Extended Supply-Use Tables and Trade in Value Added Measures for Canada: Preliminary Estimates, Issues and Challenges

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Abstract

This paper constructed extended supply-use tables (eSUTs) for Canada that take into account firm heterogeneity by size, country of control and export status and used the tables to construct trade in value added (TiVA) measures for 2010, 2011 and 2012. The extended SUTs reduced a bias in the TiVA measures estimated from the standard tables due to firm heterogeneity. The paper shows that the extended SUTs lower the estimate of the domestic value added content of exports. It also finds that the extended SUTs and TiVA measures derived from the extended SUTs provide a richer insight about the participation of small vs. large firms, domestic vs. foreign controlled firms, and non-exporters vs. exporters in the global value chain. This paper has identified a number of issues and challenges for the construction of extended SUTs including: inconsistencies in the concept of output and inputs between micro data files and the system of national accounts; little information on the final using industries of the products imported by distributors; limited information on the product details used to allocate output and inputs, and imports, limited information on inter-firm transactions of intermediate inputs between different types of firms.

1. Introduction

The rise of global production poses a number of challenges for the national accounts. Measures such as gross exports and gross imports are becoming less informative for the policy debate on the contribution of international trade to gross domestic product, income, jobs and competitiveness. Consequently, new measures are being developed. For example, Johnson and Noguera (2011) and Koopman et. al. (2008) proposed a measure of domestic value-added content of exports to better measure the contribution of exports to gross domestic product in an economy. Timmer, et. al. (2012a) proposed a measure of "global value chain income" that is based on the value-added by countries along the international production chain to examine the contribution of exports to income. Gu and Yan (2017), Timmer (2017) and Jorgenson et al. (2017) proposed a measure of productivity by product in global production to examine the contributions of global supply chains to productivity growth and competitiveness.

A number of international initiatives have responded to this challenge by developing global input/output tables and constructing new measures of trade (OECD-WTO, 2012; APEC 2014; Timmer et al, 2012b). The global input/output tables summarize the use of products broken down by their origins and present the flows of products for intermediate and final use that are split into those produced domestically and those that are imported for each country. The TiVA measures constructed using the global input/output tables provide a measure of the value-added contribution of producers in different countries to the global production of final product.

The construction of the global input/output tables and the TiVA statistics assume that firms in an industry are homogeneous in terms of their production techniques and their participation in global production and international trade. The assumption of firm homogeneity introduces a bias in the estimate of domestic value added and foreign contents of exports when firms differ in their participation in global production. The firms that are export intensive (e.g. exporters, foreign domestic controlled firms and large firms) tend to be more import intensive than the firms that are less export intensive (e.g., non-exporters, domestic controlled firms and small and medium sized firms). Combining those two types of firms in a single industry will under-estimate the foreign content of exports and over-estimate the foreign content of domestic sales (Ahmad, 2017, Araujo and Ahmad, 2011, Piacentini and Fortanier, 2015). (Koopman et al. 2008) found a large bias in the estimate of the domestic value-added content and foreign content of Chinese exports when export-processing firms are not dis-aggregated from other firms in the estimation.

To improve the TiVA statistics and to better understand the role of different types of firms in the global value chains, the OECD-WTO have been coordinating to develop extended supply/use tables (SUTs) (OECD-WTO, 2015). A number of countries have produced provincial results (Koopman et al. 2008 for

China; Saborio 2015 for Costa Rica; Chong et al. 2017 for Netherland; and Denmark and OECD, 2017 for Nordic countries). The Bureau of Economic Analysis has developed extended SUTs for the United States (Fetzer et al. 2015, 2016). OECD (2015) has shown that the extended SUTs provide information on the participation in value creation of SMEs and large firms, and of multinationals in global value chains and their contribution to host and home countries in the value creation.

This paper summarizes the work at Statistics Canada that is a part of this recent OECD-WTO initiatives on the development of the extended SUTs. Section 2 discusses the methodology for constructing extended SUTs and for estimating TiVA measures using the extended SUTs. Section 3 presents the data sources that are used to construct the extended SUTs. The data sources include the national SUTs and the linked business micro data files that provide information on output, intermediate inputs, value added, exports and imports for all enterprises in Canada. Section 4 presents the evidence on firm heterogeneity in import shares, export shares and value added shares in gross output. Section 5 presents TiVA measures constructed from the extended SUTs. Section 6 concludes and summarizes issues and challenges for the construction of extended SUTs.

2. Construction of Extended Supply-Use Tables and TiVA Statistics

The section summarizes the method that is used to develop extended supply-use tables (eSUTs). It starts with a presentation of the standard national supply-use tables in an economy and show how they can be used to construct the domestic value-added and foreign value-added contents of exports. It then presents the extended SUTs and construct TiVA measures from the extended SUTs.

In the standard SUTs, the firms in an industry are assumed to be homogenous. In the extended SUTs, the firms within industries will be disaggregated by different types of firms who are more homogeneous in their production activities that include: firm size, country of control and export status (OECD 2015).

2.1. Standard National Supply-Use Tables and TiVA Measures

The construction of TiVA measures starts with the national supply-use tables (SUTs) that are valued in basic prices, as the SUTs in basic prices provide a more accurate description of supply and demand relationship between industries and provide a measure of the direct contributions of “margin” industries such as wholesale trade, retail trade and transportation industries to production activities and value chains (UNSD, 1999, Eurostat, 2008, Fetzer, et al. 2016).

The section follows closely Ghanem and Huang (2014) who constructed the domestic value-added content of exports for Canada using the standard SUTs. Figure 1 presents the national supply-use tables which record how the supplies of different kinds of goods and services originate from domestic industries and from imports, and how those supplies are allocated between intermediate inputs, final domestic demand and exports. The following notations are used when presenting the national SUTs in Figure 1:

V = $\{v_{ji}\}$ is a supply matrix that records the output of commodity j produced by industry i;

U = $\{u_{ji}\}$ is a use matrix that records the use of commodity j as intermediate input for industry i;

M = $\{m_j\}$ is a column vector of the imports of commodity j;

g = $\{g_i\}$ is column vector of gross output of industry i;

q = $\{q_j\}$ is column vector of gross output of commodity j;

A = $\{a_i\}$ is column vector of value added of industry i;

X = $\{x_j\}$ is a column vector of the export of commodity j;

F = $\{f_j\}$ is a column vector of final demand of commodity j that includes consumption and investments; and

i = column vector of ones.

