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## Working Party on International Trade in Goods and Trade in Services Statistics

# FIRM HETEROGENEITY AND TRADE IN VALUE ADDED

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*This paper discusses how international, firm-level databases can be used to relax the assumption of homogeneity within industries of current trade in value added indicators. Combining data on exports, imports and production by firm type, the analysis confirms that the import content of exports is likely to be under-estimated because of the homogeneity assumption.*

*The paper also illustrates a simple method to integrate information on the distribution of firms by size and ownership into standard input-output or supply-use tables. Input-output tables split by firm type yield relevant insights into the role of different types of firms in global value chains.*

*Agenda item 5.3*

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# FIRM HETEROGENEITY AND TRADE IN VALUE ADDED

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## 1. Introduction

1. Up to two-thirds of the volume of international trade is accounted for by shipments of intermediate inputs (Johnson and Noguera, 2012). Traditional trade statistics count these intermediate goods at full value each time they cross the border, thus attributing the full commercial value of the product to the last country of origin no matter the real contribution of this country to its production.

2. The WTO-OECD Trade in Value Added (TiVA) database describes the position of countries in global production better than standard trade data by identifying the contributors and ultimate destination of the value embodied in final products. The measurement of value-added flows in TiVA has required the development of a new data infrastructure based on the linkage of input–output (I/O) tables and bilateral trade data. The resulting global input–output table describes how sectors in each destination country purchase intermediates from other sectors both at home and in foreign countries, as well as how each country sources final goods.

3. TiVA estimates had to rely on some simplifying assumptions because of the unavailability of data explicitly designed to trace international value-added flows. A key simplification posits the homogeneity of firms within industries; in other words, all firms within the same industry are assumed to have the same production technology and use the same proportion of imported materials. This assumption facilitates the analysis reducing the set of interactions that need to be measured through an input-output framework.

4. However, homogeneity is inconsistent with the substantial variation in productivity, capital and skill intensity observed across firms within narrowly defined industries (Bernard et al., 2007). In particular, exporting firms differ along many dimensions from firms that only serve the domestic market. Competitive advantages such as larger size, capital or skill-intensity explain why only a minority of firms are selected to enter and survive in the international market. Neglecting this heterogeneity might introduce a structural bias in the TiVA estimates, since the import and the export orientation of firms are correlated, i.e. firms that export tend to make a more intensive use of imported inputs.

5. Relaxing the homogeneity assumption is not straightforward, given that all the data used in TiVA are aggregated according to industry or product classifications, and not along firm characteristics. This paper provides a first attempt to open the black-box of firm heterogeneity and trade in value added, using supplemental data on characteristics of firms within each industry from different firm-level databases. We focus on two relevant dimensions of heterogeneity, the size of the firm and its domestic or foreign ownership. Combining at the macro level information on imports, exports, production and value added by firm type, the paper confirms that large and foreign-owned firms have a dominant position in global value chains (GVCs), often accounting for more than half of the foreign value embodied in countries' exports. The weight of these top-traders in overall use of intermediate imports varies greatly across countries and across industries.

6. The paper also illustrates a simple method to integrate information on the distribution of firms by size and ownership into standard input-output or supply-use tables. The method splits the industry rows and column values of the domestic and import I/O tables by firm size (or by ownership) according to the size distribution of output, value added, domestic and foreign inputs as measured in the enterprise-level databases. The most problematic issue of such a split is that we need to assume that transactions between different firm types are proportional to the share of each type over total inputs or output. We do not know whether, for example, large firms purchase their inputs prevalently from other large firms, and we thus assume that they are indifferent about the type of firm they purchase from. This method also implicitly

requires that the firm-level databases and national input-output tables are totally consistent, i.e. they cover the same population and refer to the same statistical units.

7. The estimates presented in this paper reflect the limits of the available data. Despite these issues, the findings show clearly that the assumption of a representative firm within each industry is very likely to cause downward-biased estimates of the foreign-content of exports. This justifies further work to identify ways to increase the granularity of the data used for TiVA.

8. In particular, the production of extended supply and use table that disaggregate the industry information by export intensity, foreign-control and size might significantly improve the quality of the TiVA estimates. Moreover, a heterogeneous, global I/O matrix would provide highly policy-relevant information on the effects of the location and production arrangements of top traders on countries competitiveness, as well as on the linkages between these top, "direct" traders and the domestic producers that "indirectly" sustain the global value chains. Preliminary estimates based on I/O table split by size suggest that the dominance of large and foreign firms in gross exports and imports co-exist with a leading role of SMEs as providers of intermediate inputs for exports.

9. The following section describes the datasets that have been combined for this study. Section 3 presents descriptive statistics on the importance of heterogeneity dimensions such as size and ownership for explaining the extensive and intensive margins of trade. Section 4 develops methods to disaggregate TiVA-like indicators by firm-characteristics, using linked firm-level data or split input-output tables. Section 5 concludes with a discussion of the data developments that are needed to produce more robust estimates of trade in value added by enterprise characteristics.

***Main conclusions and points for consideration by WPTGS delegates***

10. This paper clearly illustrates the relevance of statistics based on linked firm-level information (such as TEC, FATS, as well as SBS) for the analysis of global value chains. The information contained in these data can be used to produce relevant indicators of the heterogeneity of the firms that directly or indirectly shape the international chains of production. Moreover, the integration of these firm-level data with national or global input-output tables is a meaningful exercise for two reasons: 1) it enables verifying the sensitivity of TiVA indicators to the assumption of homogeneity of firms within industries; 2) it opens new frontiers in the analysis of interactions between different players in the value chains, with very relevant policy implications.

11. The measures that are presented in this paper – including the direct and indirect vertical specialization by firm type, as well as the estimates of indirect exports of SMEs – should however be considered as experimental and preliminary. They are developed under relatively strong assumptions, and are hampered and possibly even biased due to missing data and inconsistencies across the different underlying databases[1]. Part of these inconsistency issues can be effectively addressed by incorporating the currently ongoing work on the integration of various firm-level sources of information (see also the proposal in STD/CSSP/WPTGS(2015)19). In addition, a better understanding of how firm-level information is incorporated in national account data would be advantageous.

[1] Confidentialised data for the largest size class and for foreign-owned firms is one of the key sources of uncertainty in the estimates presented in this paper. Input-output tables describe the full structure of interactions in an economy: the split of the tables by firm types requires the availability of production and trade share for all industries, including agriculture and non-market services.

*Further improve harmonization of different sources of statistics*

12. The production of meaningful and high-quality indicators related to the roles and positions of different types of firms in the process of internationalization and in global value chains requires a combination of information on the trade, investment (ownership) and production structures of firms. The analysis in this paper shows however that a combination of existing statistics such as TEC, FATS, SBS and national accounts, at the level at which the data are published, is not only very difficult (missing data, different classifications), but also often highlights inconsistencies (i.e., more exporting firms than enterprises in an industry, or very large shares of imports by SMEs in the coke and oil industry).

13. In order to ensure that all these data are made consistent, an integrated 'micro data warehouse', with the business register at its core, would be ideal. This would not only be of benefit for the development of indicators related to globalization (or many other policy questions), but also increase the quality of individual statistics, and would facilitate the subsequent integration of this information in e.g. the national accounts. Steps towards establishing such a warehouse direction have been taken in several countries. Still, also much less ambitious projects, such as the recent addition to the TEC questionnaire of the breakdown by foreign ownership, have been shown to greatly increase the analytical and policy relevance of the database.

*Additional data needs*

14. Based on linked trade and business statistics, a variety of indicators could rather easily be made available that would support the types of work presented in this paper. For example, one of the limitations encountered in this paper was the lack of data on trade by firm type and product. More solid indicators of differences by firm size in the use of imported inputs could be developed if data on imports *by firm size and by product* were available. This type of information would allow an easier and more reliable links with supply and use tables. These ideas are also summarized into a proposal for a pilot data collection as presented in STD/CSSP/WPTGS(2015)19.

15. In addition to the pilot data collection that is proposed, countries could consider to what extent it is possible to crossing some of the dimensions, such as industry and firm ownership. For example, an extension of the country-by-country analysis in this paper towards a multi-country setting, would require data on exports of foreign owned by industry of origin and country of destination. Finally, the quality of the linking of TEC data with I/O or supply and use tables will greatly improve when trade in service data by enterprise characteristics will become available.

*Improvement in TEC statistics and metadata*

16. TEC statistics are one of the most successful experiments of data integration. It has grown into a standard statistical product, developed and used in OECD and non-OECD countries. Going beyond traditional descriptive analysis, this paper showed that TEC can also be used for measuring the use of imported goods shows, and can thereby help improve (or make available) other data products, such as import flow matrixes. However, improvements in TEC are still possible (and often already in progress).

- The use of TEC data is often hindered by the share of "unknown trade" (i.e. trade that could not be matched to firms in the business register). Future work on TEC might try to better document the factors that impact this share, and, if possible, provide indications of how this share may be distributed across firm type.

- The country coverage of TEC statistics is growing, but not still not sufficient. A wider use of the TEC data can help reinforce the case for investing in the linkage of trade transaction records and

business registers. Also, recent experiences at WPTGS members have shown that surveys may be a good alternative source to produce many of the relevant indicators, and alternative statistical matching methods could also be explored.

## 2. Available macro data measuring the heterogeneity of international traders

17. The ideal starting point to analyse how heterogeneous firms select the sources of their inputs for their export and domestic production would be a micro-database with information on the values and partners of the domestic and external transactions in intermediate and final products of each firm. Unfortunately, firm-level micro-data with detailed information on the inputs purchased for production are difficult to access. Moreover, even if accessible, these data do not generally inform about the domestic or foreign origin of the input and about whether the input is used for export or for domestic production.

18. This paper thus combines aggregated data on characteristics of enterprises from different firm-level data sources. All these data can be linked to input-output tables through the common industry classification. The advantage of this approach is that it can easily produce comparable cross-country estimates, given that it is based on harmonized international data. The drawback is that it only scratches the surface of homogeneity as the data are only available as mean values for groups defined by crossing information on broad activity classes and enterprise types. Heterogeneity within each group is still present, and different countries are also likely to have differently shaped distributions within each group. Notwithstanding these limitations, the macro linkage pursued in this paper highlights important differences across groups in key indicators of import, export intensity and value-added exports, suggesting that an increased granularity of the source data used for TiVA might substantially affect the resulting TiVA estimates.

19. Three datasets are used in combination with national input-output tables: 1) the OECD/Eurostat TEC database; 2) the Structural and Demographic Business Statistics Database (SDBS); 3) the Activity of Multinational Enterprises (AMNE) database. These three datasets target the full population of enterprises with limited exceptions. More importantly, they are based on the same statistical unit, the enterprise.

