Trade and Domestic Production Networks*

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Abstract

This paper examines how many and what kind of firms ultimately rely on foreign inputs, sell to foreign markets, and are affected by trade shocks. To capture that firms can trade indirectly by buying from or selling to domestic firms that export or import, we use Belgian data with information on both domestic firm-to-firm sales and foreign trade transactions. We reach five broad conclusions. First, most firms use a lot of foreign inputs, but only a small number of firms show that dependence through direct imports. Second, while direct exporters are rare, a majority of firms are indirectly exporting. In most firms, however, indirect export is quantitatively modest, and sales at home are the key source of revenue. Third, foreign trade is common not only at large and productive firms but also among those that are smaller and less productive. However, large firms differ in that they often enter foreign markets directly, whereas small firms tend to trade indirectly. Fourth, the way in which firms export and import is highly persistent over time. Both firms that trade directly and those that only trade indirectly are likely to continue to do so in the future. Fifth, what matters for the transmission of foreign demand shocks to a firm's revenue is how much the firm ultimately sells to foreign markets, not whether these sales are from direct or indirect export. Taken together, our findings suggest that data on and modeling of domestic production networks are essential to understanding the role and behavior of different types of firms in international trade.

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1 Introduction

The increased availability of micro datasets on firms' foreign trade has shifted the focus of research on international trade from countries and industries to firms. One important insight from these data is that exporters and importers represent a very small fraction of firms across many developed and developing economies (Tybout, 2003; Melitz and Redding, 2014). Another important insight is that firms that export or import tend to be larger, are more productive, and pay higher wages, even prior to their entry into international markets (Bernard and Jensen, 1999; Bernard, Jensen, Redding, and Schott, 2007). These empirical insights have spurred the development of new theories of trade emphasizing firm heterogeneity and self-selection (Melitz, 2003; Bernard, Eaton, Jensen, and Kortum, 2003; Antràs and Helpman, 2004). In these models, only the most productive firms are able to overcome the costs of entering foreign markets. Thus, it is argued, a reduction in trade barriers or transportation costs makes the productive firms that trade internationally expand while less productive non-trading firms shrink or exit.

The fact that only a small and selective set of firms are directly exporting or importing does not necessarily imply that few firms are relying on foreign inputs or producing goods that end up in foreign markets. Even if firms themselves do not import or export, they may buy from or sell to domestic firms that trade internationally. However, accurately capturing this notion of indirect trade is difficult since domestic firm-to-firm transactions are rarely observed. As a result, there is little direct evidence on how many and what kind of firms ultimately rely on foreign inputs, sell to foreign markets, or are affected by changes in trade barriers or transportation costs.

The goal of this paper is to help close this knowledge gap and broaden the empirical perspective on international trade to include all firms, including those that do not directly export or import. To this end, we combine data on domestic firm-to-firm sales with information on firms' foreign trade transactions. Our analyses employ a unique panel dataset of Belgian firms, which is based on several data sources that we have linked through identifiers. Annual accounts provide data on input factors and output, custom records and intra-EU declarations give information on exports and imports, and a value-added tax (VAT) registry provides information on domestic firm-to-firm transactions.

Using these data, we construct measures of import and export that capture that firms may choose to access foreign markets both directly and indirectly. In particular, we measure the total import and export of a firm as the total share of inputs that it buys directly or indirectly from abroad (i.e., the *total import share*) and the total share of output that it sells directly or indirectly to foreign markets (i.e., the *total export share*). The key assumption we make to compute these measures is that the firm's composition of inputs in production does not vary across its buyers. Under this assumption, it follows that the total import share is high if much of the firm's inputs are imported either directly from abroad or indirectly via purchases from domestic suppliers with high import shares. By comparison, the total export share is high if a lot of the firm's output is exported directly to foreign markets or indirectly

via sales to domestic buyers with high export shares.