The supply-use tables must satisfy two accounting identities. First, for each product, total supply must equal total use. That is, the domestic production plus imports equal the sum of total intermediate inputs, final demand and exports, where total intermediate inputs and final demand include those purchased domestically and abroad. Second, for each industry, total value of inputs (or the sum of intermediate inputs and value added) must equal total output of the industry. The national SUTs are often called rectangular tables as the number of rows representing various products in the tables differs from the number of columns representing various industries.

The national SUTs have to undergo two main transformations before they can be used to estimate the domestic value added and foreign value-added content of exports. First, the intermediate input use table that represents the total purchase of goods and services as intermediate inputs has to be split into those purchased domestically and those purchased from abroad. Second, the rectangular intermediate input use table that summarizes the purchase of products as intermediate inputs by industry has to be transformed

into a square intermediate input-output table that summarizes the purchase of outputs of industries by industries.

For the first transformation, the split of total intermediate input use into that which are purchased abroad and that which are purchased domestically, the import proportionality assumption is used, which assumes that the share of imports in total domestic use for a product is the same for all industries and final demand users. The share of imports in total domestic use for each product can be estimated as:

$$\hat{u} = M^T (\hat{g} - \hat{X} + \hat{M})^{-1} \ ,$$

where $\wedge$ over a vector creates a matrix with diagonal elements equal to the values of the vector and with all off-diagonal elements equal to zeros.

From that assumption, the domestic intermediate input use matrix of product by industry can be estimated as: $(\mathrm{I} - \hat{\mu})U$, where I is an identity matrix with ones on the diagonal and zeros elsewhere.

For the second transformation, the market share assumption will be adopted: the purchase of a commodity as intermediate input by an industry is allocated among supplier industries according to their shares in the total production of that commodity. The market share matrix that summarises the share of industries in the production of a commodity is estimated as follow:

$$D = \left\{ d_{ji} \right\} = \left\{ V_{ji} / \mathrm{g}_i \right\} = V * \left[\hat{\mathrm{g}} \right]^{-1} \ .$$

The square domestic intermediate input-output table is then estimated as: $\mathrm{D}^T (\mathrm{I} - \hat{\mu})U$. Each element in the square domestic intermediate input use matrix describes the output of a domestic industry i that is used as intermediate input by domestic industry j. Figure 2 summarizes the square input-output tables that include the square domestic intermediate input use table and the matrix for final demand and primary inputs. In the table, the exports and domestic final demand that represents the values by products in the rectangular tables are also transformed into the vectors representing the values by industries using the market share assumption. The total domestic final demand are also disaggregated into those purchased domestically and those imported from abroad.

The national square input-output table in Figure 2 can be used to estimate the domestic content and foreign content of exports. The square use table has the accounting identity that the output of an industry equals the use of that industry output as intermediate input, exports and final domestic demand:

$$g = Bg + \left(\mathrm{D}^T (\mathrm{I} - \hat{\mu}) \mathrm{F} + D^T X \right), \text{ and } B = \left(\mathrm{D}^T (\mathrm{I} - \hat{\mu}) U \right) \hat{g}^T \ .$$

B in the equation is the domestic intermediate input coefficient matrix where column j represents the values of output of the various industries that are used to produce a unit of output in industry j. Re-arranging the equation yields the fundamental input-output identity:

$$g = (I - B)^{-1}\left(\mathrm{D}^{T}(\mathrm{I} - \hat{\mu})\mathrm{F} + D^{T}X\right)$$

$(I - B)^{-1}$ is known as the Leontief inverse (Leontief, 1936). The element in row i and column j of this matrix gives the total production value of sector i required for the production of one unit of output in industry j. The column j of the matrix shows the total production values of various industries for the production of one unit of output in industry j. The row i of the matrix shows the output of industry i that are required directly or indirectly for the production of various exports.

Using the Leontief inverse, the gross output of industries (represented by column vector Y) that are required to produce exports $D^{T}X$ can be estimated:

$$Y = (I - B)^{-1}\left(D^{T}X\right)$$

The domestic value added content of exports can be estimated as a product of gross output required to produce the exports times the ratio of value added to gross output:

$$\mathrm{DVAX} = A^{T}\hat{g}^{-1}Y = A^{T}\hat{g}^{-1}(I - B)^{-1}\left(D^{T}X\right),$$

where the row vector $A^{T}\hat{g}^{-1}$ is the ratios of value added to gross output by industry.

The foreign content of exports is the difference between total exports and the domestic content of exports:

$$\begin{aligned}\mathrm{FVAX} &= i^{T}\left(D^{T}X\right) - A^{T}\hat{g}^{-1}(I - B)^{-1}\left(D^{T}X\right)\\ &= \left(i^{T}(I - B) - A^{T}\hat{g}^{-1}\right)(I - B)^{-1}\left(D^{T}X\right).\\ &= \mu^{T}U\hat{g}^{-1}(I - B)^{-1}\left(D^{T}X\right)\end{aligned}$$

The equation above shows that the foreign context of exports can also be calculated as the imported intermediate inputs embodied in that gross output of all industries that are required for in the production of exports.

The foreign value-added content of exports in the above equation can be further decomposed into contributions from various economies. This will require the development of the global supply-use tables that combine the national input-output tables developed from linking the national input/output tables with bilateral trade data base. In the global SUTs, imported intermediate inputs are disaggregated into the imports from different industries and different foreign countries and exports are disaggregate into those

used as intermediate inputs by industries in different foreign countries and those used as final demand by different foreign countries (OECD –WTO, 2013).

The foreign and domestic value added contents of exports depend on the following shares: the share of imports in intermediate inputs, the share of intermediate inputs in gross output, or the share of value added in gross output, and share of exports in gross output. In the standard in SUTs, it is assumed that those ratios are the same across different types of firms in an industry. When there are difference in the shares between the different types of firms, the estimates of trade in value added from the standard SUTs are likely to be biased. For example, Koopman et al. (2008) show the domestic value added contents of the Chinese exports is much lower when a distinction is made between the export processing firms and other firms for estimating the domestic value added content. This is because the export processing firms import large shares of intermediate inputs in the production of exports than other firms and they account for most exports.

2.2. Extended National Supply-Use Tables and TiVA Measures

To improve the estimates of TIVA estimates and domestic value added content of exports and to examine the contribution to global production and the global value chains from different types of the firms, the standard supply-use tables need to be extended to take into account the difference in production and international trade participation by different types of firms. Figure 3 presents the extended SUTs where industries are further dis-aggregated into different segments of the industries representing different types of firms in the industries. The following additional notations are used in Figure 3.