*OECD/Eurostat TEC database*

20. The OECD/Eurostat International trade statistics by enterprise characteristics (TEC) database offers a picture of trade flows between countries from the viewpoint of the characteristics of the trading enterprises. The data allows analysing the relative importance of firms of different sizes and sectors in countries' exports and imports, as well as measuring to what extent top trading firms are responsible for total trade values. The data collection has been recently extended to include information about the foreign and domestic ownership of the trading firms. TEC only includes trade in commodities, and current work is exploring the possibility of developing similar data for trade in services.

21. The TEC data are derived from the linkage of trade registers identifying all the traders resident in an economy with business registers, providing information on the characteristics of the enterprises. This linkage is relatively straightforward when the units in the trade register and the enterprises in the business register have a common identifier. A harmonized set of identifiers is however still not available in several countries, such as Korea and Japan. This explains why the coverage of TEC is limited to 38 countries, and will only be gradually extended to the other countries in the TiVA database. It is also important to note that matching ratios between business and trade registers vary between countries, with possible implications on international comparability and on the usefulness of the data as an input for splitting supply and use tables. The problematic issue is that the likelihood of a successful match between trade and business register

might be related to the size or foreign ownership of the firm. For example, if large trading enterprises are more likely to be included in both registers and successfully matched than small trading enterprises, then the measured difference in the export propensity of large and small firms will be biased upwards.

*OECD SDBS Database*

22. The second source of data used for the estimates are structural business statistics with an employment size class breakdown from the OECD Structural and Demographic Business Statistics Database. The data are obtained through a coordinated data collection at Eurostat and at the OECD, aimed at harmonizing as much as possible the information on the number of enterprises, employment, turnover, value-added, wages and salaries, investment as well as the tabulation of this information according to common industry and size-class classifications. The main limitation of this database for the analysis of this paper is the lack of data on value added and turnover for several non-European OECD countries.

*AMNE Database*

23. The Activity of Multinational Enterprises (AMNE) database collects data on the activity of multinationals of OECD countries. The data cover production, employment, value added, research and development, labour compensation, broken down by country of origin (inward investment) or location (outward investment) and by industrial sector for 27 OECD countries. Data on exports and imports of multinational enterprises are available for only three countries, Estonia, Italy and United States.

24. As in TEC, multinational enterprises are identified as those enterprises that are resident in one country but controlled by another enterprise or enterprise group not resident in the country. The notion of control for an enterprise implies the ability to appoint a majority on board of directors to run the enterprise, guide its activities and determine its strategy. In practice, the enterprise is 'controlled' if the foreign group has the majority of ordinary shares or voting power. The AMNE data are compiled from different sources, and generally through a combination of administrative and survey data.

*Possible inconsistencies between data sources*

25. The main challenge of this data integration exercise is that supply and use tables tend to use homogenous production units as statistical units. These homogeneous units generally correspond to establishments. The preference for establishments is motivated by the need of associating to each statistical unit one single production function; in other words, each unit is assumed to be responsible for the production of only one product, with one production technology. Enterprises are instead the most meaningful units for business statistics such as SDBS or AMNE, and several key variables included in these data can only be compiled at the enterprise level. Enterprises often engage in the production of more than one product, and the value of their secondary production is attributed to the industry of the primary product. The different way of accounting for secondary production threatens the compatibility of enterprise-level data and supply-use tables. The relevance of this issue is high for the analysis of trade in value added given that exports and imports are concentrated in a limited number of large, multi-product enterprises.

26. While both AMNE and TEC data rely on business register as a basis for identifying the relevant enterprises, the two sources of data have been developed independently and possibly with different methodologies. A simple check of the aggregates that are comparable between the two sources reveals some inconsistencies. In the Slovak Republic and Estonia, the number of foreign-controlled enterprises that export according to the TEC data is greater than the total number of foreign-controlled enterprises in AMNE. In Italy, one of the few countries providing information on export and import values by ownership both in AMNE and in TEC, the weight of multinationals in trade is not always measured consistently

across the two sources: in TEC, foreign-controlled firms account for 60% of the import value in the mining sector (NACE 05-09) in 2011, while the respective value in TEC is 38%. Similarly, in the pharmaceutical sector (NACE 21), foreign-controlled firms have a much higher weight in total imports according to TEC than according to AMNE (80% versus 47%). Part of this difference is due to the fact that the trade values in AMNE refer to both goods and service trade, while TEC is limited to goods. The lower matching rate of domestic firms with respect to multinational firms in TEC is another potential factor behind these diverging values.

## 3. Stylized facts on trade heterogeneity by firm characteristics

*Why firm heterogeneity matters for trade in value-added analysis*

27. The national input-output tables used by the OECD for TiVA are based on a harmonised set of 34 industries. Therefore, any given indicator for a particular industry assumes that all firms in an industry use the same share of imported inputs and that all consumers of that industry's output purchase exactly the same shares of products from each firm allocated to that industry. There is increasing evidence that, even within a narrowly defined industry, firms can have drastically different product choices and production technologies. Microdata from Denmark show that firms concentrate their import purchases in a narrow set of goods that are largely unique to each firm (Hummels et al. 2014). If one looks at the distribution of products by number of purchasers, just 1 firm out of 2000 importers in Denmark buys the median input. This evidence suggests that, in reality, input-output structures are specific to each firm. Such heterogeneity means, in practice, that any given shock to foreign buyers and sellers will have markedly different impacts across firms within the same industry. The industry-level TiVA estimates thus only tell part of the trade in value added story.

28. A quick look at the data described in the previous section reveals that firms within the same TiVA industry differ greatly over key indicators, such as value-added or import over output ratios. Figure 1 uses data from SDBS to show that the level of industrial aggregation (two-digit ISIC code) used for TiVA might mask substantial heterogeneity in the value-added content of production.

**Figure 1. Dispersion in value-added to turnover ratios within two-digit industries, Italy 2011**


Source: OECD Structural and Demographic Business Statistics

29. A first intuitive way of reducing the homogeneity bias would be thus to increase the number of industries and goods included in national supply and use tables. The level of sectoral aggregation chosen by each country is however adapted to the main use of tables for national income and product accounting, and constrained by issues of costs and availability of primary data.

30. The second option is to increase granularity by identifying "types" of firms, according to characteristics that are correlated with participation in global value chains. Even if the networks that operate GVCs are highly complex, relevant typologies of firms that differ in their degree of participation in GVCs are easy to identify. Perhaps the most intuitive and relevant typology is the one distinguishing exporting and non-exporting firms. The literature on heterogeneous firms in trade (beginning with Bernard and Jensen, 1995) shows that exporting firms are systematically different from other firms: they are larger, more capital and import-intensive, more likely to employ skilled worker and to pay higher wages. This selection process explains why exporting firms are relatively rare and the distribution of trade value is highly skewed, as a handful of firms account for the majority of export and import values.

31. It is well established that small firms tend to have less direct links with the international market than larger firms, while playing an important role as suppliers of intermediates used for exports (OECD, 2008). It is also well known that foreign-owned affiliates tend to make a larger use of imported inputs, sourced either through a foreign related party or through arm's length trade. Exporters vs non-exporters, large firms vs SMEs, foreign-owned vs domestic-owned firms are the three dimensions of heterogeneity that are explored in the paper. But other typologies might deserve consideration. The changing nature of

international trade has fostered the emergence of new types of firms such as Factory-less Producers[2], and firms in export processing zones dominate manufacturing exports in an increasing number of countries.

*Firm heterogeneity and the extensive margin of trade*

32. Changes in aggregate exports and imports are driven by two margins that can only be measured at the firm-level: the 'extensive margin' measuring how many firms export and import, and the 'intensive margin' measuring how much each firm exports and imports. Table 1 shows that only a minority of manufacturing firms exports. The percentage of exporting firms in manufacturing, as estimated from the linkage of TEC and SDBS data, ranges between 9% in the United States and in the Slovak Republic to 42% in Estonia. The export propensity of firms increases substantially with firm size: in France, for example, only 6% of the manufacturing enterprises with less than 10 employees export, while the majority of enterprises with more than 50 employees do export. Production for exports is also much more common among foreign-controlled enterprises. Linking issues between the trade and business registers might introduce a bias in the measurement of export propensity by firm characteristics: the problem of trade that is not possible to classify by firm type is particularly severe in Belgium and Germany, where over 30% of firms in the trade register were not matched to the business register in 2011.

[2] These firms are formally classified in the wholesale sector in official statistics, but they perform pre-production activities, such as design and engineering, and exert control over the production of manufactured goods.

**Table 1. Percentage of exporters, by number of employees and foreign ownership, mining and manufacturing (ISIC rev 4 5 to 39) 2011**

| Country | All firms (1) | 0-9 employees (2) | 10-49 (3) | 50-249 (4) | 250+ (5) | Foreign-controlled (6) |
|---|---|---|---|---|---|---|
| Austria | 31 | 19 | 56 | 90 | 97 | 86 |
| Belgium | 24 | 15 | 62 | 84 | 96 | 97 |
| Bulgaria | 18 | 7 | 38 | 72 | 77 | |
| Canada | 28 | 14 | 44 | 91 | 100 | |
| Germany | 24 | 17 | 28 | 51 | 52 | 36 |
| Denmark | 30 | 19 | 55 | 83 | 100 | 91 |
| Spain | 12 | 6 | 37 | 76 | 86 | 75 |
| Estonia | 42 | 31 | 69 | 79 | 79 | 100 |
| Finland | 18 | 11 | 44 | 72 | 89 | 81 |
| France | 12 | 5 | 45 | 83 | 100 | 80 |
| United Kingdom | 24 | 14 | 48 | 72 | 77 | 58 |
| Hungary | 20 | 11 | 63 | 80 | 87 | 78 |
| Italy | 20 | 12 | 53 | 84 | 87 | 71 |
| Lithuania | 21 | 8 | 61 | 81 | 86 | |
| Luxembourg | 45 | 27 | 71 | 91 | 100 | |
| Latvia | 31 | 18 | 66 | 83 | 84 | |
| Poland | 14 | 8 | 48 | 65 | 87 | 100 |
| Portugal | 19 | 11 | 53 | 82 | 89 | 57 |
| Romania | 15 | 5 | 27 | 63 | 81 | |
| Slovak Republic | 9 | 4 | 63 | 99 | 100 | 100 |
| Slovenia | 25 | 19 | 68 | 78 | 90 | |
| Sweden | 19 | 12 | 65 | 80 | 88 | 78 |
| United States | 9 | 5 | 16 | 51 | 53 | |

Source: OECD TEC Database, OECD SDBS database, OECD AMNE database.
Note: The estimates are based on a macro linkage of TEC data on the number of exporters (numerator) with SDBS data on the number of enterprises (denominator), using the common industry and size identifiers. Possible differences in the population of the two databases might cause inconsistencies, such as the number of exporters in a particular size by industry cell being greater than the number of enterprises. In those limited number of cases, the indicator has been normalized to 100.

33. The TEC data also show that the probability that a firm exports goods varies greatly across sectors. As expected, the percentage of exporters of commodities tends to be greater in capital-intensive manufacturing industries, such as chemicals and plastic (table 2). The heterogeneity in the extensive margin of trade by size tends to vary by country: for example, the difference in the export propensity of large firms and SMEs is across all sectors greater in Italy than in Germany.