Our paper offers five sets of results. First, we show that most firms rely a lot on foreign inputs, but only a small number of firms show that dependence through the direct imports observed in trade transaction data. Indeed, many of the firms with high total import shares do not directly import. Moreover, the total import shares tend to be high even in industries with little direct import, such as the service sector. We show that indirect import remains important even if one excludes the inputs that are directly imported by wholesalers or retailers.

Second, while direct exporters are rare, a majority of firms are indirectly exporting through sales to domestic buyers that subsequently trade internationally. Still, the total export share is relatively small in a majority of firms. This finding shows that sales at home are the key source of revenue for most firms, even in a small open economy such as Belgium.

Third, accounting for indirect export and import not only increases the fraction of firms that participate in international trade but also makes the trading firms much more comparable to non-trading firms in terms of size, productivity, and wages. In particular, the key difference between large and small firms is *how* they export and import, rather than whether or how much the firms ultimately rely on foreign inputs or sell to foreign markets. Firms that directly trade are systematically larger than the firms that only trade indirectly; this finding holds true even if we look within industries and condition on the total import or export shares. Yet, in many small firms, their total import or export shares are as high as those of large firms. Taken together, these findings suggest that smaller and less productive firms overcome the costs of entering foreign markets by selling to or buying from domestic firms that trade internationally.

Our fourth set of results are informative about the structure of the domestic production network and the persistence of the foreign trade behavior of firms. As we show, the way in which firms export and import is highly persistent: both firms that trade directly and those that only trade indirectly are likely to continue to do so in the future. Indeed, a small set of individual buyer-supplier links explain most of the indirect trade, and these links are highly persistent over time. In other words, the Belgian economy can be described as a sparse production network in which most firms have a handful of important and relatively long-lasting buyer-supplier links.

The final set of results demonstrate that what matters for the transmission of foreign demand shocks to a firm's revenue is how much it ultimately sells to foreign markets, not whether these sales are from direct or indirect export. Following Hummels, Jørgensen, Munch, and Xiang (2014), we measure the direct export shock to a firm through the changes in world demand of country-product combinations with which the firm had a previous trade relationship. To measure the total export shock to the firm, we take into account both its direct sales to foreign markets and its indirect export through sales to domestic buyers that subsequently trade internationally. When estimating the transmission of these trade shocks to revenues, we find that two firms with the same total export shock are equally affected, regardless of whether the sales to foreign markets are from direct or indirect export.

Taken together, these sets of results highlight that data on domestic production networks are key to understanding how many and what kind of firms ultimately rely on foreign inputs, sell to foreign markets, and are affected by trade shocks. Huneeus (2018) is arguably the closest study to ours.[1] He uses firm-to-firm transaction data to model and estimate how trade shocks during the Great Recession propagated in Chile. By comparison, Barrot and Sauvagnat (2016), Boehm, Flaaen, and Pandalai-Nayar (2015), and Carvalho, Nirei, Saito, and Tahbaz-Salehi (2016) use natural disasters as exogenous variation to demonstrate the propagation of shocks in production networks. Acemoglu, Akcigit, and Kerr (2016a) and Acemoglu, Autor, Dorn, Hanson, and Price (2016b) study the propagation of supply and demand shocks through sectoral input-output networks.

The research on production networks and firm-to-firm connections naturally connects to a recent literature on the role of intermediation in trade (see, e.g., Bernard, Jensen, Redding, and Schott, 2010; Ahn, Khandelwal, and Wei, 2011; Bernard, Blanchard, Van Beveren, and Vandenbussche, 2016a; Fujii, Ono, and Saito, 2017; Ganapati, 2018). In this work, intermediaries are firms that are exploiting economies of scale or scope in trading abroad and, thus, are able to lower the per-product fixed costs of export or import. To date, most empirical work on intermediation in trade is centered on the direct export and import of wholesalers or retailers, and we have little if any direct evidence on how many and what kind of firms sell to or buy from these intermediaries. At the same time, the work on firm-to-firm connections typically does not distinguish between producers and intermediaries. Making this distinction, we find that indirect trade remains important even if one excludes import and export by wholesalers or retailers. Thus, indirect trade is more than just the channeling of export or import through pure intermediaries.