$S^V = \{s_{ik}^V\}$ is a share matrix of different types of firms in the gross output of an industry where element; s_{ik}^V is the share of firm type k in the gross output of industry i;

$S^U = \{s_{ik}^U\}$ is a share matrix of different types of firms in the intermediate inputs of an industry where element s_{ik}^U is the share of firm type k in the intermediate input of industry i;

$S^A = \{s_{ik}^A\}$ is a share matrix of different types of firms in the value added of an industry where element s_{ik}^U is the share of firm type k in the valued added of industry i;

$S^X = \{s_{ik}^X\}$ is a share matrix of different types of firms in the exports of an industry where element s_{ik}^X is the share of firm type k in exports of industry i; and

$S^M = \{s_{ik}^M\}$ is a share matrix of different types of firms in the imports of an industry where element s_{ik}^M is the share of firm type k in the imports of industry i.

The extended SUTs take into account firm heterogeneity in intermediate input intensities, value added intensities, import intensities and export intensities. For example, the higher export and import intensities, lower value-added ratios for the foreign controlled firms compared with the domestic controlled firms are incorporated in the extended SUTs. To construct the extended SUTs, industry columns are dis-aggregated by firm types according to their shares in industry gross output, intermediate inputs and value added. The implicit assumption in this procedure is that the input and output mix are the same for different types of the firms. It is also assumed that the product mix for imports and exports are the same across different types of firms. This assumption about the product mix for production, intermediate inputs, exports and imports will be relaxed in the future version of the ESUTs.

When output, inputs and value added for an industry are split into different types of firms according to their shares of output, input and value added, there will be a discrepancy between the sum of value added and intermediate inputs, and the value of gross output for each type of firms in an industry. To maintain consistency, the output and value added are split first in the extended SUTs and the values of intermediate inputs by firm types are calculated residually.

For the construction of the extended domestic intermediate input square matrix from the extended rectangular SUTs, two additional assumptions are made that are similar to the two assumptions that are made to construct the domestic intermediate input square tables: the market share assumption and the import proportionality assumption. According to the market share assumption, the purchase of an intermediate input by industries or firms is allocated between industries or firms in a proportion to their shares in the total production of that commodity. For example, if a firm purchases a commodity of which 60% is produced by large firms and 40% is purchased by small firms, it is assumed that the firms purchased 60% of the intermediate input from large firms and the remainder 40% from small firms.

For the extended SUTs in Figure 3, no split was made for rows that represent products. Such split would relax the market share assumption, but require data on inter-firm transactions. The data on inter-firm transaction are not available in most countries. But such data exists for Belgium and Costo Rica that would allow for such split (Soborio, 2015, Dhyne and Rubínová, 2016)

The extended square domestic intermediate input-output table is estimated as follows:

$$\left(E^T U\right) * diag(S^U) - \left(E^T \hat{\mu} U\right) * diag(S^M) \ ,$$

where E is the market share matrix in the extended supply tables and each element in a row represents the share of and industry /firm type in the total output of the commodity. The operation *diag of a matrix* creates a new matrix with each element on the diagonal equal to the row vector of the matrix and zeroes elsewhere. The domestic and foreign contents of exports are estimated using the Leontief inverse of this extended domestic intermediate input use table. The difference between the domestic value-added content of exports from the extended SUTs and the domestic value added content from the standard SUTs depends on the difference in the following shares between different types of firms: the share of imports in intermediate inputs, the share of intermediate inputs in gross output, the share of value added in gross output, and the share of exports in gross output. Those shares are found to be different for exporters vs. non-exporters, foreign vs. domestic controlled firms, and large vs. small firms. The larger the difference in those shares, the larger will be the difference between the domestic value added content of exports from the extended SUTs and the domestic value added content from the standard SUTs that assume the same shares for the different types of firms.

3. Data Sources

The extended national SUTs are derived from combining the standard national SUT table with the firm level data on production, country of control, imports, and exports.

The standard SUTs are published annually for a reference year with about a three year lag. The tables at the most detailed classification level include 481 products and 235 industries. To create an extended SUTs, The SUTs at the linked level of classification are used with 466 products and 98 industries that consists of 97 business sector industries and 1 aggregate nonbusiness sector. The 98 industries are further aggregated to 87 industries by combining the detailed construction industries and combining the detailed beverage industries (e.g., wine, beverage).

The firm level data used to take into account firm heterogeneity in the extended SUTs is derived from linking a number of the firm level survey and administrative databases using the common enterprise identifiers that are found in those various micro databases. The data bases include the national accounts microdata file, the trade by enterprise statistics (TEC) micro data files for imports and exports, international trade in commercial services, and the country of control from the Foreign Affiliate Statistics (FAS) microdata file. The final linked micro data file provides information on output, intermediate inputs, value added, imports and exports of goods, imports and exports of commercial services, country of control at the enterprise level for all incorporated business in Canada.

3.1 National Accounts Microdata File

The data on gross output, intermediate inputs, and value added at the enterprise level is from the National Accounts Microdata File (NALMF (Rollin, 2013). The data is similar to the Structural Business Statistics (SBS) micro data files in the other countries. The file is derived from linking the administrative data base from the Canada Revenue Agency. In Canada, a new business needs to obtain a business number (BN) from the Canada Revenue Agency (CRA) before filing any documents. This number allows the business to open the various types of accounts needed to meet its tax obligations. There are three main types of accounts. The first one is the payroll account. It contains information that employer businesses file regarding their payroll deductions and remittances (PD7) as well as statements of remuneration paid (T4 slips) that are given to each of their employees at the end of the calendar year. The second type of account (T2) contains the tax returns plus the income and financial statements that the corporations file along with their tax returns. The third type of account contains the goods and services tax (GST) filings or the harmonized sales tax (HST) filings depending on the province of activity. The national accounts micro data is derived from linking those various administrative tax databases (PD7, T4, T2 and GST/HST) using the common BN number.

The data at the BN level is aggregated to the enterprise level. Gross output is measured by total sales. Gross output in current dollars is the sum of costs of capital, costs of labour and costs of intermediate inputs. The cost of capital is measured as net income plus capital cost allowance, and the cost of labour is measured by total payroll. The cost of intermediate inputs is calculated residually as the difference between sales and the sum of capital income and total payroll.

While the national accounts micro data file is being developed as a longitudinal file that will track the business over time, for the purpose of the construction of the extended SUTs, the cross sectional micro data files are used.

