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ABSTRACT

We use Belgian data on domestic firm-to-firm transactions and ask how the measurement of the share of imports in final consumption is affected when one uses data recorded at higher levels of aggregation. We find that aggregating detailed firm-to-firm transaction data to the firm level and imposing homogeneity assumptions in the composition of firms' input and output do not substantially affect the measurement of the share of imports in final consumption. However, using the national IO tables alone may understate the share of imports in final consumption and, thereby, the gains from trade.

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1 Introduction

In a wide class of models, one of the relevant statistics for calculating the welfare effects of trade is the share of imports in final consumption (Dhyne et al., 2021). It measures the share of imported inputs that are used in the production of final goods consumed domestically. To accurately measure the foreign content of what we consume, we need to account for imports obtained indirectly through the domestic supplier network.[1]

The purpose of this paper is to use data from Belgium that contain detailed information on domestic firm-to-firm transactions and ask how the measurement of the share of imports in final consumption is affected when one uses data recorded at higher levels of aggregation. Answering this question is important because only a few countries provide detailed transaction data at the level of firm-to-firm relationships. Researchers often have to rely on data that are recorded at the firm level or on national input-output (IO) tables that are recorded at the sectoral level. Analyses using such data require homogeneity assumptions on how firms source their inputs and sell their output.[2] We test the implications of these restrictive but common assumptions in the measurement of the share of imports in final consumption.

We find that aggregating detailed firm-to-firm transaction data to the firm level and imposing homogeneity assumptions in the composition of firms' input and output do not substantially affect the measurement of the share of imports in final consumption. However, if researchers have to rely on the national IO tables alone, our results caution that the usage of such data may understate the share of imports in final consumption and thereby the gains from trade. Our exploration reveals that when researchers use the national IO tables, wholesale and retail firms—which account for a sizable share of final consumption—have significantly lower total import shares.

2 Data

We draw on three data sources provided by the National Bank of Belgium (NBB).[3] The first data source is the business-to-business (B2B) transactions database (Dhyne, Magerman and Rubinova, 2015). The B2B transactions database allows us to measure all domestic firm-to-firm transactions provided that the amount of annual sales in a given relationship exceeds 250 euro. The second data source consists of the Belgian customs records and the intra-EU trade declarations. These

[1] Note that the share of imports in final consumption is distinct from the ratio of aggregate imports to aggregate domestic final consumption since imports can also be used in the production of exports. Furthermore, depending on the structure of the domestic production network, the usage of imports may differ between domestic final consumption and exports.

[2] Similar challenges in measurement arise in the context of Global Value Chain statistics (see, for example, Johnson and Noguera, 2012 and Johnson, 2018.). See also de Gortari (2018) for recent attempts to improve these measurement issues using microdata. For similar attempts using Belgian data, see Hambye, Hertveldt and Michel (2018), Bems and Kikkawa (2021), and Hambye and Michel (2022).

[3] All three data sources are recorded at the level of value-added tax (VAT) identifiers. We follow Dhyne et al. (2021) and Dhyne, Kikkawa and Magerman (2022) to aggregate VAT identifiers to the level of firms. For each firm that consists of multiple VAT identifiers, we assign the industry code of the largest VAT identifier.

data sources allow us to observe the values of imported and exported goods by Belgian firms. The third data source is the annual account filings of Belgian firms. Importantly, this dataset contains information on firms' sales and the cost of inputs, as well as their four-digit NACE industry codes. By subtracting a firm's sales to other firms and exports from its total sales, we can back out its sales to domestic final demand.

For the analysis in this paper, we focus on the cross-section of private and non-financial sector firms in the year 2012. We refer to Dhyne et al. (2021) for a more detailed description of the variables, sample selection procedures, and the coverage of the selected sample of firms.

In addition to the microdata provided by the NBB, this paper uses the national IO table to compute the share of imports in final consumption. When doing so, we use the 2012 national IO table for Belgium, available in the World Input-Output Database (WIOD, Timmer et al., 2015). We also complement the analysis by using the IO table published by the Belgian Federal Planning Bureau for the year 2010.[4]

3 Measurement

The share of imports in final consumption captures the share of household consumption that originates from abroad. It is thus measured as $\sum_j s_{jH} s_{Fj}^{Total}$, where we sum across all firms' total import shares, s_{Fj}^{Total}, that capture the shares of imports in firms' input usage, with each firm weighted by its sales share in domestic final consumption, s_{jH}.