The remainder of the paper proceeds as follows. Section 2 discusses the data sources, the sample selection, and the key variables. Section 3 describes how we construct measures of import and export that capture that firms may choose to access foreign markets both directly and indirectly. In the next four sections, we use these measures to develop several empirical findings. Sections 4 and 5 show how many and what kind of firms ultimately rely on foreign inputs or sell to foreign markets. Section 6 examines the structure of the domestic production network and the persistence of the foreign trade behavior of firms. In Section 7, we explore the consequences of indirect trade for the transmission of foreign demand shocks to firms. The final section concludes with a discussion of how our findings both challenge existing views and raise new questions about the role and behavior of different types of firms in international trade.

[1]Several other papers have used firm-to-firm transactions to study a wide array of topics ranging from taxation to the effects of infrastructure (see, e.g., Atalay, Hortacsu, Roberts, and Syverson, 2011; Bernard, Moxnes, and Saito, 2016b; Magerman, De Bruyne, Dhyne, and Van Hove, 2016; Bernard, Dhyne, Magerman, Manova, and Moxnes, 2018; Kikkawa, Magerman, and Dhyne, 2018; Gadenne, Nandi, and Rathelot, 2019).

2 Data Sources and Sample Selection

Our analyses draw on three administrative data sources from Belgium for the period 2002-2014. These data sources can be linked through unique identifiers, assigned and recorded by the government for the purpose of collecting value-added taxes (VAT). Below we briefly describe our data and sample selection; additional details are given in Online Appendix C.

The first data source is the Business-to-Business (B2B) transactions database (for details, see Dhyne, Magerman, and Rubinova, 2015). By law, all Belgian firms are required to file the amount of annual sales to each buyer (provided that the amount of annual sales to a given buyer exceeds 250 euro). Thus, the B2B dataset allows us to accurately measure the identity of the firms' suppliers and buyers. The second data source is the annual accounts that Belgian firms are required to file. These data contain detailed information from the firm's balance sheets on sales, revenues, costs of inputs (such as capital, labor, and intermediates), as well as four-digit (NACE) industry codes and geographical identifiers at the zip code level. In addition, the annual accounts include information about ownership shares in other enterprises. The third data source consists of the Belgian customs records and the intra-EU trade declarations. These data contain information about the international trade transactions of firms.[2] Both imports and exports are disaggregated by product and origin or destination.

One challenge with using the Belgian data is that all the information is recorded at the level of the VAT identifier. This creates a challenge because a firm may have several VAT identifiers (for accounting or tax reasons).[3] While organizational choices and transactions across units within a firm are of interest, our paper is centered on trade between firms. Thus, if a firm has multiple VAT identifiers, we aggregate the data up to the firm level using information from the balance sheets about ownership structure. Details of the aggregation are outlined in Online Appendix C.4. In 2012, for example, the aggregation converts 896,000 unique VAT identifiers into 860,000 unique firms. Of these firms, 842,000 had a single VAT identifier. However, the 18,000 firms with multiple VAT identifiers are important, accounting for around 60 percent of the total output in the dataset.

After constructing the firm-level dataset, we impose a few sample restrictions. We restrict our analysis to firms in the private and non-financial sectors with positive labor costs, at least one full-time-equivalent employee, and positive output. Following De Loecker, Fuss, and Van Biesebroeck (2014), we also restrict our analysis to firms with tangible assets of more than 100 euro and positive total assets in at least one year during our sample period. Applying these criteria reduces the number of firms significantly. In 2012, for example, only 98,745 firms satisfy the above criteria. The large reduction in sample size is mostly driven by the exclusion of local firms without employees (self-employed) from the sample (750,100 firms

[2]See Online Appendix C.2 for reporting thresholds for these international good transactions and Online Appendix C.3 for the concordance between the B2B dataset and the customs records.

[3]Existing papers tend to ignore this issue, analyzing the data as if each firm has a single unique VAT identifier. See, for example, Amiti, Itskhoki, and Konings (2014), Magerman et al. (2016), and Bernard et al. (2016a).