3.2 Trade by Enterprise Statistics (TEC) Micro Database (Imports and Exports)

The TEC-Exports and Imports is a database obtained from linking the customs trade records to the Canadian Business Register. The customs data are extracted from administrative files from the Canadian Border Services Agency (CBSA). When goods are imported to or exported from Canada, declarations must be filed with CBSA and include the description and value of the goods, their place of origin and port of clearance and the mode of transport of the goods into or out of the country.

Import data are received from the Canada Border Services Agency through electronic import transaction entries. Data for Canada's exports to countries other than United States are compiled by the Canadian

International Merchandise Trade Statistical Program (CIMTSP) from export declarations received via the CBSA.

Since 1990, Canada and the United States have exchanged import data; the import data of one partner country are used to derive the export data of the other. Canada's exports to the United States are compiled using United States import statistics (from the U.S. Customs Border Protection via the U.S. Census Bureau) and account for the majority of Canada's export trade. This procedure is used for all of Canada's exports to the United States except exports of natural gas and electricity. These two commodities are recorded directly from Canadian sources in both Canadian and U.S. Customs data, as the Canadian sources are viewed as more accurate than U.S. import data for these series.

The statistical unit for exports and imports are the business number (BN) that are required for all businesses that deal with CBSA for various programs including exports-imports, taxes, and payroll. A BN number could be factory, plant or head office. The data on exports and imports at the BN level are aggregated to the enterprise level using the Business Registry.

3.3 International Transactions in Commercial Services

There are four types of international trade in services: travel, transportation, commercial services and government services. For the extended SUT table, only international trade in commercial services by enterprises are used.

The survey of International Transactions in Commercial Services is an annual survey that Statistics Canada conducted and used to prepare Canada's International Balance of Payments. The questionnaires are sent to Canadian enterprises known to have or believed to have significant international trade in services activity. Enterprises reporting moderate amounts of international transactions in commercial services are rotated in a three year cycle in the annual sample, whereas enterprises reporting larger amounts are included in the sample each year. For those companies that are part of the three year cycle for sample rotation, the most recent reported values are carried forward during the two years a company is out of sample. Coverage of businesses with smaller amounts of international transactions in services is not as good, due to difficulty identifying such units. There are, however, other administrative data sources that help provide the desired coverage.

3.4 Inward Foreign Affiliate Statistics

Inward Foreign Affiliates Statistics (FAS) describe the activities and financial positions of majority-owned domestic affiliates (MODAs) by foreign investors operating in the Canadian economy. Majority-owned domestic affiliates are defined as domestic entities where a foreign direct investor owns more

than 50% of the voting shares. Inward Foreign Affiliate Statistics are an extension of statistics on Foreign Direction Investment, and they provide insight on the effect of foreign controlled enterprises on output, employment, productivity, and international trade in the Canadian economy.

The country of control in the FAS can be defined as the country of the ultimate investor or the country of immediate investor. The country of the ultimate investor gives information about who controls a domestic direct investment enterprise. The country of the immediate investor expands on this by providing, down the chain of related enterprises, the country that is the direct investor before entering the domestic economy. In the context of multinational enterprises using complex enterprise structures, the notions of both ultimate and immediate investors provide relevant perspectives on majority ownership and control in the domestic economy. For the extended SUTs, we will use both concepts to define foreign and domestic controlled enterprises, but will present the results using the concept of ultimate control as the results based on the concept of intermediate control are similar.

Almost all the enterprises in TEC-exports data, FAS database, trade in commercial services database are linked to the enterprises in the national accounts business micro data file. For TEC-imports database, about 75% of business units BNs are linked to the national account business micro database, accounting for about 95% of the total imports in the imports database. The businesses that are not linked are small and are likely to be unincorporated businesses and they cannot be found in the national accounts businesses microdata file which only includes the incorporated businesses.

To develop extended SUTs, the enterprises in the linked file are classified by size, country of control or export status:[1]

Firm Size: small (0 to 49); medium (50 to 249) and large (250 or above);

Export Status: exporters and non-exporters, and

Country of Control: Foreign- and domestic-controlled firms.

The firms are dis-aggregated with one characteristic at a time. When the firms are dis-aggregated with more than one characteristic, the number of firms in a large number of industry –firm type cells are found to be small. Those cells will be confidential and the estimates for those cells are not likely to be reliable.

The extended SUTs have been constructed for 2010, 2011 and 2012 when both the national SUTs and TEC database are available. The results will be presented for 2012 only. The results for other years are similar.

[1] The firm size categories follow the OECD classification.

4. Firm Heterogeneity for Trade in Value Added Measures

The domestic valued added content of exports depend on the share of imports in intermediate inputs, the share of intermediate inputs in gross output, or the share of value added in gross output, and share of exports in gross output. This section presents those shares by firm characteristics. It will focus on three shares: the share of exports in gross output, the share of imports in gross output, and the share of value added in gross output. Those three shares can be used to estimate the share of imports in intermediate inputs and the share of intermediate inputs in gross output that are directly entered into the formula for estimating the TiVA statistics. For example, the share of imports in intermediate inputs is equal to the share of imports in gross output divided by the share of intermediate inputs in gross output.

While the extended SUTs are developed at a more detailed level of industry classification (link-level), we will present the results at the main sector level.

Table 1 presents the shares of exports, imports and value added in gross output by firm size. For total economy, the export and import shares are positively associated with firm size. The large firms have higher shares of output that is exported and higher shares of imports compared with small firms. But the share of value added in gross output is similar between firms of different sizes. The value added accounted for about half of gross output for small, medium and large sized firms. The intermediate inputs accounted for the remaining half of gross output.

Tables 2 and 3 present the shares of exports, imports and value added in gross output by ownership and export status. The results in the tables show that foreign controlled firms and exporters tend to have higher export and import shares than the domestic controlled firms and non-exporters for almost all industries. For total economy, the foreign controlled firms exported about 41% of their output, compared with 10% for the domestic controlled firms in 2012. The foreign controlled firms also have higher import shares than the domestic controlled firms (19% vs. 5% in 2012).

Tables 2 and 3 also show that the share of value added in output in the foreign controlled firms are lower than the domestic controlled firms. For the total economy, the share of value added in output was 42% for the foreign controlled firms and 49% for the domestic controlled firms. The evidence is consistent with the previous evidence for Canada and many other countries. Fetzer et al. (2015) found that the value added as a share of output is lower for foreign owned firms than for domestically owned firms in the United States and that exports and imports as a share of output are larger for foreign owned firms. Piacentinit and Fortanier (2015) find that the share of value added in gross output is lower in most OECD countries. Gu and Li (2017) found the foreign-controlled firms have lower shares of value added than the domestically controlled firms using the Annual Survey of Manufacturers.