**Table 2. Percentage of exporters, by industry and number of employees, 2011**

| | Germany | | | United Kingdom | | | Italy | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Large | SMEs | Total | Large | SMEs | Total | Large | SMEs |
| Mining | 22 | 47 | 22 | 17 | 73 | 15 | 15 | 50 | 14 |
| Food products | 7 | 39 | 7 | 21 | 56 | 19 | 13 | 98 | 13 |
| Textile | 26 | 64 | 26 | 27 | 90 | 27 | 22 | 96 | 22 |
| Wood | 13 | 57 | 13 | 7 | 86 | 7 | 9 | 100 | 9 |
| Paper products/printing | 28 | 52 | 28 | 15 | 86 | 15 | 20 | 95 | 20 |
| Chemicals | 56 | 54 | 56 | 54 | 86 | 52 | 54 | 98 | 53 |
| Rubber and plastic | 48 | 54 | 47 | 37 | 88 | 36 | 45 | 100 | 45 |
| Other mineral | 16 | 49 | 16 | 18 | 86 | 17 | 20 | 96 | 19 |
| Basic metals | 39 | 62 | 37 | 42 | 90 | 41 | 39 | 97 | 38 |
| Fabricated metals | 21 | 58 | 21 | 18 | 80 | 18 | 16 | 96 | 16 |
| Computers | 44 | 58 | 43 | 44 | 100 | 44 | 40 | 97 | 40 |
| Electrical machinery | 41 | 54 | 40 | 47 | 88 | 46 | 38 | 100 | 38 |
| Machinery n.e.c. | 46 | 60 | 45 | 42 | 85 | 41 | 50 | 98 | 49 |
| Motor vehicles | 36 | 55 | 34 | 37 | 82 | 35 | 47 | 95 | 45 |
| Other transport | 35 | 50 | 34 | 26 | 75 | 24 | 32 | 97 | 31 |
| Manufacturing n.e.c | 16 | 49 | 16 | 20 | 79 | 20 | 13 | 91 | 13 |
| Utilities | 16 | 12 | 16 | 6 | 30 | 6 | 4 | 2 | 4 |
| Construction | 2 | 25 | 2 | 1 | 31 | 1 | 0 | 53 | 0 |
| Wholesale and retail trade | 24 | 78 | 24 | 27 | 100 | 27 | 13 | 100 | 13 |
| Service industry | 2 | 13 | 2 | 4 | 33 | 4 | 0 | 23 | 0 |

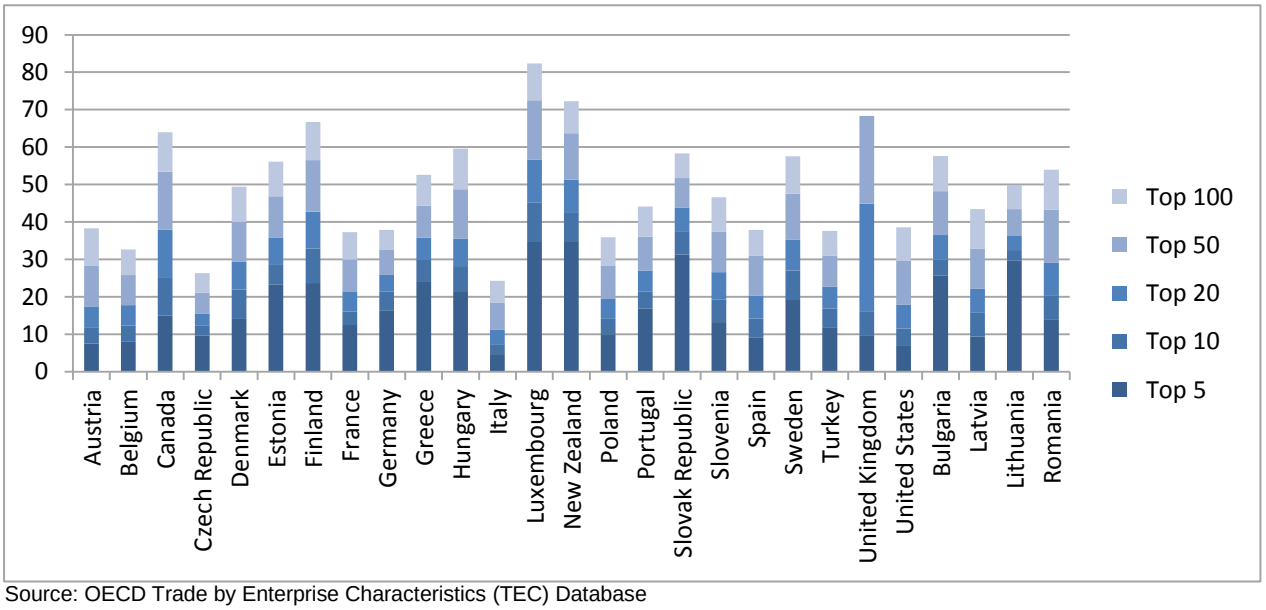
Source: OECD Trade by Enterprise Characteristics (TEC) Database

Note: The estimates are based on a macro linkage of TEC data on the number of exporters (numerator) with SDBS data on the number of enterprises (denominator), using the common industry and size identifiers. Possible differences in the population of the two databases might cause inconsistencies, such as the number of exporters in a particular size by industry cell being greater than the number of enterprises. In those limited number of cases, the indicator has been normalized to 100.

*Firm heterogeneity and the intensive margin of trade*

34. The evidence on the heterogeneity of trading firms is even more striking when looking at the intensive margin of trade. Only five firms account for more than 30% of the export value of Luxembourg, New Zealand and the Slovak Republic (figure 2). Several mechanisms can explain this high concentration of international trade. If high productivity is necessary to enter the export markets, an extremely skewed distribution of productivity can produce a highly unequal distribution of trade (Bernard et al. 2007). High sunk costs to enter overseas markets can also generate important economies of scale leading to concentration.

**Figure 2. Share of top exporters in total export values, 2011**

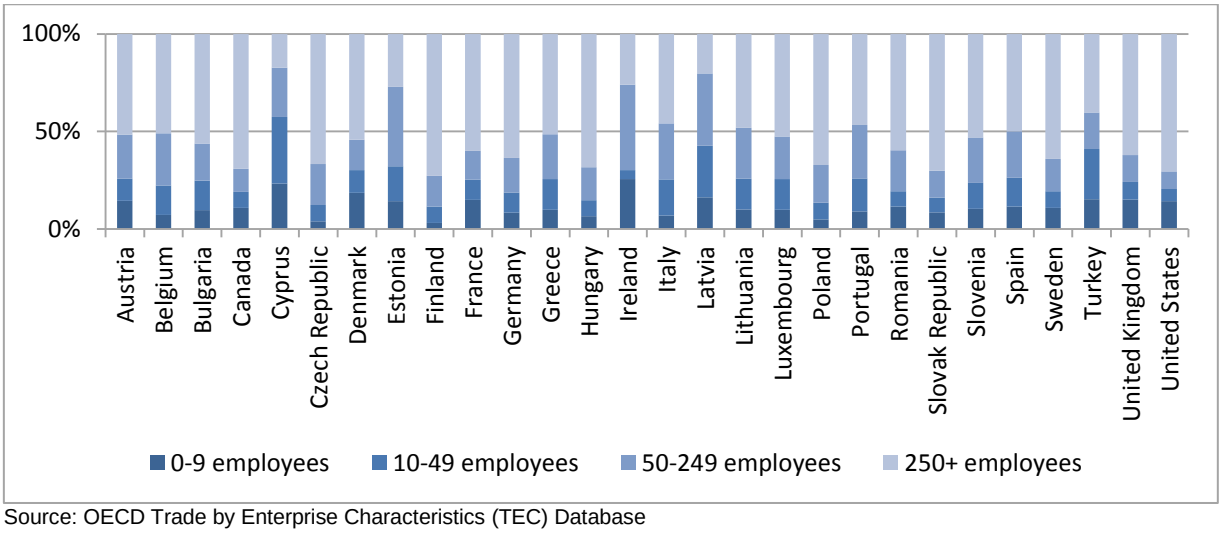



Source: OECD Trade by Enterprise Characteristics (TEC) Database

35. This selected minority of exporting firms absorbs the majority of imports. Imports by exporters account for at least three fourth of total imports across all European countries with data in the TEC database. The intensive margin of imports is clearly higher for exporters than for firms that do not export: the value of imports per firm is from 10 to 40 times higher for exporters than non-exporters, confirming that exporting firms are on average much larger and suggesting a strong connection between importing and exporting.

36. The focus on the intensive margin reveals also more clearly the dominance of particular types of firms in international trade flows. Figure 3 shows that firms with more than 250 employees are responsible for more than half the total exports in the majority of OECD countries. These large firms represent less than 5% of the enterprise population across all OECD countries.

**Figure 3: Export value by number of employees of exporting enterprises, total economy, 2011**




Source: OECD Trade by Enterprise Characteristics (TEC) Database

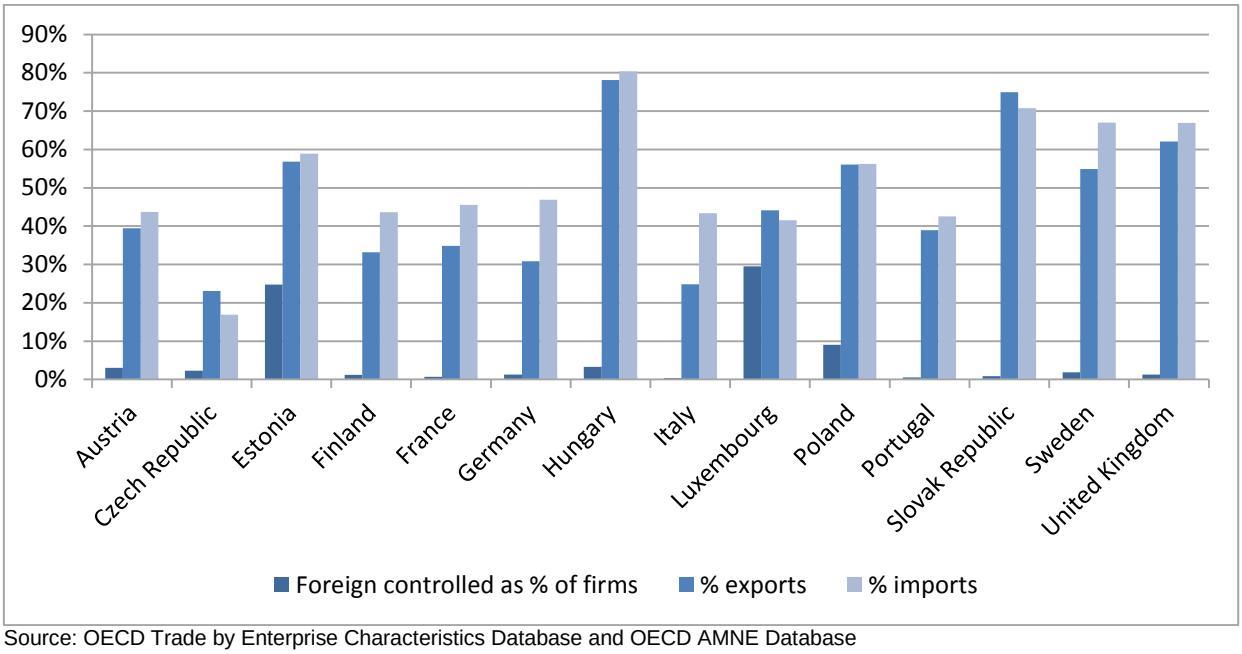
37. Foreign-controlled firms account for a small minority of firms in most OECD countries, but for a substantial share of imports and exports (figure 4). It is well known that a significant fraction of this multinational trade happens between related parties and there is some evidence that the share of intermediate goods exported from parents to their affiliates has been increasing (Borga and Zeile, 2002). Our data do not allow distinguishing between the intra-firm and arms-length component of multinationals' trade, and this distinction is clearly relevant to fully understand the value-added and income flows associated to these international transactions[3].