Table 1: Coverage of selected sample

Year	Aggregate statistics				Selected sample						
	GDP (Excl. Gov. & Fin.)	Output	Imp	Exp	Count	V.A.	Sales Total	Sales Netw.	Labor cost	Imp	Exp
2002	182	458	178	193	88,301	119	564	199	75	175	185
2007	230	593	254	267	95,941	152	728	206	89	277	265
2012	248	671	317	319	98,745	164	796	225	100	292	292

Notes: All numbers except for count are denominated in billion euro in current prices. Belgian GDP and output are for all sectors excluding the public and financial sectors. See Online Appendix C.5 for the statistics of the sample of all Belgian firms. Data for Belgian GDP, output, imports, and exports are from Eurostat. Firms' value added is from the reported values from the annual accounts. Firms' sales consist of their sales to firms in the selected sample (network sales), sales to households at home, and direct export to foreign markets. See Online Appendix C.1 for the definition and construction of each variable.

in 2012). These criteria also remove from the sample foreign firms with no local economic activity in Belgium.

As evident from Table 1, our selected estimation sample of firms covers most of the aggregate value added, gross output, exports, and imports.[4] Consistent with this finding, we show, in Online Appendix D.3, the robustness of our results to including purchases from and sales to the excluded firms.

3 Measuring Direct and Indirect Trade

In this section, we construct measures of import and export that capture that firms may choose to access foreign markets both directly and indirectly. The key assumption we make is that the firm's composition of inputs in production does not vary across its buyers. Under this assumption, we can measure the total import and export of a firm by the total share of inputs that it buys directly or indirectly from abroad (i.e., the *total import share*) and the total share of output that it sells directly or indirectly to foreign markets (i.e., the *total export share*).

Formally, firm j's total import share, s_{Fj}^{Total}, is defined as the share of inputs that it directly imports, s_{Fj}, plus the share of inputs that it buys from other domestic firms, multiplied by the total import shares of those firms:

$$s_{Fj}^{Total} = s_{Fj} + \sum_{i \in Z_j^D} s_{ij} \underbrace{\left[s_{Fi} + \sum_{k \in Z_i^D} s_{ki} \left(s_{Fk} + \cdots \right) \right]}_{s_{Fi}^{Total}}, \tag{1}$$

where Z_j^D denotes the set of domestic suppliers of firm j and s_{ij} is the share of j's inputs

[4]The amount of total sales in our sample is larger than that reported in the national statistics because the output of trade intermediaries in the national statistics is measured by their value added instead of their total sales. The amount of total sales is even larger in the sample of all Belgian firms (see Online Appendix C.5). Online Appendix C.6 shows the sectoral composition of our sample.

that it buys from firm i. The denominator of the input shares is the sum of the firm's labor costs, purchases from other domestic firms, and direct imports. In the same fashion, the total export share of firm j, r_{jF}^{Total}, is defined as the share of revenue from direct export, r_{jF}, and the share of revenue coming from sales to other domestic firms, multiplied by the total export shares of those firms:

$$r_{jF}^{Total} = r_{jF} + \sum_{i \in W_j^D} r_{ji} \underbrace{\left[r_{iF} + \sum_{k \in W_i^D} r_{ik} \left(r_{kF} + \cdots \right) \right]}_{r_{iF}^{Total}}, \tag{2}$$

where W_j^D denotes the set of domestic buyers of firm j and r_{ji} is the share of j's revenue that comes from sales to firm i. The denominator of the export shares is the total revenue of the firm, which consists of sales to other domestic firms, sales to households, and direct exports.

Note that the definitions in equations (1) and (2) are recursive. For example, a firm's total import share is the sum of its direct import share and the share of its inputs from other domestic firms multiplied by the total import shares of those firms. In other words, the expression s_{Fj}^{Total} reflects the direct import share of firm j's suppliers, suppliers' suppliers, and so forth, each weighted by the share of inputs that each firm buys from other domestic firms. Thus, the total import share is high if much of the firm's inputs are imported either directly from abroad or indirectly via purchases from domestic suppliers with high import shares. By comparison, the total export share is high if a lot of the firm's output is exported directly to foreign markets or indirectly via sales to domestic buyers with high export shares.