The share of value added in output for exporters is slighter higher that for non-exporters. For the total economy, the share of value added in output was 49% for exporters and 47% for non-exporters.

The difference in the export and import shares between foreign and domestic-controlled firms and between exporters and non-exporters is much larger compared with the difference between small and large firms. This suggests that the effect of taking into account firm heterogeneity by ownership and export status on TiVA measures is likely to be larger than the effect of taking into account firm heterogeneity by firm size.

5. Trade in Value Added Measures

This section presents the estimates of domestic value added in exports. The estimates are constructed using the extended SUTs for 2010, 2011 and 2012. The discussion will focus on the results for 2012 and will answer the following four questions.

First, what is the estimated domestic value-added and foreign contents of exports by firm size, country of control and export status? It is expected that foreign-controlled firms and exporters will have higher foreign content and lower domestic value added content in their exports compared with domestic controlled firms and non-exporters. But the difference in foreign and domestic value added content between large, medium and small firms will be smaller as the differences in export and import shares are smaller between the firms of different sizes.

Second, what is the contribution of different types of firms to the value added exports and gross exports? The small, domestic controlled firms and non-exporters are found to account for a lower share of total exports compared with large, foreign controlled and exporters. But as the small, domestically controlled firms and non-exporters are indirectly involved in the production of exports as suppliers of intermediate inputs, those firms are indirectly involved in the production of exports. Therefore, it is expected that the contribution of those firms to the value-added exports are much larger than their contributions to gross output.

Third, what is the relative contribution of service and goods producing sectors to value added exports and gross exports? The service sectors are expected to make a contribution to value added exports that is larger than what their share in gross exports would suggest, as the services sector are indirectly involved in the production of exports as suppliers of intermediate service inputs.

Fourth, what is the effect of taking into account firm heterogeneity on the TiVA measures? The effect of firm heterogeneity by ownership and export status on the domestic value added and foreign content of

exports are expected to be larger compared with the effect of firm size, as there is much larger differences in export and import shares by ownership types and by export status than that by firm size.

The results are presented in Tables 4 to 9 and Figures 5 to 9. The main findings can be summarized as follows.

First, the domestic value added content of exports are the lowest for the medium-sized firms and higher for the small and large firms (Table 4). There are also differences in the domestic value added content of exports by country of control and export status (Tables 5 and 6). The domestic value added content of exports are much lower for the foreign controlled firms than for domestic controlled firms. For total economy, the share of domestic value added in gross exports in 65% for foreign controlled firms compared with 69% for the domestic controlled firms.

Second, the contribution of the small, domestic controlled firms and non-exporters to value added exports is higher than what their share of gross exports would suggest as they are indirectly involved in the production of exports by supplying goods and services that are used in the production of exports (Tables 7 to 9 and Figures 5 to 7). In 2012, small firms (with 0 to 49 workers) accounted for 15% of gross exports, but they contributed 24% of value added exports in Canada. The domestic controlled firms accounted for about half of exports, and contributed 64% of value added exports. For the non-exporters, although they are not directly involved in exports, they contributed 17% of value added exports through their supply of intermediate inputs to the production of exports

Third, the service sectors are found to make a contribution to value added exports that is larger than what their share in gross exports (Figure 8). In 2012, the services accounted for 23% of gross exports in Canada. But services accounted for about 43% of value added exports as the services are used for the production of goods exports.

Fourth, the effect of taking into account firm heterogeneity by ownership and export status in the extended SUTs are found to lower the estimate of the domestic value added content of exports by 6 and 5 percentage points in 2012 in total economy (Figure 10). The domestic value added content of exports is 73% from the standard tables. It is 67% from the extended SUTs that accounts for firm heterogeneity in ownership and it is 68% from the extended SUTs with export status. The effect of taking into account heterogeneity by firm size on TiVA measure is smaller. It reduced the estimate of domestic value added content in exports by 4 percentage points in Canada from 73% to 69%.

The results for Canada can be compared with the results for other countries. Araujo and Ahmad (2011) find that the share of domestic value added content in Turkish exports is 6 percentage points lower in the

extended SUTs. Compared with the standard SUTs, Koopman et al. (2012) find that the domestic value added content of Chinese exports is much lower and the foreign value added content of Chinese exports doubled when taking into account the lower domestic value added content of processing exports.

6. Conclusions

This paper constructed extended SUTs for Canada that take into account firm heterogeneity by size, country of control and export status and used the tables to construct the TiVA measures for 2010, 2011 and 2012. The extended SUTs reduced bias in the TiVA measures estimated from the standard tables due to firm heterogeneity. The paper shows that the extended SUTs lower the estimate of the domestic value added content of exports by 4 to 6 percentage points. It also finds that the extended SUTs and TiVA measures derived from the extended SUTs provide a richer insight about the participation of small vs. large firms, domestic vs. foreign controlled firms, and non-exporters vs. exporters in the global value chain.

This work has identified a number of issues and challenges for the construction of extended SUTs including: limited information on inter-firm transactions of intermediate inputs between different types of firms; little information on the final using industries of the products imported by distributors; limited information on the product details used to allocate output and inputs, limited data on product details used for allocating imports; inconsistencies in the concept of output and inputs between micro data files and the system of national accounts. Those challenges for Canada are similar to those in other countries (Ahmad, 2017).

The input/output relationship between the different types of firms are not known from the existing micro data and, it has to be estimated using the existing national input/output tables. This paper made use of the market share assumption: the purchase of an input by a firm is allocated among the firms producing the intermediate input in a proportion to their shares in the total production of that intermediate input.

The end use of the total imports among intermediate users (firms) and final demand users are not known and it has to be estimated using the import proportionality assumption. Baldwin et al. (2017) examined the potential use of various data bases for reducing the bias from the assumption.

There are inconsistency between microdata files and the national SUTs due to the difference in coverage and the difference in the concepts of outputs, inputs and valued added, and the difference in the measurement and valuation. For example, the linked micro data files include incorporated businesses and excludes un-incorporated business, but the national SUTs include both incorporated and un-incorporated

businesses. The micro data files that are used to take into account heterogeneity are available at the enterprise level. But the national SUTs are based on establishments.

The future work on the extended SUTs will address some of those challenges. First, the commodity information on exports and imports from the TEC database and commodity information on output and inputs for the manufacturing firms from the Annual Survey of Manufacturers will be used for the construction of eSUTs. This will relax the import proportionality assumption and take into account the difference in output and input mixes between different types of firms in the construction of the extended SUTs. Second, the estimates will be developed for more recent years to examine the change in the TiVA measures and value added exports and the sources of those changes.