38. Large firms and foreign-owned firms distinguish themselves also along another margin, the number of distinct product they import and export. Bernard et al. (2007) measured that, in the year 2000, firms that export more than one ten-digit Harmonised System product account for more than 99.6 percent of U.S. export value. Empirical evidence has shown that these multi-product firms adjust their export product mix following trade liberalization (Iacovone and Javorcik, 2008), and that these within-firm reallocations drive aggregate output growth (Bernard et al., 2006).

39. The TEC data do not yet include information on the turnover or value-added of trading firms. This limits the use of these data for analysis of the performance premium associated with importing or exporting. Survey data from Canada show that revenues are clearly related with export intensity: firms that export 50 percent or more of total revenues have average sales that are three times higher than the non-exporting firms (Seens, 2015). Exporters in Canada are also more likely than non-exporters to invest in research and development (R&D), information and communications technologies (ICTs), machinery and equipment (M&E) and employee training.

[3] Bernard, Jensen and Scott (2005) are able to make this distinction using U.S. custom data that record for each export and import transaction whether the transaction takes place between "related parties". Multinationals are defined in their data as all firms with positive related-party trade.

**Figure 4: Foreign controlled enterprises as a percentage of total enterprises, total imports and total exports, 2011**




Source: OECD Trade by Enterprise Characteristics Database and OECD AMNE Database

40. Empirical studies systematically find that exporters are more productive than non-exporters (Bernard et al., 2012). Causality runs here in both directions: only the most productive firms are 'selected' to become exporters, and exporting might improve firm efficiency through learning. Accounting for productivity differences between exporters and non-exporters is crucial to understand the impact of increasing openness on national production. How many firms get out of the market, and how many graduate into exporters following trade liberalization crucially depends on the firm-level distribution of labour productivity and of other firm characteristics that matter for international competitiveness.

## 4. Integrating firm heterogeneity in TiVA indicators

41. The integration of information on firm heterogeneity in TiVA measures is clearly a complex endeavour and experimental work in this direction has started only recently. Chen et al. (2012) construct an input-output table for China that contains separate coefficients for "processing" exports and "non-processing" exports, finding that the domestic value added of processing exports is much lower than that of non-processing exports. Similarly, Koopman, Wang and Wei (2012) found that for China the import content of exports doubles when taking into account the high levels of foreign value added contained in processing exports. Ahmad et al. (2012) use firm-level data from Turkey to produce distinct input-output coefficients for firms that sell primarily to the domestic market and for firms that sell primarily to the world market. They find that the share of foreign content in Turkey's exports in 2005 is 6 percentage points higher with the disaggregated data than with the aggregated data.

42. Firm-level data on turnover, value added, employment, exports and imports are already available in most countries, even if scattered across different databases. It is also generally possible to link these data with information on the domestic or foreign ownership of the enterprises, so that, for example, the turnover of domestic-owned, exporting enterprises can be compared with the turnover of foreign-owned, exporting enterprises in the same industry. However, these data linkages have been so far implemented mostly in academic studies with micro-data for specific countries. A further challenge is to make this firm-level

information fully compatible with supply and use tables so to measure the contribution of domestic and foreign value-added along all the stages of the value chain.

43. This paper makes a first step in addressing these challenges by disaggregating industry-level data on trade, output and value-added by the size and foreign-ownership of the firms, two relevant dimensions of firm heterogeneity that are correlated with participation in global value chains. We start by studying the impact of these two heterogeneity dimensions on one key TiVA indicator, the import content of exports. This indicator of vertical linkages quantifies to what extent imported intermediate goods are used by a country to make goods which are themselves exported to another country. As already mentioned, the incorporation of firm-heterogeneity in the trade in value added framework would not only improve the quality of the estimates, but also allow producing new estimates of interactions between different types of firms in the global value chains. Preliminary estimates on the contribution of SMEs to value-added exports are thus presented to illustrate the potentials of this development of the TiVA framework.

### *4.1 Measuring direct vertical specialization by firm characteristics with linked enterprise data*

*The direct import content of exports*

44. The best known measure of import content of exports was defined by the seminal work of Hummels, Ishii and Yi (HIY in subsequent discussion) in 2001. The import content of exports was labelled as "Vertical specialization (VS) ratio", and defined as the value share of imported intermediates in total output:

$$VS = \left(\frac{M}{Y}\right) \cdot X \qquad (1)$$

45. Where $M$ is a measure of imported intermediates, $Y$ is output and $X$ is exports. HIY applied this measure to I/O tables of 20 OECD countries, finding that the use of imported inputs account for 21% of the value exports, and that vertical specialization grew almost 30% between 1970 and 1990. Their input-output calculation allows accounting not only for the value of imports directly contained in the production, but also for the value of the imported inputs embodied in domestic inputs.

46. Only the subset of intermediate imports that become embodied in exported goods contribute to vertical specialization. This means that the reference population for this measure is ideally restricted to the sub-sample of firms that export. The use of homogeneous input-output tables instead assumes that imported inputs are used evenly in production for domestic sales and exports. If domestic production is different from production for exports, i.e. the input-output structure of exporters is different from the one of non-exporters, than the measure based on standard I/O tables is biased. The direction of the bias is clear: as exporters make a more intensive use of intermediate imports than non-exporters, the standard measure under-estimate vertical specialization.

47. Vertical specialization is a function of three main parameters: 1) the share of value added in total output, 2) the import content of the inputs used for production, 3) the fraction of total output that gets exported. Tables 3a and 3b show that all these parameters vary significantly according to the size of the enterprise and to foreign participation in ownership[4]. These descriptive statistics support the intuition that size and foreign ownership are both relevant dimensions of heterogeneity. Columns (4) show that large and

[4] We use here turnover as a proxy for production because of the larger country and sector coverage of the data on turnover and of the observed strong correlation between production and turnover.

foreign-owned firms outmatch the "average firm" also in apparent labour productivity (gross value added per person employed): this difference suggests that heterogeneity matters also for other key TiVA indicators, such as the number of jobs sustained by global value chains.

**Table 3a. Value Added, Export, Import to turnover ratios and apparent labour productivity by firm size, 2011**

| | Value Added/turnover | | Exports/turnover | | Imports/turnover | | Value Added/Employment | |
|---|---|---|---|---|---|---|---|---|
| | SMEs | Large | SMEs | Large | SMEs | Large | SMEs | Large |
| | (1) | | (2) | | (3) | | (4) | |
| Austria | 24 | 29 | 30 | 51 | 23 | 33 | 0.09 | 0.15 |
| Belgium | 20 | 15 | 31 | 45 | 24 | 39 | 0.11 | 0.17 |
| Brazil | 29 | 21 | | | | | 0.02 | 0.07 |
| Bulgaria | 19 | 21 | 28 | 51 | 25 | 28 | 0.01 | 0.02 |
| Czech Republic | 22 | 19 | 23 | 41 | 16 | 29 | 0.03 | 0.06 |
| Denmark | 26 | 27 | 28 | 51 | 12 | 22 | 0.10 | 0.13 |
| Estonia | 26 | 20 | 52 | 77 | 30 | 53 | 0.03 | 0.04 |
| Finland | 28 | 17 | 21 | 36 | 14 | 23 | 0.09 | 0.12 |
| France | 25 | 20 | 18 | 30 | 15 | 26 | 0.08 | 0.12 |
| Germany | 24 | 18 | 15 | 25 | 10 | 12 | 0.07 | 0.11 |
| Greece | 33 | 16 | 21 | 32 | 22 | 54 | 0.04 | 0.11 |
| Hungary | 17 | 19 | 27 | 50 | 25 | 43 | 0.02 | 0.06 |
| Ireland | 28 | 34 | 100 | 22 | 40 | 7 | 0.13 | 0.44 |
| Israel | 33 | 33 | | | | | 0.07 | 0.13 |
| Italy | 23 | 18 | 22 | 28 | 12 | 21 | 0.07 | 0.13 |
| Korea | 33 | 32 | | | | | 0.10 | 0.32 |
| Latvia | 23 | 25 | 46 | 33 | 26 | 32 | 0.02 | 0.04 |
| Lithuania | 22 | 13 | 44 | 70 | 36 | 74 | 0.02 | 0.03 |
| Luxembourg | 27 | 14 | 100 | 36 | 97 | 36 | 0.08 | 0.10 |
| Netherlands | 24 | 16 | | | | | 0.10 | 0.20 |
| Norway | 35 | 23 | | | | | 0.20 | 0.31 |
| Poland | 24 | 24 | 21 | 34 | 15 | 28 | 0.02 | 0.06 |
| Portugal | 22 | 21 | 23 | 42 | 17 | 39 | 0.03 | 0.08 |
| Romania | 21 | 20 | 27 | 45 | 26 | 38 | 0.01 | 0.02 |
| Slovak Republic | 26 | 14 | 36 | 57 | 28 | 46 | 0.03 | 0.05 |
| Slovenia | 21 | 27 | 34 | 70 | 25 | 39 | 0.04 | 0.06 |
| Spain | 26 | 21 | 19 | 27 | 14 | 32 | 0.07 | 0.13 |
| Sweden | 27 | 27 | 24 | 53 | 15 | 26 | 0.09 | 0.16 |
| Switzerland | 38 | 32 | | | | | 0.15 | 0.24 |
| Turkey | 16 | 20 | 9 | 14 | 10 | 27 | 0.02 | 0.07 |
| United Kingdom | 37 | 29 | 18 | 25 | 15 | 23 | 0.08 | 0.17 |