It is important to observe that we do not explicitly add the user cost of capital to the denominator of the input shares. This is because we do not observe how much of the input costs come from purchases of capital goods. Thus, adding the user cost of capital goods as another input could lead to double counting of capital goods. As a robustness check, we nevertheless include the user cost of capital in the construction of the input shares. Reassuringly, including the user cost of capital does not materially change the comparison of total versus direct import shares across firms (see Online Appendix D.2).

A natural question is whether our measures of total export and import shares can be motivated or justified by economic theory. To answer this question, we consider, in Appendix A, a broad class of models with fixed firm-to-firm linkages and constant markups. In these models, our measures of total import and export shares are key to quantifying the costs and benefits of trade shocks. For example, if the production functions have constant returns to scale, then—to a first-order approximation—how firms' costs are affected by a change in the foreign price is a weighted average of the change in the foreign price and the change in the domestic wage. The weight assigned to the change in the foreign price is the firm's total import share, not its direct import share. Another example arises if one assumes a Cobb-Douglas functional form for both the utility and production functions. Then, we can

express how the firm's revenue is affected by a change in the aggregate expenditures as a weighted average of the changes in aggregate foreign and domestic expenditures. The weight assigned to the change in the foreign expenditure is the firm's total export share, not the direct export share.

4 Direct and Total Trade of Firms

This section uses the measures defined in the previous section to examine how many and to what extent firms ultimately rely on foreign inputs and sell to foreign markets.

4.1 Direct and Total Import Shares

Panel (a) of Figure 1 shows the distributions of direct and total import shares across firms. It is evident that most firms rely a lot on foreign inputs, but only a small number of firms show that dependence through the direct imports observed in trade transaction data. While only 19 percent of firms import directly, nearly all firms use some foreign inputs in production.[5] Indeed, most firms are heavily relying on foreign inputs once indirect import is taken into account. For example, the median firm in the distribution of total import shares is, directly or indirectly, importing about 39 percent of its inputs. By comparison, if we look at the 20th and 80th percentiles, the total import shares are 20 and 58 percent, respectively. In Appendix B.2, we plot the distribution of total import shares separately for the firms that directly import (19 percent of the sample) and those that only indirectly import (81 percent of the sample). The distributions display considerable overlap, implying that a substantial number of firms with relatively high total import shares do not directly import.

In Online Appendix D.1, we break down the direct and total import shares by sector. Interestingly, foreign inputs are important in all sectors once one accounts for indirect import. Indeed, the total import shares are sizable even in industries with little direct import, such as the service sector. Breaking down the data by sector also reveals that indirect import is more than just the channeling of foreign inputs through pure intermediaries. In Online Appendix D.4, we exclude direct imports that come from wholesalers and retailers (which account for 29 percent of aggregate imports) and then recalculate the total import shares of firms in the other sectors. We find that many firms rely heavily on foreign inputs even after excluding the goods that are directly imported by wholesalers or retailers.