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Table 1. Shares of Exports, Imports and Value Added in Gross Output by Firm Size, 2012

	Exports/Output			Imports/Output			Value Added/Output		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Agriculture, Forestry, Fishing and Hunting	0.18	0.57	0.65	0.01	0.11	0.08	0.42	0.23	0.15
Mining and Oil and Gas Extraction	0.30	0.10	0.58	0.03	0.04	0.07	0.44	0.42	0.67
Utilities	0.03	0.01	0.06	0.09	0.01	0.04	0.49	0.20	0.80
Construction	0.00	0.00	0.00	0.10	0.14	0.16	0.40	0.47	0.54
Manufacturing	0.21	0.54	0.45	0.17	0.23	0.28	0.35	0.35	0.25
Wholesale Trade	0.28	0.14	0.14	0.03	0.03	0.03	0.62	0.56	0.68
Retail Trade	0.01	0.00	0.01	0.02	0.01	0.04	0.57	0.53	0.70
Transportation and Warehousing	0.16	0.10	0.11	0.06	0.05	0.07	0.41	0.51	0.53
Information and Cultural Industries	0.08	0.19	0.06	0.10	0.14	0.08	0.34	0.47	0.63
Finance, Insurance and Real Estate	0.01	0.06	0.05	0.01	0.02	0.03	0.60	0.65	0.50
Other Private Services	0.04	0.08	0.17	0.01	0.02	0.06	0.64	0.67	0.54
Non-business sector	0.02	0.01	0.03	0.00	0.01	0.00	0.66	0.19	0.47
Total Economy	**0.07**	**0.17**	**0.21**	**0.05**	**0.08**	**0.10**	**0.53**	**0.43**	**0.47**

Table 2. Shares of Exports, Imports and Value Added in Gross Output by Ownership, 2012

	Exports/Output		Imports/Output		Value Added/Output	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Agriculture, Forestry, Fishing and Hunting	0.24	0.85	0.01	0.08	0.38	0.19
Mining and Oil and Gas Extraction	0.24	0.71	0.04	0.06	0.77	0.49
Utilities	0.06	0.02	0.04	0.04	0.77	0.63
Construction	0.00	0.00	0.09	0.27	0.43	0.51
Manufacturing	0.36	0.53	0.22	0.34	0.31	0.24
Wholesale Trade	0.24	0.13	0.02	0.04	0.69	0.53
Retail Trade	0.01	0.01	0.01	0.05	0.60	0.64
Transportation and Warehousing	0.10	0.36	0.06	0.11	0.49	0.44
Information and Cultural Industries	0.05	0.25	0.08	0.20	0.59	0.32
Finance, Insurance and Real Estate	0.03	0.09	0.01	0.08	0.57	0.51
Other Private Services	0.05	0.27	0.02	0.06	0.53	0.75
Non-business sector	0.03	0.00	0.00	0.08	0.46	0.12
Total Economy	**0.10**	**0.41**	**0.05**	**0.19**	**0.49**	**0.42**

Table 3. Shares of Exports, Imports and Value Added in Gross Output by Export Status, 2012

	Exports/Output		Imports/Output		Value Added/Output	
	Non-exporters	Exporters	Non-exporters	Exporters	Non-exporters	Exporters
Agriculture, Forestry, Fishing and Hunting	0.00	0.83	0.01	0.10	0.48	0.15
Mining and Oil and Gas Extraction	0.00	0.60	0.02	0.07	0.41	0.66
Utilities	0.00	0.06	0.01	0.04	0.31	0.86
Construction	0.00	0.01	0.07	0.24	0.43	0.49
Manufacturing	0.00	0.47	0.13	0.29	0.38	0.27
Wholesale Trade	0.00	0.29	0.02	0.03	0.70	0.59
Retail Trade	0.00	0.02	0.01	0.04	0.58	0.66
Transportation and Warehousing	0.00	0.25	0.04	0.09	0.45	0.52
Information and Cultural Industries	0.00	0.11	0.07	0.10	0.42	0.59
Finance, Insurance and Real Estate	0.00	0.09	0.01	0.04	0.58	0.53
Other Private Services	0.00	0.29	0.01	0.06	0.67	0.41
Non-business sector	0.00	0.10	0.00	0.00	0.32	0.84
Total Economy	**0.00**	**0.33**	**0.02**	**0.14**	**0.47**	**0.49**

Table 4. Share of Domestic Value Added in Gross Exports by Firm Size, 2012

	Small	Medium	Large	All
Agriculture, Forestry, Fishing and Hunting	0.46	0.64	0.66	0.55
Mining and Oil and Gas Extraction	0.87	0.82	0.88	0.88
Utilities	0.84	0.86	0.94	0.94
Construction	0.79	0.78	0.78	0.79
Manufacturing	0.67	0.56	0.56	0.57
Wholesale Trade	0.89	0.87	0.90	0.89
Retail Trade	0.90	0.90	0.91	0.90
Transportation and Warehousing	0.78	0.83	0.84	0.81
Information and Cultural Industries	0.78	0.76	0.86	0.81
Finance, Insurance and Real Estate	0.92	0.92	0.88	0.89
Other Private Services	0.90	0.93	0.81	0.86
Non-business sector	0.66	0.81	0.47	0.51
Total Economy	**0.76**	**0.64**	**0.68**	**0.69**

Table 5. Share of Domestic Value Added in Gross Exports by Ownership, 2012

	Domestic	Foreign	All
Agriculture, Forestry, Fishing and Hunting	0.41	0.64	0.44
Mining and Oil and Gas Extraction	0.92	0.84	0.86
Utilities	0.93	0.77	0.93
Construction	0.80	0.68	0.76
Manufacturing	0.63	0.48	0.56
Wholesale Trade	0.90	0.84	0.88
Retail Trade	0.90	0.88	0.89
Transportation and Warehousing	0.84	0.67	0.79
Information and Cultural Industries	0.84	0.66	0.76
Finance, Insurance and Real Estate	0.90	0.84	0.87
Other Private Services	0.84	0.88	0.85
Non-business sector	0.46	0.00	0.46
Total Economy	**0.69**	**0.65**	**0.67**