While some firms directly import inputs from abroad, the majority of firms only use imported inputs indirectly from their suppliers that import, or suppliers' suppliers that import, and so on (Dhyne et al., 2021). We follow Dhyne et al. (2021) and define firms' total import share as follows:

$$s_{Fj}^{Total} = s_{Fj} + \sum_i s_{ij} s_{Fi}^{Total}. \tag{1}$$

Firm j's total import share is recursively defined as the sum of its direct import share, s_{Fj}, and the total import shares of its suppliers, each weighted by the supplier's input share in firm j, s_{ij}.

The key assumption underlying this measure is that the firm's composition of inputs in production does not vary across its buyers. Furthermore, in a broad class of models where households have homothetic preferences, firms produce with constant returns, firm-to-firm linkages are fixed, and firms charge constant markups, the share of imports in consumption, $\sum_j s_{jH} s_{Fj}^{Total}$, becomes a key statistic in predicting the change in the aggregate price index in response to changes in trade costs (Dhyne et al., 2021).[5]

In the following subsections, we outline how we measure s_{jH}, s_{Fj}, s_{ij}, and hence s_{Fj}^{Total} under different assumptions on the structure of the domestic production network and data availability.

[4] Because this IO table is only available every five years, we use the WIOD as the baseline dataset for the national IO table. As discussed below, we focus on the same private and non-financial sectors when using the national IO tables.

[5] Another important assumption is that all inputs are variable inputs. Dhyne et al. (2022) relax this assumption and calculate the total import shares separately for variable and fixed inputs. They find that doing so makes the total import shares in variable costs larger and that the total import shares in fixed inputs are relatively small.

3.1 Baseline

As our baseline, we make use of the richness of the Belgian data to compute the share of imports in final consumption. Using these data allows us to capture heterogeneities in firms' sourcing and selling patterns within sectors. For example, firms source from different sets of firms and sell to different sets of firms even if they are in the same sector. Furthermore, firms allocate different shares of input costs to purchases from suppliers and different shares of revenue to sales to buyers.

In this baseline case, s_{jH} is measured as the share of firm j's sales to domestic final demand among all other firms' sales to domestic final demand. The direct import share of firm j, s_{Fj}, is measured as the share of imports in its total input cost. The total input cost of a firm is calculated as the sum of the firm's labor cost, purchases from other firms, and imports. Finally, s_{ij} is measured as the share of firm i's sales to firm j in firm j's total input cost. With these shares, we use equation (1) to compute firms' total import shares, s_{Fj}^{Total}, and calculate the share of imports in final consumption.

3.2 Simple roundabout

When researchers lack detailed data on firm-to-firm transactions, they need to approximate the network structure, which leads to different measurements of s_{jH} and s_{ij}. We first consider a simple roundabout production economy, following the spirit of Eaton and Kortum (2002). We assume that the production of goods requires labor input and a composite good that is used as an intermediate. As this composite good is aggregated using all firms' output, all firms in this economy are using inputs from every other firm through the composite good.

Since standard firm-level datasets do not distinguish firms' sales to other domestic firms from their sales to domestic final demand, we additionally assume that this composite good is also used as the final consumption good. Therefore, in this simple roundabout case, firms' shares in final consumption, s_{jH}, are measured using firms' domestic sales shares, s_{jD}, in the calculation of the share of imports in final consumption. A firm's domestic sales share, s_{jD}, is defined as the share of the firm's domestic sales (sum of its sales to domestic final demand and its sales to other firms) among all other firms' domestic sales.

Furthermore, input shares in equation (1), s_{ij}, are no longer read directly from the data in the simple roundabout case. Since all firms are assumed to be directly connected with each other through the composite good, for every firm pair, we measure s_{ij} as the product of the supplier's share in total domestic sales by all firms, s_{iD}, and the share of domestic purchases in the buyer's total input cost, s_{Dj}. The measurement of firms' direct import shares, s_{Fj}, remains the same as in the baseline case.

These measures, taken together, allow us to compute firms' total import shares from the following equation:

$$s_{Fj}^{Total,Rd} = s_{Fj} + \sum_i s_{iD} s_{Dj} s_{Fi}^{Total,Rd}, \tag{2}$$

and calculate the import share in final consumption from $\sum_j s_{jD} s_{Fj}^{Total,Rd}$.