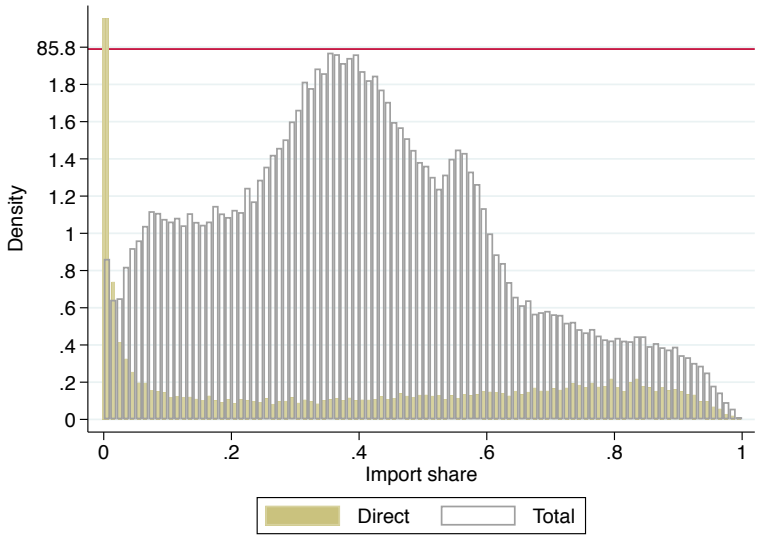
4.2 Direct and Total Export Shares

Panel (b) of Figure 1 displays the distributions of direct and total export shares of firms. While only 12 percent of firms are exporting directly, 88 percent of firms are indirectly

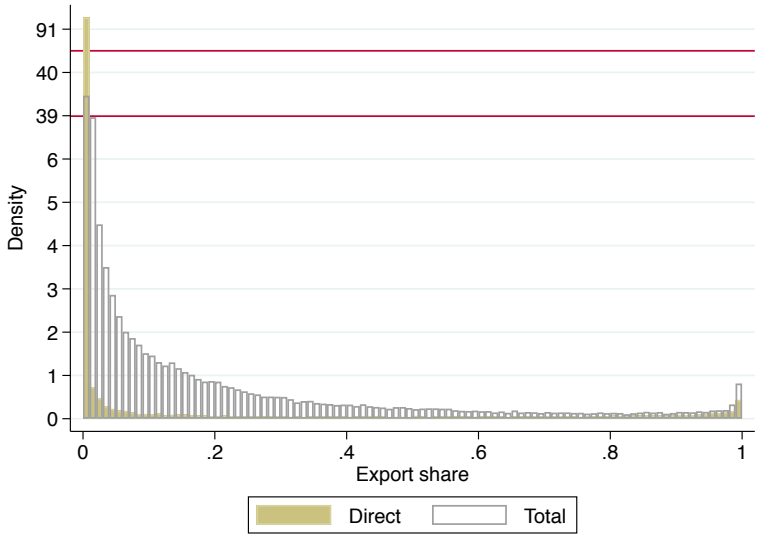
[5]Note that most, if not all, firms are likely to use certain types of materials, such as gasoline, that are not produced in Belgium. We may not observe all these purchases because of the 250 euro reporting threshold for domestic firm-to-firm transactions. Still, the use of certain essential inputs that are not produced in Belgium could be a key reason why we find that virtually all firms are using some foreign inputs.

Figure 1: Distributions of direct and indirect trade across firms

(a) Direct and total import share



(b) Direct and total export share



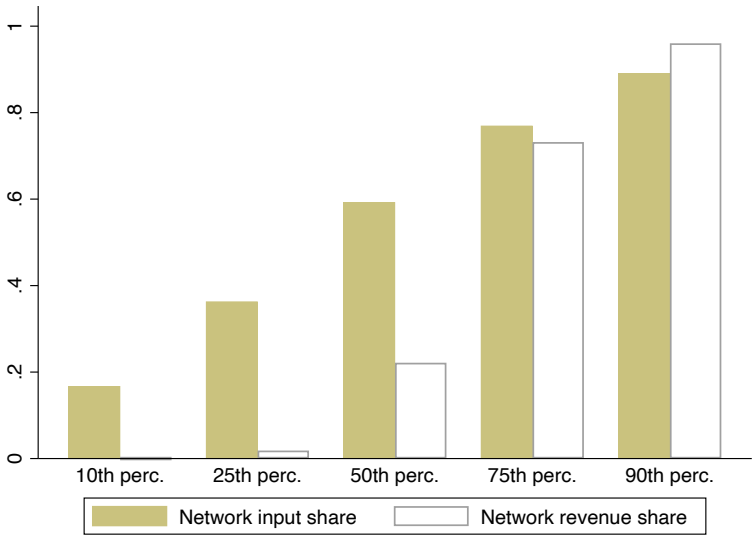
Notes: The total import share of firm i, s_{Fj}^{Total}, is calculated by solving $s_{Fj}^{Total} = s_{Fj} + \sum_{i \in Z_j^D} s_{ij} s_{Fi}^{Total}$ where s_{Fj} is firm j's direct import share and s_{ij} is firm i's share among firm j's inputs. The total export share of firm j, r_{jF}^{Total}, is calculated by solving $r_{jF}^{Total} = r_{jF} + \sum_{i \in W_j^D} r_{ji} r_{iF}^{Total}$ where r_{jF} is firm j's direct export share and r_{ji} is the share of firm j's revenue that arises from sales to firm i. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012. The horizontal lines represent scale breaks on the vertical axis.