Table 6. Share of Domestic Value Added in Gross Exports by Export Status, 2012

	Non-exporters	Exporters	All
Agriculture, Forestry, Fishing and Hunting	0.00	0.65	0.65
Mining and Oil and Gas Extraction	0.00	0.87	0.87
Utilities	0.00	0.95	0.95
Construction	0.00	0.70	0.70
Manufacturing	0.00	0.55	0.55
Wholesale Trade	0.00	0.87	0.87
Retail Trade	0.00	0.89	0.89
Transportation and Warehousing	0.00	0.81	0.81
Information and Cultural Industries	0.00	0.78	0.78
Finance, Insurance and Real Estate	0.00	0.87	0.87
Other Private Services	0.00	0.78	0.78
Non-business sector	0.00	0.84	0.84
Total Economy	**0.00**	**0.68**	**0.68**

Table 7. Contributions of Firms to Value-Added Exports and Gross Exports by Firm Size, 2012

	Value-Added Exports			Gross Exports		
	Small	Medium	Large	Small	Medium	Large
Agriculture, Forestry, Fishing and Hunting	0.80	0.14	0.05	0.52	0.30	0.18
Mining and Oil and Gas Extraction	0.08	0.02	0.90	0.09	0.01	0.90
Utilities	0.05	0.02	0.93	0.05	0.02	0.92
Construction	0.60	0.20	0.20	0.57	0.16	0.27
Manufacturing	0.11	0.25	0.65	0.07	0.21	0.72
Wholesale Trade	0.50	0.22	0.28	0.56	0.21	0.23
Retail Trade	0.38	0.17	0.44	0.48	0.12	0.40
Transportation and Warehousing	0.38	0.12	0.50	0.46	0.10	0.44
Information and Cultural Industries	0.13	0.21	0.66	0.19	0.34	0.47
Finance, Insurance and Real Estate	0.38	0.11	0.51	0.17	0.13	0.70
Other Private Services	0.43	0.20	0.37	0.26	0.15	0.59
Non-business sector	0.22	0.05	0.73	0.12	0.05	0.83
Total Economy	**0.24**	**0.14**	**0.62**	**0.15**	**0.16**	**0.69**

Table 8. Contributions of Firms to Value-Added Exports and Gross Exports by Country of Control, 2012

	Value-Added Exports		Gross Exports	
	Domestic	Foreign	Domestic	Foreign
Agriculture, Forestry, Fishing and Hunting	0.95	0.05	0.87	0.13
Mining and Oil and Gas Extraction	0.39	0.61	0.21	0.79
Utilities	0.93	0.07	0.96	0.04
Construction	0.91	0.09	0.70	0.30
Manufacturing	0.62	0.38	0.50	0.50
Wholesale Trade	0.72	0.28	0.72	0.28
Retail Trade	0.76	0.24	0.73	0.27
Transportation and Warehousing	0.82	0.18	0.72	0.28
Information and Cultural Industries	0.81	0.19	0.55	0.45
Finance, Insurance and Real Estate	0.77	0.23	0.63	0.37
Other Private Services	0.55	0.45	0.54	0.46
Non-business sector	1.00	0.00	1.00	0.00
Total Economy	**0.64**	**0.36**	**0.51**	**0.49**

Table 9. Contributions of Firms to Value-Added Exports and Gross Exports by Export Status, 2012

	Value-Added Exports		Gross Exports	
	Non exporters	Exporters	Non exporters	Exporters
Agriculture, Forestry, Fishing and Hunting	0.64	0.36	0.00	1.00
Mining and Oil and Gas Extraction	0.03	0.97	0.00	1.00
Utilities	0.06	0.94	0.00	1.00
Construction	0.79	0.21	0.00	1.00
Manufacturing	0.03	0.97	0.00	1.00
Wholesale Trade	0.16	0.84	0.00	1.00
Retail Trade	0.47	0.53	0.00	1.00
Transportation and Warehousing	0.20	0.80	0.00	1.00
Information and Cultural Industries	0.11	0.89	0.00	1.00
Finance, Insurance and Real Estate	0.40	0.60	0.00	1.00
Other Private Services	0.46	0.54	0.00	1.00
Non-business sector	0.29	0.71	0.00	1.00
Total Economy	**0.17**	**0.83**	**0.00**	**1.00**

Table 10. Alternative Estimates of Value Added Share of Exports in Canada, 2012

	Value Added Share of Exports	Difference with Estimate from Standard SUTs
Standard SUTs	0.73	---
Extended SUTs with Firm Size	0.69	0.04
Extended SUTs with Ownership	0.67	0.06
Extended SUTs with Export Status	0.68	0.05

Figure 1. National Supply-Use Tables

Supply Table			
	Industry	imports	Total supply
commodity	V	M	q+M
Total industry output	g^T		
Use Table			
	Industry	Final use	Total use
commodity	U	F + X	q+F+X
Value added	A^T		
Industry output	g^T		

Figure 2. National Input-Output Tables

	Industry	Final Domestic Demand and Exports	Industry Output
Industry	$D^T U - D^T \hat{\mu} U$	$D^T (I - \hat{\mu}) F + X$	g
Imported intermediates	$D^T \hat{\mu} U$		
Value added	A^T		
Industry output	g^T		

Figure 3. Extended National Supply-Use Tables

Supply Table			
	Industry and firm types	imports	Total supply
commodity	$V * diag(S^V)$	M	q+M
Total output by industry and firm types	$g^T * diag(S^V)$		
Use Table			
	Industry and firm types	Final use	Total use
Commodity	$U * diag(S^U)$	F + X	q+F+X
Value added	$A^T * diag(S^A)$		
Output by industry and firm types	$g^T * diag(S^V)$		

Note: The operation *diag* of a matrix creates a new matrix with each element on the diagonal equal to the row vectors of the matrix and zeroes elsewhere.