3.3 Sectoral roundabout

The second approximation of the network structure we consider is the sectoral roundabout economy. We follow Blaum, Lelarge and Peters (2018) that extend the simple roundabout approach to incorporate sectoral linkages. We assume that firms' output is aggregated up to create a sector-specific composite good, and firms use a Cobb-Douglas aggregate of these sectoral composite goods as intermediates. Firms are heterogeneous in their share of domestic purchases in total input costs but are homogeneous within sectors in the share they allocate toward each sectoral composite good in their total domestic purchases. We use the aggregated two-digit NACE industry codes as our definition of sectors and focus on 48 of them that fall in the category of private and non-financial sectors.

We denote the Cobb-Douglas share of sector v inputs in the production of sector u goods by γ_{vu}. We measure these Cobb-Douglas shares by aggregating all firm-to-firm transactions in the data to the level of sector-to-sector pairs. With these shares in hand, firms' total import shares in the sectoral roundabout case can be computed from

$$s_{Fj}^{Total,SecRd} = s_{Fj} + \sum_i s_{iv(i)} \gamma_{v(i)u(j)} s_{Dj} s_{Fi}^{Total,SecRd}, \tag{3}$$

where we consider firm i in sector v and firm j in sector u. As in the simple roundabout case, we continue to assume that the sectoral composite goods that are used as intermediates for production are also used as final consumption goods. Therefore, $s_{iv(i)}$ is defined as firm i's share in total domestic sales by all firms in its sector v. Finally, we calculate the import share in final consumption as $\sum_j s_{jD} s_{Fj}^{Total,SecRd}$.

3.4 Using the national IO table

The final approach we consider to compute the share of imports in final consumption is to use the national IO tables. When researchers do not have access to any microdata or when they have access to detailed data for only a subset of firms in the economy, they have to rely on the national IO tables by assuming homogeneity in firms within sectors in terms of the composition of their input and output. To be consistent with the analysis done using the NBB datasets, we focus on the same set of 48 sectors as in the sectoral roundabout case.

The total import shares for each sector can be computed using equation (1) where the indices i and j now represent sectors. The IO tables also allow us to measure each sector's share in domestic final demand, s_{jH}.[6] Therefore, we calculate the import share in final consumption from $\sum_j s_{jH} s_{Fj}^{Total,IO}$.

[6] We take a broad definition of domestic final demand, which includes final consumption not only by households but also by non-profits and government, and also includes capital formation.

4 Results

Figure 1 reports the computed share of imports in final consumption under the four different approaches. In the baseline case, where we account for heterogeneity in the composition of firms' input and output within sectors, we find that 58 percent of domestic final consumption in Belgium is produced using inputs that originate from abroad. The figure also shows that assuming roundabout structures in the production network does not quantitatively alter the measurement of the share of imports in final consumption. Assuming a simple roundabout structure implies that the share of imports in final consumption is 61 percent, and assuming a sectoral roundabout structure implies that the share is 60 percent.

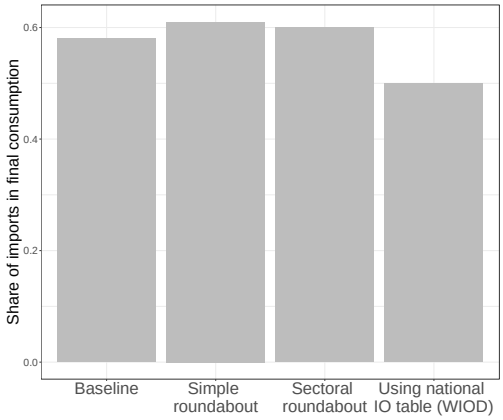

Figure 1: Share of imports in final consumption

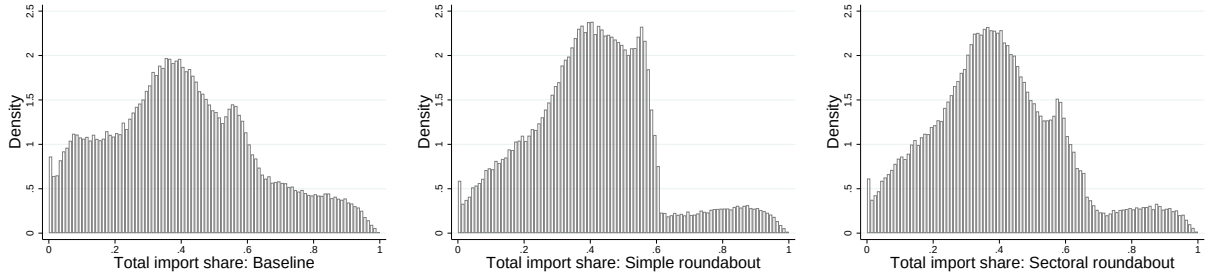

Figure 2: Total import shares

The similarities between the baseline case and the two roundabout cases can be explained by the similar distributions of s_{jH} and firms' total import shares, which together constitute the share of imports in final consumption. In the baseline case, s_{jH} is measured by the firm's sales share in domestic final demand. In the two roundabout cases, we measure s_{jH} with s_{jD} (the firm's share in domestic sales), since standard datasets only record firms' domestic sales. In the Appendix, we plot the distributions of the two and find that they closely overlap, with the correlation coefficient between s_{jH} and s_{jD} at 97 percent. The high correlation between the two is due to the fact that