exporting through sales to domestic buyers that subsequently trade internationally. Still, the total export share is relatively small in a majority of firms. For example, the median firm in the distribution of total export shares is, directly or indirectly, exporting only 3 percent of its output. In fact, the total export share remains low across most of the distribution, reaching only 23 percent at the 80th percentile. These findings show that sales at home are the key source of revenue for most firms, even in a small open economy such as Belgium. In

Appendix B.2, we plot the distribution of total export shares separately for the firms that directly export (12 percent of the sample) and those that only indirectly export (75 percent of the sample). These results reveal that most firms with relatively high total export shares are directly exporting.

In Online Appendix D.1, we investigate the total and direct export shares by sectors. The results show that in certain sectors, such as services, nearly all the export shares come from sales to domestic buyers that subsequently trade internationally. In Online Appendix D.4, we exclude direct exports that come from wholesalers and retailers (which account for 18 percent of aggregate exports) and then recalculate the total export shares of firms in the other sectors. The main findings about direct and total export shares do not change: while a majority of firms are indirectly exporting, most of their sales are at home.

Figure 2: Percentiles of the network input and revenue shares



Notes: The figure shows the percentiles of firms' network input shares and their network revenue shares. The network input share is defined as the share of inputs purchased from domestic suppliers, $\sum_{i \in Z_j^D} s_{ij}$. The network revenue share is defined as the share of output sold to domestic buyers, $\sum_{i \in W_j^D} r_{ji}$. The figure is based on the analysis of 98,745 private sector firms in Belgium in 2012.

Comparing the results in panel (a) with those in panel (b) of Figure 1, we find that a majority of firms are relying heavily on foreign inputs but relatively few are selling a lot to foreign markets.[6] This finding reflects that the network revenue share, $\sum_{i \in W_j^D} r_{ji}$, is much smaller than network input shares, $\sum_{i \in Z_j^D} s_{ij}$, for most firms, as shown in Figure 2.[7] In other words, a typical Belgian firm purchases a lot of its inputs from domestic suppliers but sells relatively little of its output to domestic firms.

[6]This finding does not reflect a trade deficit in Belgium, as aggregate imports are comparable to aggregate exports.

[7]Note that $\sum_{i \in Z_j^D} s_{ij}$ is an upper bound for firm j's share of indirect imports and that $\sum_{i \in W_j^D} r_{ji}$ is an upper bound for firm j's share of indirect exports. See equations (1) and (2).

4.3 Import and Export Shares within and across Industries

The above findings point to the importance of measuring indirect trade to accurately estimate how many and to what extent firms rely on foreign inputs and sell to foreign markets. In the absence of data on domestic firm-to-firm sales, it is necessary to approximate production networks. One possible approach is to use information on aggregate sales across industries, as reported in industry input-output tables (see, e.g., Caliendo and Parro, 2015; Acemoglu et al., 2016a; Acemoglu et al., 2016b). This approach gives an accurate description of the firm-level indirect and total trade insofar as the firms within each industry are homogeneous in the total import and export shares of the goods they buy from and sell to other domestic firms.

In Appendix B.3, we show that this homogeneity restriction is grossly at odds with the data. In that appendix, we decompose the variation across firms in import and export shares into between-industry and within-industry components (where industry is defined rather narrowly at the level of four-digit NACE codes). We find that most of the variation in total import and export shares arises from differences within industries, not between industries. The large within-industry variation does not reflect heterogeneity in direct import and export shares across firms. In fact, the explanatory power of the within-industry component is even larger if we restrict attention to the variation across firms in indirect export and import shares.