**Table 3b. Value Added, Export, Import to turnover ratios and productivity by firm ownership, 2011**

| | Value Added/turnover | | Exports/turnover | | Imports/turnover | | Value Added/Employment | |
|---|---|---|---|---|---|---|---|---|
| | foreign | domestic | foreign | domestic | foreign | domestic | foreign | domestic |
| | (1) | | (2) | | (3) | | (4) | |
| Austria | 26 | 30 | 56 | 46 | 36 | 33 | 0.14 | 0.10 |
| Belgium | 15 | 22 | 48 | 17 | 39 | 19 | | |
| Germany | 19 | 28 | 19 | 20 | 13 | 9 | | |
| Denmark | 24 | 32 | 59 | 45 | 31 | 16 | 0.10 | 0.11 |
| Spain | 18 | 26 | 33 | 24 | 33 | 25 | | |
| Estonia | 19 | 29 | 89 | 55 | 64 | 22 | 0.04 | 0.03 |
| Finland | 27 | 18 | 52 | 27 | 29 | 11 | 0.13 | 0.09 |
| France | 21 | 22 | 37 | 25 | 35 | 20 | | |
| United Kingdom | 28 | 38 | 31 | 18 | 31 | 11 | | |
| Hungary | 19 | 23 | 64 | 24 | 59 | 13 | 0.05 | 0.03 |
| Italy | 22 | 22 | 41 | 27 | 40 | 14 | 0.13 | 0.09 |
| Luxembourg | 16 | 22 | 65 | 58 | 44 | 58 | | |
| Poland | 22 | 23 | 51 | 25 | 40 | 22 | | |
| Portugal | 20 | 21 | 56 | 31 | 44 | 28 | 0.06 | 0.03 |
| Slovak Republic | 14 | 29 | 63 | 57 | 50 | 47 | 0.04 | 0.03 |
| Sweden | 26 | 29 | 56 | 41 | 36 | 16 | 0.15 | 0.12 |

Source: Author's calculations based on OECD TEC database, OECD SDBS database, OECD AMNE database

*Estimates of the direct import content of exports through linked TEC, SDBS and AMNE data*

48. This first application produces a measure of the direct import content of export (from here on 'direct VS') for groups of firms defined from either the crossing of activities (ISIC codes) and employment size classes, or from the crossing of activities and ownership (domestic or foreign). It exploits the possibility of disaggregating import, export and turnover values by firm characteristics using the common industry identifier to merge different sources of enterprise-level data at the macro-level. The direct VS is simply estimated as in (1) by multiplying the export of each group for their share of intermediate imports over total output. Kee and Tang (2012) and Upward et al. (2012) also produce estimates of the domestic content of exports without using input-output information: however, both studies are based on linked micro-data.

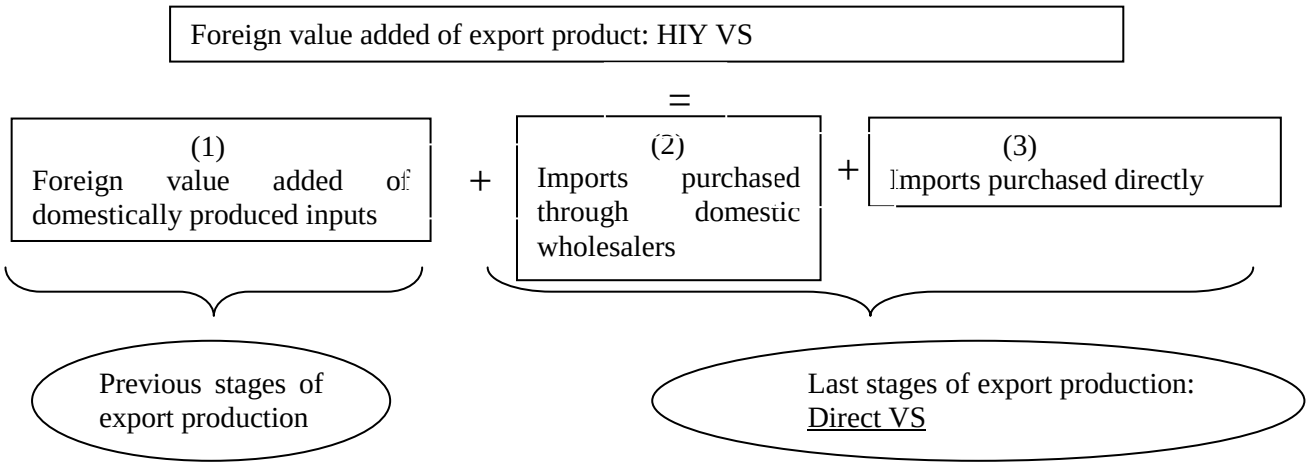
49. The obvious limitation of this method is that it can only account for the inputs produced abroad that the firm imports *directly* and uses for production. Foreign value-added can enter into export production also when embedded in inputs produced domestically. These imports used in previous stages of the production chain can only be measured through input-output calculations. The direct measure discussed here should thus be interpreted as the fraction of the HIY measure accounted for by one single transaction between foreign providers of intermediate inputs and domestic exporters, disregarding the origin of the value-added content of the domestically produced inputs.

50. While conceptually very simple, this measure of direct import-export linkages is not easy to compute on the available macro data. There are two main difficulties, both related to the key issue of estimating the value of imports used in production from the value of total firm's imports. The first is that TEC data do not distinguish between imports of final and of intermediate goods. The second is that a significant share of the imports used in production is channelled through international wholesalers, which import the intermediate goods and re-sell them to final users with little transformations. Wholesalers and retail traders (enterprises classified as 45, 46 or 47 ISIC codes) account for a large share of imports across

all countries, ranging from 22% in Turkey to 74% in Sweden according to the 2011 TEC data. As these traders do not use much of these imports for their own production, using the TEC import values to approximate import use under-estimates the use of imports by all the industries not classified as wholesalers.

51. The diagram below distinguishes three sources of foreign value added of an exported product: 1) the foreign value added embedded in domestically produced inputs, 2) the imports purchased through wholesalers, 3) the direct intermediate imports of the firm. While the first component can be only estimated through I/O tables, the second component can be accounted for in our measure of direct VS through an estimate of the destination use of wholesale's imports.

**Figure 5. Direct and indirect components of vertical specialization**




52. The source of import data for the implementation of the direct VS measure is the TEC table of imports by industry and product. Imported products are aggregated into CPA (classification of product by activities) classes that are consistent with those used in national I/O tables. The intermediate imports are simply estimated by multiplying the TEC import value by the ratio between intermediate and total imports available in the I/O import matrixes for products. The assumption underlying this solution is that the fraction of intermediate inputs in each CPA class of imported product is the same for all the industries importing the product[5].

53. The estimation of intermediate imports purchased through wholesalers also requires the use of supplemental data and assumptions. We use information from SDBS on the 'Purchases of goods and services purchased for resale in the same condition as received', to approximate the value of intermediate goods that are purchased in the international market and then redistributed internally by each industry (component 2 in the diagram of figure 5). The SDBS variable refers to total purchases, so the assumption here is that wholesalers re-sell domestically a similar share of the goods they purchase in the domestic and

[5] An alternative solution would have been to use the unique product-use mapping provided by the Bilateral Trade by Industry and End Use (BTDIxE), aggregating traded products in BTDIxE at the level of the CPA product classes in TEC. We preferred the first option because it allows the intermediate shares to vary across countries. The import by product TEC table is only available by industry: an import by product table disaggregated by firm type would have allowed taking into account a possible difference in the share of intermediates over total imports by firm type.

international market. It is interesting to note that the share of purchases that are resold with no transformation can be high in sectors other than wholesale. In several countries, the value is over 15% for capital intensive industries such as manufacture of petroleum products (ISIC 19), chemicals (ISIC 20), pharmaceutical (ISIC 21) and motor vehicles (ISIC 29).

54. We redistribute to using industries the imports that are estimated to re-circulate internally, according to each industry's share of total imports net of re-sold imports. The trade sector (45, 46 or 47 ISIC rev. 4 codes) is excluded from the re-distribution: we assume that the trade sector does not acquire imports indirectly from other importers for its own production. In table 4, we compare the results to the Italian import flow matrix for 2010 in order to check whether such re-distribution approximates import use better than standard TEC data.

**Table 4. Imports over total intermediates from supply and use tables, proportional allocation and TEC, Italy 2010**

| ISIC industry | % Official data (IO and SU) (1) | Proportional allocation (2) | Intermediate imports in TEC (3) | TEC with reallocation (4) |
|---|---|---|---|---|
| Food products, beverages and tobacco | 13% | 17% | 4% | 7% |
| Textiles, textile products, leather and footwear | 19% | 13% | 10% | 17% |
| Wood and products of wood and cork | 20% | 18% | 12% | 20% |
| Pulp and paper products | 22% | 20% | 15% | 23% |
| Printing and publishing | 23% | 20% | 19% | 26% |
| Coke, refined petroleum products and nuclear fuel | 10% | 17% | 8% | 13% |
| chemicals and chemical products | 46% | 21% | 37% | 42% |
| pharmaceutical | 32% | 25% | 21% | 30% |
| Rubber and plastics products | 35% | 28% | 40% | 48% |
| Other non-metallic mineral products | 23% | 24% | 18% | 26% |
| Basic metals | 14% | 19% | 8% | 12% |
| Fabricated metal products | 36% | 27% | 32% | 41% |
| computer, electronic and optical products | 14% | 21% | 10% | 15% |
| Electrical machinery and apparatus n.e.c | 31% | 23% | 15% | 25% |
| machinery and equipment n.e.c. | 24% | 23% | 17% | 25% |
| Motor vehicles, trailers and semi-trailers | 18% | 18% | 10% | 16% |
| Other transport equipment | 21% | 19% | 12% | 18% |
| Electricity, gas, steam and air conditioning | 20% | 18% | 11% | 17% |
| Utilities | 28% | 19% | 1% | 1% |
| Construction | 4% | 16% | 2% | 3% |
| Wholesale & retail trade, repair of motor vehicles | 6% | 14% | 2% | 3% |
| Wholesale trade, except of motor vehicles | 7% | 15% | 23% | 6% |
| Retail trade | 8% | 15% | 46% | 14% |
| Transport and storage | 4% | 15% | 14% | 3% |
| Information and communication | 7% | 16% | 1% | 2% |
| Real estate activities | 11% | 12% | 3% | 6% |
| Professional, scientific and technical activities | 6% | 10% | 1% | 2% |
| Administrative and support service activities | 10% | 13% | 6% | 10% |
| Food products, beverages and tobacco | 7% | 13% | 1% | 2% |
| Correlation with official import flow matrix (column 1) | | 0.8 | 0.55 | 0.87 |

Source: Author's calculations based on Eurostat Supply and Use tables and OECD TEC database

55. The share of imported intermediates over total intermediates as measured in TEC (table 4, column 3) departs significantly from what measured in the official supply and use tables (column 1). The correlation between these measures is 0.55, lower than what is obtained by allocating imports to industries through a proportionality assumption (0.8 in column 2)[6]. The correlation with official estimates improves greatly after reallocating re-sold imports with the method described above, moving up to 0.87. While in most industries the modified TEC data perform better than the proportionality assumption, problems remain in some sectors, such as electricity, transport and storage.