the sales to domestic final demand account for a large share of the total revenue of many firms. For the median firm, its sales to domestic final demand account for 72 percent of its total revenue (Dhyne et al., 2021).

Figure 2 shows the distributions of the total import shares in the baseline case alongside those in the two roundabout cases. The figure reveals that in the two roundabout cases, the distributions of the total import shares are more compressed than in the baseline case. This is because the roundabout cases fail to capture the rich heterogeneity in firms' input usage, and hence the heterogeneity in their exposure to imports. Nevertheless, the two roundabout cases capture well the typical firm's exposure to imports. While the median firm's total import share is 39 percent in the baseline case, the simple and sectoral roundabout cases imply that the median total import shares are 41 percent and 38 percent, respectively. The total import shares under the simple and sectoral roundabout cases correlate highly with those under the baseline case, with the correlation coefficients being 91 and 92 percent, respectively.[7]

Turning to the share of imports in final consumption when using the national IO table available in the WIOD, we see in Figure 1 that the share is lower than the baseline or the two roundabout cases, at 50 percent.[8] In addition to the fact that the numbers are computed using distinct datasets, a key driver of the difference is the treatment of the retail and wholesale sectors in the national IO tables. The B2B transactions database records the gross sales of firms in the wholesale and retail sectors in the same way as it records sales of firms in other sectors. However, in the national IO table, wholesalers and retailers are treated as supplying services. Their input is measured by the inputs used to provide wholesale and retail services, excluding the goods that are purchased for resale. Their output is measured by the total value of the trade margins realized on the goods they purchase for resale.[9]

This treatment understates the role of wholesale and retail firms in intermediating goods with foreign content. The total sales share in domestic final demand for the wholesale and retail firms (the sum of s_{jH}) is smaller in the national IO table (15 percent) than in the firm-level dataset (38 percent). These wholesale and retail firms are also measured to have lower total import shares. For firms outside the wholesale and retail sectors, the average total import share (weighted by s_{jH}) is 53 percent in the baseline case and 54 percent when using the national IO table. However, for wholesale and retail firms, while the weighted average total import share in the baseline case is not far from the other firms at 66 percent, the share is significantly lower at 24 percent when using the national IO table.[10] These results remain robust to using an alternative dataset for the national

[7] Once weighted by s_{jH}, the correlation coefficients become 92 and 93 percent, respectively.

[8] The correlation between the firm-level total import shares in the baseline case and those when using the national IO table (which vary at the sector-level) is as low as 0.11.

[9] This is a standard treatment that is not specific to Belgium (UN, 2018).

[10] With the baseline values on the left and the values using the national IO table on the right, we can decompose the share of imports in final consumption as

$$\underbrace{\sum_{j\in WR} s_{jH}}_{0.38\,vs\,0.15} \times \underbrace{\sum_{j\in WR} s_{Fj}^{Total} \frac{s_{jH}}{\sum_{i\in WR} s_{iH}}}_{0.66\,vs\,0.24} + \underbrace{\sum_{k\notin WR} s_{kH}}_{0.62\,vs\,0.85} \times \underbrace{\sum_{k\notin WR} s_{Fk}^{Total} \frac{s_{kH}}{\sum_{i\notin WR} s_{iH}}}_{0.53\,vs\,0.54} = 0.58\,vs\,0.50,$$

IO table. When we use the 2010 IO table published by the Belgian Federal Planning Bureau, the share of imports in final consumption is measured at 53 percent.[11]

which divides firms into wholesale and retail firms and the rest of firms.

[11] When we use the 2010 IO table, the sales share in domestic final demand for the wholesale and retail firms is close to what is obtained from the WIOD at 17 percent. Moreover, the weighted average total import share for these firms is significantly lower than the other sectors at 39 percent.

References

Bems, Rudolfs, and Ayumu Ken Kikkawa. 2021. "Measuring trade in value added with firm-level data." *Journal of International Economics*, 129: 103434.