Figure 4. Extended National Input-Output Tables

	Industry and firm types	Final Domestic Demand and Exports	Output by industry and firm types
Industry and firm types	$\left(E^T U\right) * diag(S^U)$ $-\left(E^T \hat{\mu} U\right) * diag(S^M)$	$diag(S^V)^T *$ $D^T\left((\mathrm{I}-\hat{\mu})\,\mathrm{F}+\mathrm{X}\right)$	$diag(S^V)^T * g$
Imported intermediates	$\left(E^T \hat{\mu} U\right) * diag(S^M)$		
Value added by industry and firm types	$A^T * diag(S^A)$		
Output by industry and firm types	$g^T * diag(S^V)$		

Figure 5. Share of Small, Medium and Large Firms in Value-Added Exports and Gross Exports, 2012

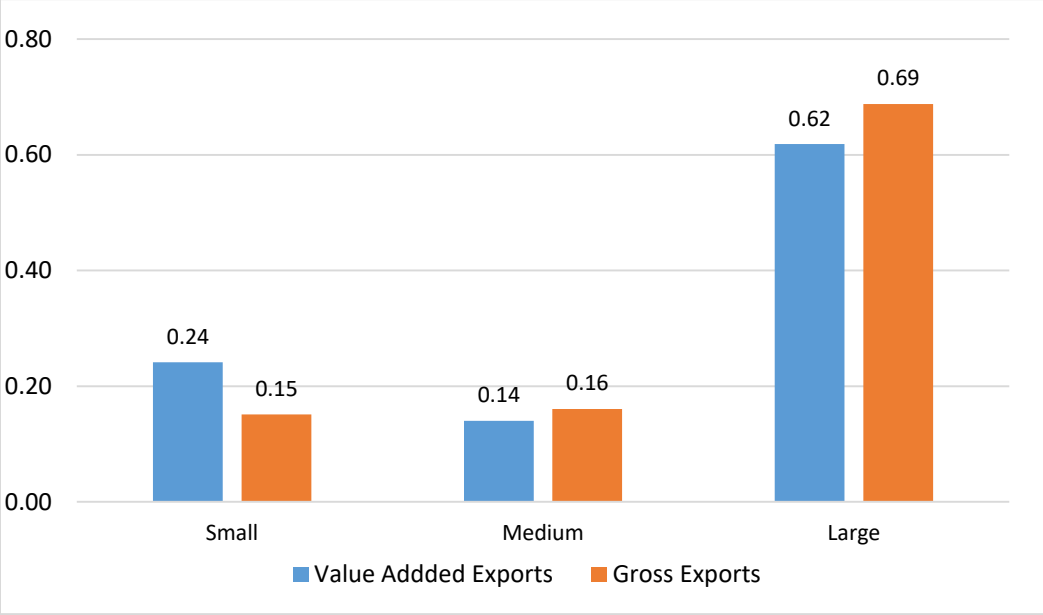

Figure 6. Share of Domestic and Foreign Controlled Firms in Value-Added Exports and Gross Exports, 2012

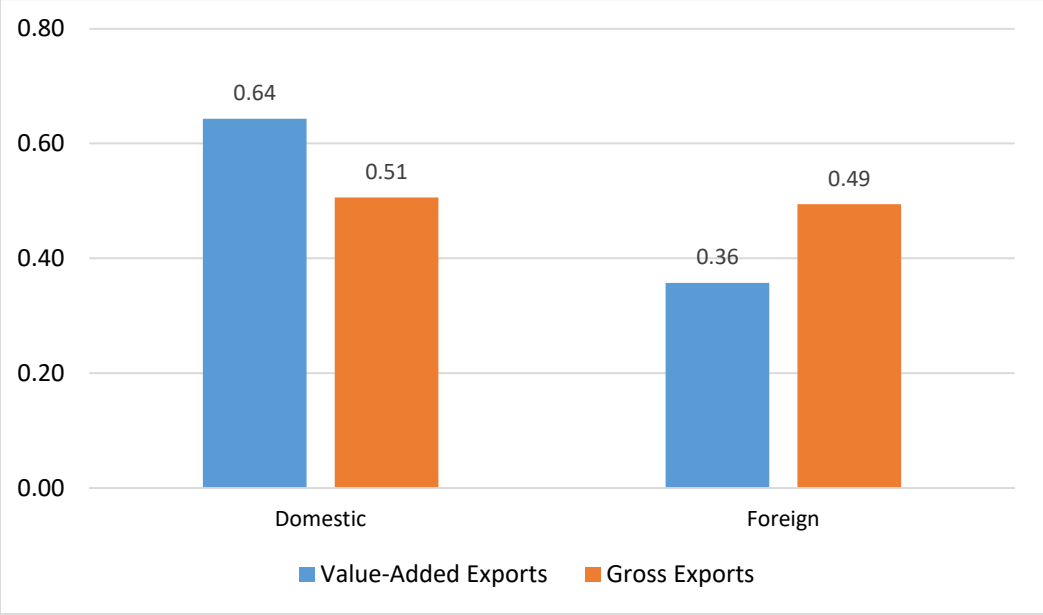

Table 7. Share of Non-exporters and Exporters in Value Added Exports and Gross Exports, 2012

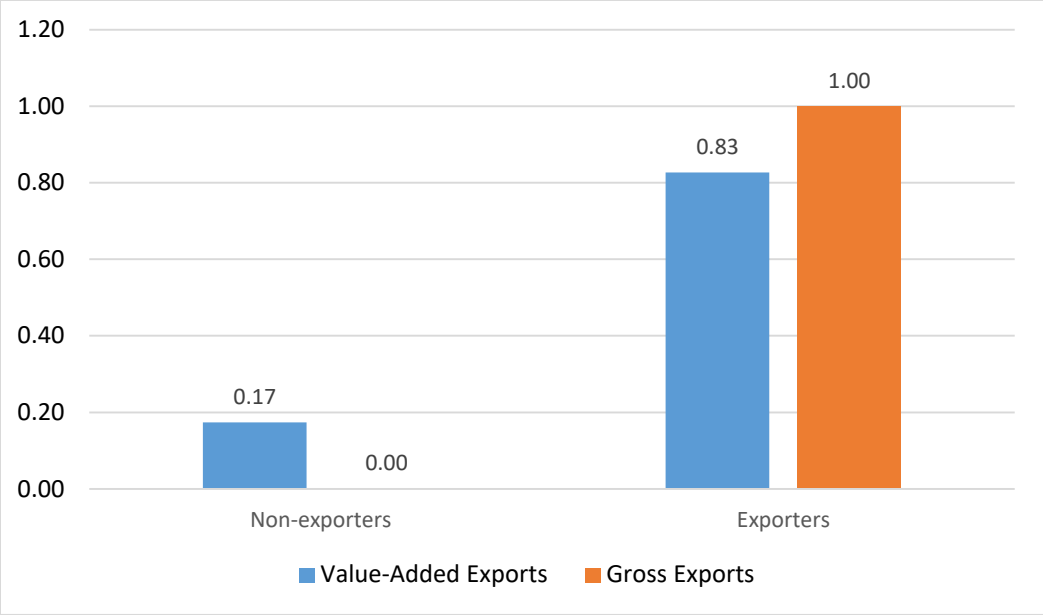

Figure 8. Share of Goods and Services in Value-Added Exports and Gross Exports, 2012