56. Tables 5 and 6 show the direct VS ratios (the ratio of intermediate imports over turnover) for firms of different size and ownership types, for European countries included in TEC with supplemental data on production available in SDBS and AMNE. Table 5a confirms that the largest firms (those with more than 250 employees) account for the majority of direct imports used for exports in all countries (column 3). This is the consequence of the high weight of large firms in gross exports and of their relatively higher direct intermediate imports. Table 5b shows that the relationship between firm size and intensity of use of intermediate imports tends to vary greatly across industries.

**Table 5a. Direct VS ratios by size and change in estimated direct VS with the size split, 2011, mining and manufacturing (ISIC rev.4 sections 05 to 39)**

| Country | Intermediate Imports/Turnover (%) | Intermediate Imports/Turnover (%) | Share of direct VS accounted by SMEs(%) | Percentage change in VS with size split |
|---|---|---|---|---|
| | SMEs | Large firms | | |
| | (1) | (2) | (3) | (4) |
| Austria | 16 | 22 | 26 | 6.0 |
| Belgium | 13 | 21 | 25 | 6.1 |
| Bulgaria | 24 | 31 | 29 | 3.7 |
| Germany | 6 | 9 | 13 | 4.3 |
| Spain | 10 | 12 | 38 | 1.8 |
| Finland | 8 | 10 | 18 | 2.9 |
| France | 14 | 19 | 24 | 3.1 |
| United Kingdom | 15 | 18 | 22 | 1.5 |
| Hungary | 23 | 36 | 15 | 6.2 |
| Italy | 12 | 16 | 44 | 1.8 |
| Poland | 9 | 12 | 18 | 4.4 |
| Portugal | 18 | 26 | 40 | 6.0 |
| Romania | 23 | 26 | 23 | 1.5 |

Source: Author's calculations based on OECD TEC and SDBS databases

6 The proportionality assumption is used in several countries to allocate imports to industry within I/O and S/U tables. According to the assumption, each industry's imports of each commodity, relative to its total demand, is the same as the economy-wide imports relative to total demand for the commodity.

**Table 5b. Direct VS ratios by size and change in estimated direct VS with the size split by industry, Belgium and France 2011**

| | Belgium | | | | France | | | |
|---|---|---|---|---|---|---|---|---|
| | Interm. Imports/ Turnover (%) | Interm.Imports/ Turnover (%) | Share of direct VS by SMEs(%) | Percentage change in VS with size split | Interm. Imports/ Turnover (%) | Interm. Imports/ Turnover (%) | Share of direct VS by SMEs (%) | Percentage change in VS with size split |
| | SME | Large | | | SME | Large | | |
| Food products | 10 | 14 | 46 | 1 | 5 | 9 | 25 | 12 |
| Textile | 18 | 22 | 49 | 3 | 17 | 26 | 48 | 9 |
| Wood | 20 | 20 | 48 | 0 | 18 | 22 | 81 | 1 |
| Paper products/printing | 15 | 25 | 29 | 6 | 39 | 25 | 40 | -6 |
| Chemicals | 20 | 26 | 22 | 2 | 20 | 23 | 28 | 0 |
| Rubber and plastic | 19 | 17 | 63 | -1 | 22 | 25 | 42 | 1 |
| Other mineral | 10 | 12 | 34 | 4 | 12 | 16 | 25 | 4 |
| Fabricated metals | 16 | 15 | 79 | 0 | 46 | 85 | 13 | 4 |
| Fabricated metals | 0 | 0 | 0 | | 14 | 14 | 57 | 0 |
| Electrical machinery | 9 | 19 | 16 | 3 | 18 | 15 | 29 | 0 |
| Machinery n.e.c. | 8 | 14 | 22 | 7 | 17 | 23 | 20 | 1 |
| Motor vehicles | 25 | 18 | 9 | -1 | 14 | 24 | 22 | 7 |
| Other transport | 9 | 15 | 11 | 6 | 16 | 10 | 11 | 0 |
| Manufacturing n.e.c | 24 | 9 | 86 | 15 | 10 | 13 | 50 | 3 |
| Utilities | 9 | 29 | 8 | 28 | 7 | 15 | 58 | -30 |
| Construction | 2 | 2 | 75 | -2 | 1 | 2 | 18 | 49 |
| Wholesale and retail trade | 7 | 9 | 72 | 0 | 6 | 7 | 62 | 0 |
| Service industry | 38 | 16 | 95 | 11 | 2 | 3 | 55 | -2 |

Source: Author's calculations based on OECD TEC and SDBS databases

57. Differences in the use of intermediate imports become even more marked when comparing foreign and domestically owned firms (table 6a and 6b). With the exception of Germany, foreign-owned firms account for the majority of the direct intermediate imports used for exports (table 6a, column 3). The measured direct VS share of large firms is around 90% or higher in Hungary, Estonia and Belgium. Looking at the distribution by industry, in Belgium, foreign-owned firms employ much more direct imports as a fraction of their sales across all industries. Differences by ownership are much less marked in France, especially because of a greater use of imports by domestic producers.

**Table 6a. Direct VS ratios by ownership and change in estimated direct VS with the size split, 2011, mining and manufacturing (ISIC rev.4 sections 05 to 39)**

| Country | Intermediate Imports/Turnover(%) | Intermediate Imports/Turnover(%) | Share of direct VS accounted by Foreign(%) | Percentage change in VS with ownership split |
|---|---|---|---|---|
| | Domestic | Foreign | | |
| | (1) | (2) | (3) | (4) |
| Austria | 18 | 25 | 54 | 4 |
| Belgium | 14 | 24 | 89 | 10 |
| Estonia | 13 | 50 | 91 | 18 |
| Finland | 7 | 22 | 56 | 19 |
| France | 15 | 35 | 62 | 14 |
| Germany | 6 | 12 | 41 | 1 |
| Hungary | 17 | 38 | 95 | 6 |
| Italy | 12 | 36 | 50 | 12 |
| Poland | 6 | 22 | 86 | 26 |
| Portugal | 16 | 42 | 69 | 22 |
| Sweden | 8 | 14 | 57 | 3 |
| United Kingdom | 12 | 29 | 84 | 12 |

**Table 6b. Direct VS ratios by ownership and change in estimated direct VS with the ownership split by industry, Belgium and France 2011**

| | **Belgium** | | | | **France** | | | |
|---|---|---|---|---|---|---|---|---|
| | Intermediate Imports/ Turnover (%) | Intermediate Imports/ Turnover(%) | Share of direct VS by Foreign (%) | Percentage change in VS with ownership split | Intermediate Imports/ Turnover (%) | Intermediate Imports/ Turnover (%) | Share of direct VS by Foreign (%) | Percentage change in VS with ownership split |
| | Domestic | Foreign | | | SME | Large | | |
| Mining | | | | | 5 | 18 | 84 | 53 |
| Food products | 3 | 30 | 96 | 84 | | | | |
| Wood | | | | | 14 | 41 | 65 | 34 |
| Paper products/printing | 2 | 49 | 99 | 123 | 12 | 32 | 83 | 22 |
| Chemicals | 6 | 31 | 99 | 20 | 16 | 36 | 63 | 4 |
| Rubber and plastic | 9 | 36 | 91 | 49 | 23 | 29 | 48 | 2 |
| Other mineral | 3 | 21 | 98 | 70 | 10 | 25 | 66 | 14 |
| Basic metals | 36 | 46 | 85 | 4 | 38 | 100 | 87 | 12 |
| Fabricated metals | 4 | 62 | 98 | 177 | 10 | 28 | 61 | 19 |
| Computers | 11 | 27 | 78 | 30 | 14 | 23 | 50 | 3 |
| Electrical machinery | 13 | 18 | 65 | 1 | 19 | 30 | 58 | 5 |
| Machinery n.e.c. | 2 | 19 | 98 | 45 | 9 | 31 | 88 | 12 |
| Motor vehicles | 3 | 22 | 100 | 8 | 11 | 14 | 32 | 2 |
| Other transport | 8 | 18 | 86 | 21 | 34 | 22 | 7 | 0 |
| Manufacturing n.e.c | | | | | 8 | 26 | 70 | 31 |
| Utilities | 35 | 1 | 0 | 102 | 14 | 7 | 26 | -14 |
| Construction | 1 | 13 | 98 | 442 | 1 | 5 | 71 | 79 |
| Wholesale & retail trade | 1 | 18 | 99 | 136 | 3 | 12 | 55 | 2 |

Source: Author's calculations based on OECD TEC, SDBS and AMNE databases

58. Tables 5a and 6a also confirm the intuition that increasing the granularity of the data by firm type would increase the estimates of the foreign content of value added in exports. Columns 4 in the two tables simply compare the value of the direct VS when calculated on data split by firm type (e.g. the sum of the VS of SMEs and Large firms) with the value obtained without splits by type. Calculating separately the direct VS by enterprise types (defined either by size or by ownership) produces higher estimates across all countries and the majority of industries. The magnitude of the change tends to be higher for the split by ownership rather than for the split by size. The effect of the split is also markedly different across different industries (tables 5b and 6b). Incorporating heterogeneity thus allows better accounting for the correlation between importing and exporting.

### *4.2. Measuring direct and indirect vertical specialization by ownership, an application to Mexico*

59. We now show how it is possible to use aggregated data on imports, exports, intermediate inputs and value added to split national input-output tables by firm types. The split here is between internationally integrated, foreign-controlled firms (the 'Global Manufacturers') and other Mexican firms.

60. Data on Global Manufacturers (GM) have been produced by the Mexican Statistical Institute (INEGI) through a linkage of economic census, industrial surveys and custom trade data (INEGI, 2014)[7]. GMs are identified as those firms that: a) import the majority of their purchases (imports account for at least 2/3 of their export value); b) produce only for exports; and c) are controlled by a foreign owner. These global firms were responsible for 55% of the imported intermediate consumption and for 71% of gross exports of the Mexican manufacturing sector in 2008.