Blaum, Joaquin, Claire Lelarge, and Michael Peters. 2018. "The gains from input trade with heterogeneous importers." *American Economic Journal: Macroeconomics*, 10(4): 77–127.

de Gortari, Alonso. 2018. "Disentangling Global Value Chains."

Dhyne, Emmanuel, Ayumu Ken Kikkawa, and Glenn Magerman. 2022. "Imperfect Competition in Firm-to-Firm Trade." *Journal of the European Economic Association*.

Dhyne, Emmanuel, Ayumu Ken Kikkawa, Magne Mogstad, and Felix Tintelnot. 2021. "Trade and Domestic Production Networks." *The Review of Economic Studies*, 88: 643–668.

Dhyne, Emmanuel, Ayumu Ken Kikkawa, Toshiaki Komatsu, Magne Mogstad, and Felix Tintelnot. 2022. "Foreign Demand Shocks to Production Networks: Firm Responses and Worker Impacts." Working Paper.

Dhyne, Emmanuel, Glenn Magerman, and Stela Rubinova. 2015. "The Belgian production network 2002-2012." *NBB Working Paper Series*, 288.

Eaton, Jonathan, and Samuel Kortum. 2002. "Technology, Geography, and Trade." *Econometrica*, 70(5): 1741–1779.

Hambye, Caroline, and Bernhard Michel. 2022. "Export-sustained employment: accounting for exporter-heterogeneity in input–output tables." *Economic Systems Research*, 34.

Hambye, Caroline, Bart Hertveldt, and Bernhard Michel. 2018. "The Role of Exporters and Domestic Producers in GVCs: Evidence for Belgium based on Extended National Supply-and-Use Tables Integrated into a Global Multiregional Input-Output Table." National Bureau of Economic Research Working Paper 25155.

Johnson, Robert C. 2018. "Measuring Global Value Chains." *Annual Review of Economics*, 10: 207–236.

Johnson, Robert C., and Guillermo Noguera. 2012. "Accounting for intermediates: Production sharing and trade in value added." *Journal of International Economics*, 86(2): 224–236.

Timmer, Marcel P, Erik Dietzenbacher, Bart Los, Robert Stehrer, and Gaaitzen J De Vries. 2015. "An illustrated user guide to the world input–output database: the case of global automotive production." *Review of International Economics*, 23(3): 575–605.

UN. 2018. *Handbook on Supply and Use Tables and Input Output-Tables with Extensions and Applications,*. United Nations.

A Appendix

A.1 s_{jH} and s_{jD}

Figure 3 plots the log distributions of s_{jH} and s_{jD}. The share s_{jH} is defined as the firm's sales share in domestic final demand. The share s_{jD} is defined as the share of the firm's domestic sales (sales to domestic final demand and sales to other domestic firms) among all firms.

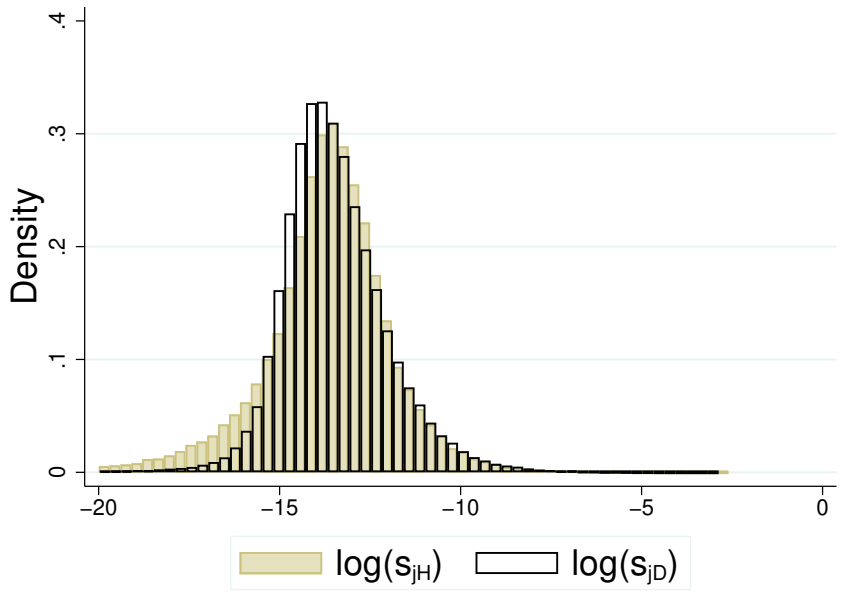

Figure 3: Distributions of $\log s_{jH}$ and $\log s_{jD}$