%
	MEX	4					141		69%
	NLD			14			9	7	14%
	POL						3	7	5%
	PRT			14			4	7	12%
	ROU			7				7	7%
	SVK			28				7	17%
	SVN			14			10		11%
	SWE						8	7	7%
	TUR						36	7	20%
	USA			7			144		72%
large firms' share in gross outputs	AUT			14					7%
	BEL			14			2	7	11%
	CZE			7				7	7%
	DEU							7	3%
	DNK			14					7%
	ESP							7	3%
	FIN			21					10%
	FRA							7	3%
	GBR							7	3%
	HUN			14				7	10%
	ITA			7					3%
	MEX	4					141		69%
	NLD			14			7	7	13%
	POL							7	3%
	PRT			14				7	10%
	ROU							7	3%
	SVK			28				7	17%
	SVN			14			8		10%
	SWE							7	3%
	TUR		11				25	7	20%

	USA			7			144	72%
large firms' share in imports	AUT			7		42		23%
	BEL	2		7		35		21%
	CZE					36	8	21%
	DEU					24	44	32%
	DNK		7			42	9	28%
	ESP	8				42		24%
	FIN	1		21		30	13	31%
	FRA	11				38	8	27%
	GBR	2				36	12	24%
	HUN					36	28	30%
	ITA	6		7	7	39	5	30%
	MEX	1		76	7			40%
	NLD			7		30	37	35%
	POL	6				42		23%
	PRT	1		7		42		24%
	ROU					36	8	21%
	SVK	5		20		28	1	26%
	SVN		14	21		42		37%
	SWE			14		42	4	29%
	TUR	3	11		7	27	11	28%
	USA			42	7	1	30	38%
large firms' share in exports	AUT			14		42		27%
	BEL	1		7		35		20%
	CZE					42		20%
	DEU					36	28	30%
	DNK		7	7		42	5	29%
	ESP					42		20%
	FIN			21		30	16	32%
	FRA	9				39	7	26%
	GBR	5				40	3	23%
	HUN					36	28	30%
	ITA	4		14	7	22	20	32%
	MEX			77	7			40%
	NLD			7		36	28	34%
	POL	2				42		21%
	PRT	1		14		42	2	28%
	ROU	1				42		20%
	SVK	8		25		27	5	31%
	SVN		14	21		42		37%
	SWE			21		42	6	33%
	TUR	1	11			33	7	25%
	USA				35	4	43	39%

Note: Observation count is based on industries in ISIC rev. 4. Imputation flags: C: corrected after mean imputation; L: logic check; M: mean imputation; O: gross output share used in absence of other data; S: services imputation for imports and exports shares only; T: time series imputation and X: exports imputation for value added and gross outputs in Agriculture sector.

Table A C.2. Percent of data corrected with nearest possible solution

2008-2014

	gross output shares	value added shares	Import shares	Export shares
AUT		11%	3%	1%
BEL		15%		4%
CZE		17%		4%
DEU		1%	3%	3%
DNK		6%	4%	1%
ESP		2%		2%
FIN		9%	7%	8%
FRA		5%	1%	3%
GBR		4%		1%
HUN		16%	1%	3%
ITA		15%	2%	
MEX		19%	2%	6%
NLD		4%		5%
POL		21%	1%	0%
PRT		5%		1%
ROU		29%		3%
SVK		22%	7%	8%
SVN		12%	4%	10%
SWE		9%	2%	5%
TUR	1%	27%	1%	
USA		12%	0%	