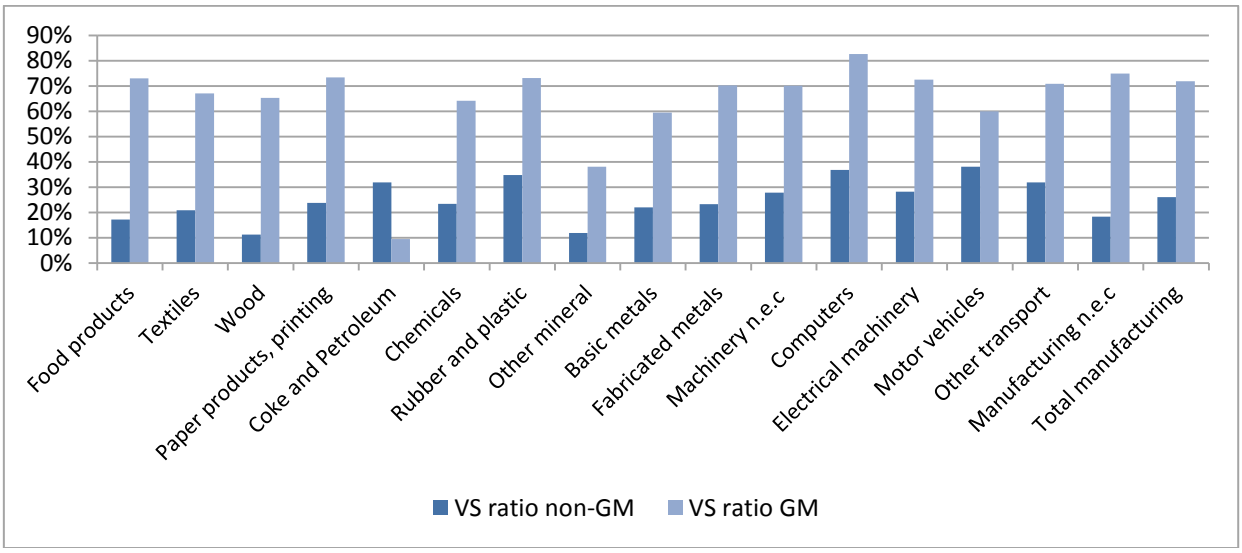
61. The INEGI's tabulations on global manufacturers provide information on total intermediate consumption by industry that is consistent with the one published in I/O tables; however, the main issue with this split is that we only have aggregate consumption by industry and no by-product information. For example, we know the total imports of global manufacturers in industry *j*, but not the industries those global manufacturers in *j* purchase these imports from (as in a I/O matrix for imports) or the composition by product of these imports (as in a use table for imports).

62. We thus need to make an assumption to allocate imports and domestic consumption of global manufacturers to source industries. The assumption is that global manufacturers purchase their inputs from the same industries and in the same proportions as the other firms in the industry, according to the inter-industry linkages described by the standard I/O table. In practice, the split tables for the two types of firms do account for differences in the import, domestic and value-added composition of global manufacturers' production, but not for the possible use of a different combination of industry inputs in the production technology.

63. TiVA indicators can be calculated separately for global manufacturers and other firms using the split tables. As an illustration, figure 6 presents the VS ratios (the value of direct and indirect imports used in production as a share of gross export value) for exports of global manufacturers and non-global manufacturers. It is evident that the foreign-content of export production is much greater for global manufacturers across all the manufacturing industries, with the only exception of 'Coke, refined petroleum products and nuclear fuel'. Overall, 72% of the value added in global manufacturer's exports has a foreign origin, while the foreign content is 26% for the exports of other manufacturing firms.

[7] http://www3.inegi.org.mx/sistemas/tabuladosbasicos/LeerArchivo.aspx?ct=44462&c=33654&s=est&f=4

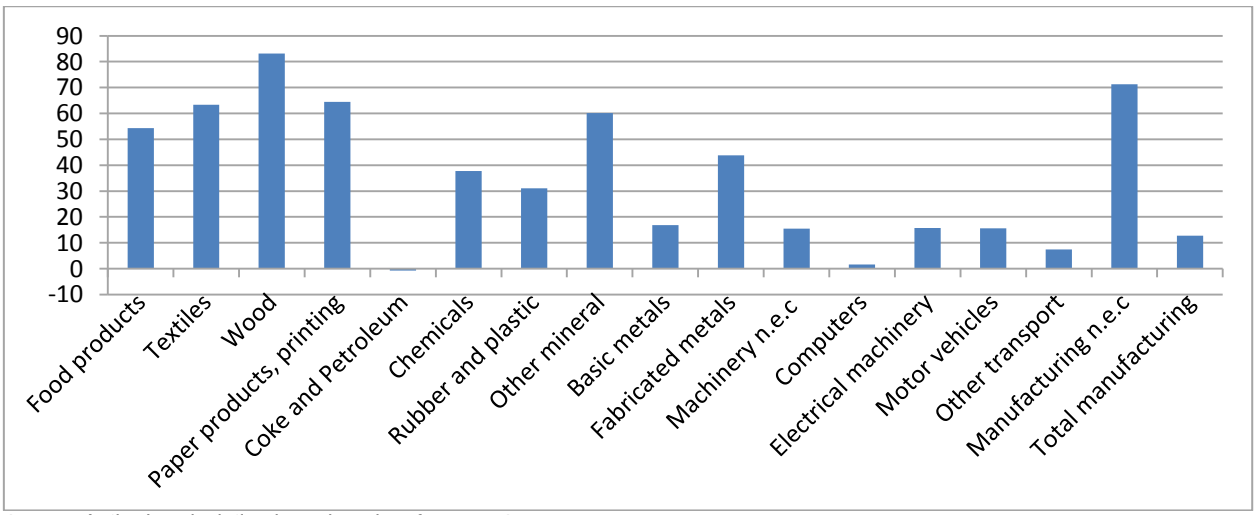
**Figure 6. Import content share in exports of global manufacturers and in exports of other firms, Mexico 2008**




Source: Author's calculation based on data from INEGI

64. Accounting for the higher import intensity of Mexican top-exporters has important implications for TiVA indicators. Figure 7 shows the percentage change in the estimated VS (import content of exports) when the split tables are used instead of the standard ones. The effect is heterogenous but of significant magnitude for most exported products. In absolute terms, the estimated foreign value added clearly increases more where the weight of global manufacturers in gross export is larger. Only for exports of motor vehicles, the results of this split suggest that calculations based on the standard input-output table under-estimate the foreign value-added content of Mexican exports of 47 billion of Mexican pesos in 2008 (around 4,2 billion of USD).

**Figure 7. Percentage change in estimated foreign content of exported products using split I/O tables for global manufacturers, Mexico 2008**




Source: Author's calculation based on data from INEGI

### *4.3 Measuring indirect exports of SMEs with split input-output tables*

65. This third application illustrates how input-output or supply and use tables split by firm type can unveil linkages between different types of firms in the value chain. Preliminary results based on split I/O tables show that the measured contribution of SMEs to exports increases substantially when accounting for their role as suppliers to exporting firms, i.e. when taking into account their "indirect exports". The results should be considered as illustrative since they depend heavily on the assumptions chosen to estimate the unobserved transactions between firm types.

66. The measurement of indirect exports of SMEs requires a split of both the columns and the row of national industry-by-industry I/O tables, so to obtain four partitions of the standard matrix describing the full set of interactions between SME and Large firms. In standard matrix notation with the *L* superscript referring to large firms and the *S* superscript referring to SMEs, the I/O model can be represented as follows (see USITC 2010):

$$\begin{bmatrix} X^{L\prime} \\ X^{S\prime} \end{bmatrix} = \begin{bmatrix} D^{LL} & D^{LS} \\ D^{SL} & D^{SS} \end{bmatrix} \begin{bmatrix} X^{L\prime} \\ X^{S\prime} \end{bmatrix} + \begin{bmatrix} Y^{L} \\ Y^{S} \end{bmatrix} \quad (2)$$

Where $X^L$ is gross output and $Y^L$ is final demand of large firms. $D^{LL} = \left[\frac{z_{ij}^{LL}}{x_j^L}\right]$ ; $D^{SL} = \left[\frac{z_{ij}^{SL}}{x_j^L}\right]$ ; etc.. are direct I/O coefficient matrixes, with $z_{ij}^{SL}$ denoting the good *i* produced by SMEs and used as input by large firms in industry *j*.

67. The model holds under the constraints:

$$\mathrm{u}D^{LL}+\mathrm{u}D^{SL}+A_v^L=\mathrm{u} \quad (3)$$
$$\mathrm{u}D^{SL}+\mathrm{u}D^{SS}+A_v^S=\mathrm{u} \quad (4)$$

where u is a unit vector and $A_v^L$, $A_v^S$ are value added to output ratio for large and small firms, respectively.

68. Rearranging equation (2) yields:

$$\begin{bmatrix} X^{L\prime} \\ X^{S\prime} \end{bmatrix} = \begin{bmatrix} 1-D^{LL} & -D^{LS} \\ -D^{SL} & 1-D^{SS} \end{bmatrix}^{-1} \begin{bmatrix} Y^{L} \\ Y^{S} \end{bmatrix} = \begin{bmatrix} B^{LL} & B^{LS} \\ B^{SL} & B^{SS} \end{bmatrix} \begin{bmatrix} Y^{L} \\ Y^{S} \end{bmatrix} \quad (5)$$

Where the Bs are the four partitions of the split Leontief inverse matrix. For example, $B^{SL}$ indicates, for each industry, the amount of SMEs' gross output required for one-unit increase in final demand of large firms.

69. From equation (5), it is possible to decompose the value of gross exports into its value added sources by size. For example, the indirect value added produced by SMEs and embodied in large firms' exports is:

$$IVE^S = A_v^S B^{SL} E_L' = A_v^S (1 - D^{SS})^{-1} D^{SL} B^{LL} E_L' \quad (6)$$

Where $E_L'$ is a row vector of exports of large firms.

70. The total value added contribution of SMEs to exports is thus made of what they contribute in value added (direct) and intermediate inputs (indirect) to gross SME exports plus the indirect SME's value added embodied in large firms' gross exports:

$$Value\ added\ exports^S = A_v^S B^{SS} E_S' + A_v^S B^{SL} E_L' \quad (7)$$

71. Our main indicator is the SMEs share in value added exports (direct and indirect), simply defined as:

$$\boldsymbol{VAD\_Share^S} = \frac{Value\ added\ exports^S}{Value\ added\ exports^S + Value\ added\ exports^L} \quad (8)$$

72. The first step in the estimation of value added exports by firm type is the allocation of intermediate domestic inputs into transactions within ($z_{ij}^{LL}$ , $z_{ij}^{SS}$) and between firm types ($z_{ij}^{SL}$ , $z_{ij}^{LS}$).

73. Two main assumptions are made to estimate these transactions. First of all, she split of each industry's intermediate domestic and foreign inputs into those purchased by SMEs and those purchased by large firms (the column split of the I/O matrix) is based on the share of SMEs in domestic purchases and in imports. The share of SMEs in imports by industry is derived from TEC, and the domestic purchases are derived by crossing the information on output and value added from SDBS and on imports from TEC[8]. For example, if SMEs account for 20% of the imports of the paper industry according to TEC, then 20% of all import purchases of the paper industry in the I/O import matrix are allocated to SMEs.

74. Secondly, the shares of intermediate inputs from each source industry produced by SMEs and large firms (the row split of the I/O matrix) are determined by the share of SMEs and large firms in gross output, as measured in SDBS. For example, if SMEs produce 20% of the output in the paper industry, 20% of the intermediate domestic consumption of paper by large firms and SMEs is sourced from SMEs. The final domestic demand (private consumption, government consumption, fixed capital investments, changes in inventory) is also split proportionally to the SME's gross output in the source industry.

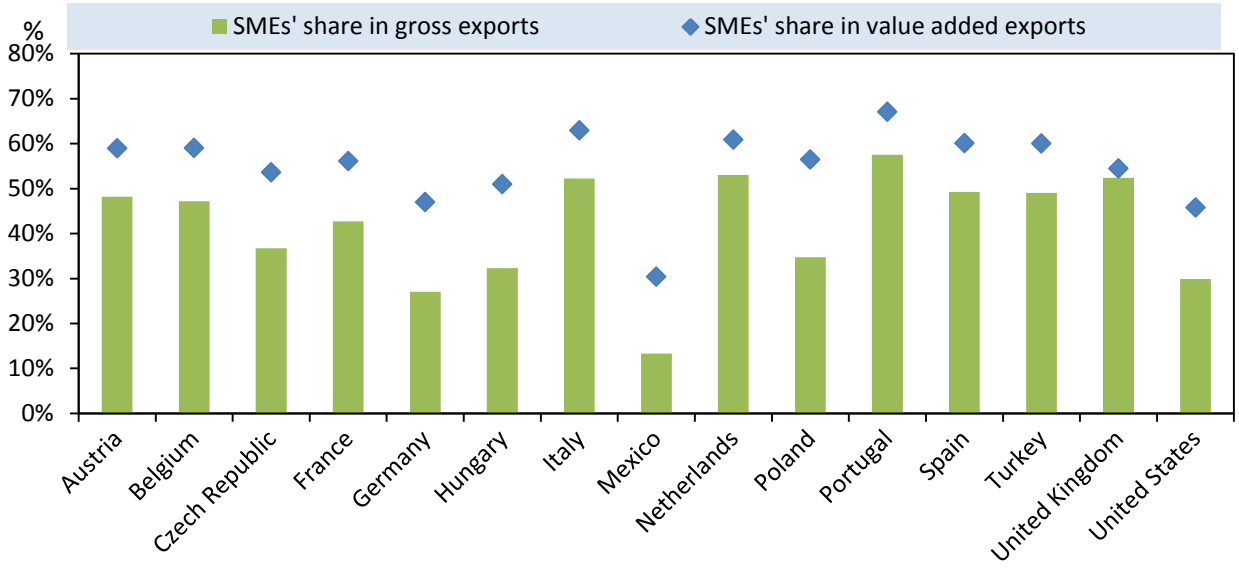
75. These assumptions rule out any preferential transaction according to the size of the firm: in other words, a SME is indifferent about whether the input it uses is produced by another SME or by a large firm. The assumption does not seem to be too strong in an analysis of transactions between firms of different size, as it is not easy to identify strategic advantages SMEs could gain by giving preferences to other SMEs

[8] The domestic consumption of SMEs in each industry is estimated as a residual from the difference between SMEs' output (from SDBS's share) and the sum of SMEs' value added (from SDBS) and SMEs' imports (from TEC). This guarantees that the adding up constraints in (3) and (4) are verified. Inconsistencies between TEC and SDBS generate a limited number of cases when the residual is negative, indicating an impossible negative consumption of domestically produced inputs. In those cases, the import shares in TEC are adjusted to yield a domestic consumption equal to 0 under the adding up constraints.

or to large firms in their purchases. It would be more problematic to rule out preferential behaviours in an analysis of transactions between domestic and foreign-owned firms.

76. Figure 9 compares the SME's share in value added exports calculated as in (8) with the SME's share in gross exports for 15 countries in 2009, using input-output data from the OECD TiVA international input-output matrix. It is evident that a shift from a gross export to a value added export perspective changes the conclusions about the 'weight' of SMEs in global value chains. Taking into account indirect exports shows that the SMEs' contribution to exports in value added terms is close or higher than 50% in most countries. The magnitude of the change is particularly large in those countries, such as Poland, Germany and the United States, where the share of SMEs in gross exports is lower. A possible conclusion can be that SMEs in those countries specialize in upper segments of the value chain, as the competitive advantage in production for direct exports is highly correlated with firm size. A likely implication is that any shock, positive or negative, in foreign demand has an impact on SMEs that is much larger than what could be anticipated by looking merely at the SME's gross export share.

**Figure 9. Comparison of SMEs' contribution to exports in gross and value-added terms, 2009**




Source: Author's calculation based on OECD/WTO International Input-Output matrix, OECD SDBS database, OECD TEC database, and national statistics offices.

77. Table 7 shows that indirect exports of SMEs are a significant fraction of the total export value in all countries. In Mexico, in particular, the value of inputs produced by SMEs for other firms' exports is much larger than the direct value added in SMEs' direct exports.

**Table 7. Decomposition of the value added exports in direct and indirect components by firm size, 2009**

Values in USD millions and percentage in total value added exports in parenthesis

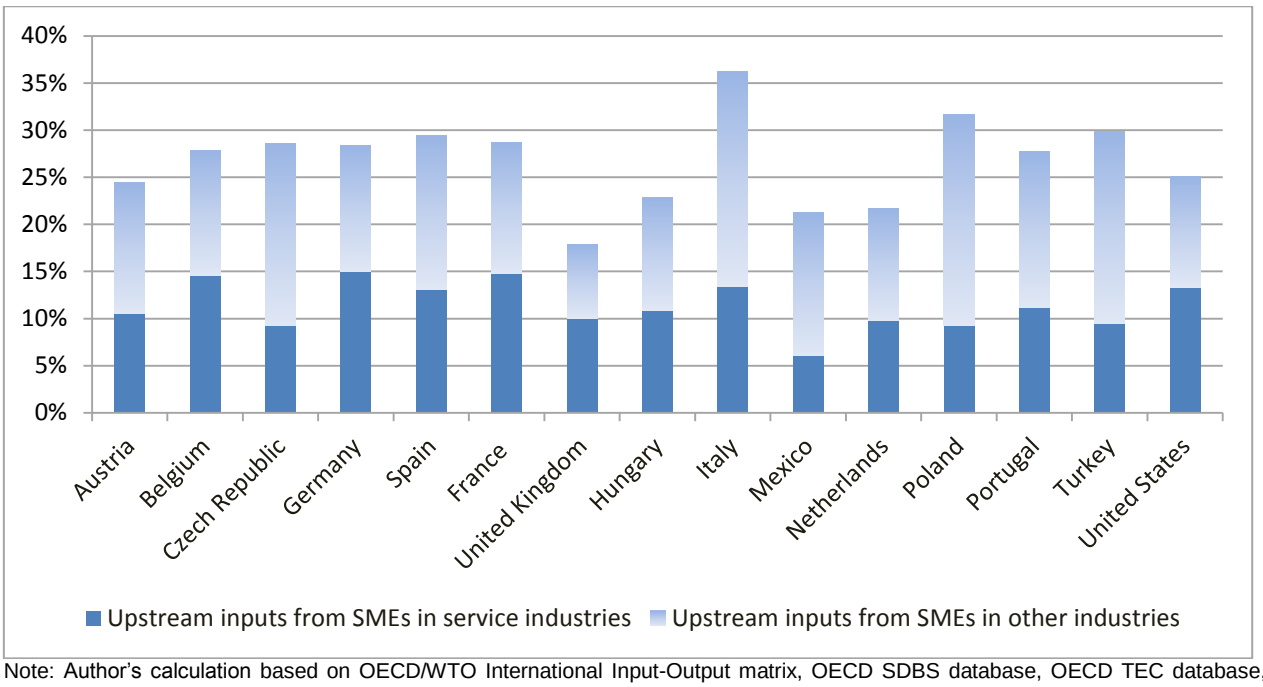
| Country | Direct value added in exports Large firms | Indirect value added in exports Large firms | Direct value added in exports SMEs | Indirect value added in exports SMEs |
|---|---|---|---|---|
| Austria | 28264 (27) | 14379 (13) | 35797 (34) | 25383 (24) |
| Belgium | 38687 (26) | 20597 (14) | 45124 (31) | 40233 (27) |
| Czech Republic | 18320 (32) | 7898 (13) | 14152 (25) | 16137 (28) |
| France | 95301 (25) | 71128 (18) | 103769 (27) | 108567 (28) |
| Germany | 257134 (33) | 152029 (19) | 143447 (18) | 219022 (28) |
| Hungary | 15322 (38) | 4231 (10) | 11215 (28) | 9090 (22) |
| Italy | 70894 (20) | 55313 (16) | 90567 (26) | 123187 (36) |
| Mexico | 70105 (47) | 33299 (22) | 13525 (9) | 31571 (21) |
| Netherlands | 44408 (21) | 36737 (17) | 81169 (39) | 45008 (21) |
| Poland | 26659 (26) | 17029 (16) | 24851 (24) | 31690 (31) |
| Portugal | 8404 (22) | 3870 (10) | 14636 (39) | 10302 (27) |
| Spain | 53990 (24) | 35510 (15) | 68745 (30) | 65851 (29) |
| Turkey | 22424 (24) | 13797 (15) | 27326 (30) | 27017 (29) |
| United Kingdom | 102713 (25) | 79120 (19) | 146044 (36) | 71423 (17) |
| United States | 455939 (40) | 157594 (13) | 234178 (20) | 283326 (25) |

Note: Author's calculation based on OECD/WTO International Input-Output matrix, OECD SDBS database, OECD TEC database, and national statistics offices. The shares might not sum to 100 because of rounding. Data on SMEs' turnover and valued added shares for US are obtained from U.S. census data for 2007

78. The split tables also allow calculating to what extent SMEs as upstream industries contribute to the domestic value added of each exported goods. Figure 10 shows that, in all countries, SMEs in the service sector are responsible for a significant share of the value added embedded in exports: in some countries, such as United Kingdom, Germany or the United States, SMEs in the service sector contribute more to exports as upstream producers than SMEs in all the other sectors together.

79. As already said, the estimate of indirect exports of SMEs depends on the assumptions used to split the I/O matrixes. The split of the rows according to the gross output share of SMEs, in particular, posits that the ratio of production for intermediate use and production for final use is the same for SMEs and for large firms. The indirect exports of SMEs would increase if SMEs, within each industry, were relatively more involved than large firms in the production of intermediate goods. We tested the sensitivity of the estimate of the value added export share of SMEs to the assumption, under the two opposite scenarios where SMEs fully specialize either in intermediate production or in final production. Even under the unlikely scenario that SMEs specialize in the production of final goods, the contribution of SMEs to exports in value added terms remains greater than their share in gross exports in most industries. The availability of data on the relative upstreamness of SMEs within each industry (e.g. tabulations of production data by industry, product and size of the firm) would help refine the split of the I/O matrix.

**Figure 10. SMEs' upstream inputs as a share of domestic value added in exported products**




Note: Author's calculation based on OECD/WTO International Input-Output matrix, OECD SDBS database, OECD TEC database, and national statistics offices. Data on SMEs' turnover and valued added shares for US are obtained from U.S. census data for 2007

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