5 Comparing Firms that Trade Directly and Indirectly

This section examines the importance of incorporating indirect trade for drawing conclusions about what kind of firms rely (the most) on foreign inputs or sell (a lot) to foreign markets.

5.1 Exporter Premia

We start this section by investigating the extensive margin of trade. Table 2 shows that accounting for indirect trade not only increases the fraction of firms that participate in international trade but also makes the trading firms much more comparable to non-trading firms in terms of size, productivity, and wages. Each cell reports an estimate from a regression of a characteristic of a firm on an indicator variable for whether the firm is exporting and a full set of fixed effects for industry. The variables listed on the left are the two measures of export participation that we consider: one is an indicator variable for having a positive direct export share, while the other is an indicator variable for having a positive total export share. We do not look at import participation as nearly all firms have positive import shares once one takes indirect trade into account. The firm characteristics listed in the columns are the dependent variables. For each column, we run one regression per measure of export participation. Thus, comparing the regression results across rows allows us to infer how the so-called exporter premium depends on whether one includes indirect exports. By contrast,

comparing the results across columns tells us how these exporter premia vary from one firm characteristic to the other.

The estimates reported in the first row show that direct exporters tend to be larger, have higher sales and productivity, and pay more than other firms. Since the outcome variables are in logs, the coefficients can be interpreted as percentages. The results reported in columns (1), (2), (4), and (6) suggest that direct exporters have 117 percent more employment, 188 percent more sales, 25 percent higher value added per worker, and 22 percent higher wages. As shown in columns (3), (5), and (7), the observed differences between direct exporters and other firms are not driven solely by size.

The findings in the first row of Table 2 are emblematic of what is typically found in empirical work on the exporter premia (e.g., Bernard and Jensen, 1999; Bernard et al., 2007). Firms that export look very different from non-exporters along a number of important dimensions. The findings in the second row are novel, showing that exporter premia are smaller but still significant once indirect export is included in the definition of export participation. For example, the exporter premia in employment, sales, and wages are about half as large if one includes indirect export. We can thus conclude that by including indirect exports, firms that sell to foreign markets become more—but not completely—comparable to firms that only sell at home.

Table 2: Exporter premia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Log emp.	Log sales		Log v.a./worker		Log avg. wage	
Direct export share > 0	1.17	1.88	0.87	0.25	0.29	0.22	0.13
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
Total export share > 0	0.50	0.90	0.44	0.21	0.22	0.11	0.07
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
Industry (four-digit) FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log employment control	No	No	Yes	No	Yes	No	Yes

Notes: Standard errors are in parentheses. All results are from OLS regressions of the firm characteristics noted at the top of each column, on dummy variables listed on the left, in separate regressions for each dummy variable, as well as industry (four-digit) fixed effects. The regression results are based on the analysis of 98,745 private sector firms in Belgium in 2012.

5.2 Direct and Indirect Trade in Large and Small Firms

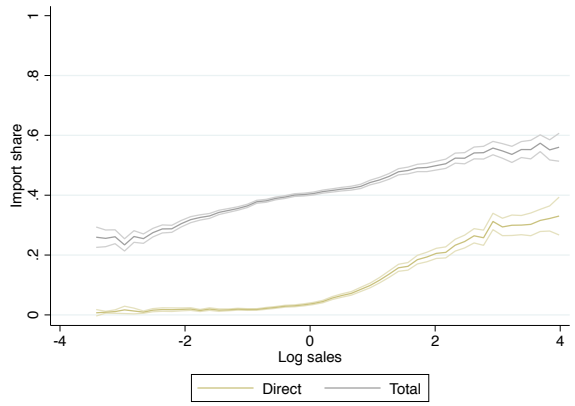
We now shift attention from the extensive margin of export to examining what kind of firms are heavily involved in trade.

In Figure 3, we graph the estimated relationships between firm size (as measured by log sales) and our measures of total and direct trade (defined in Section 3). To adjust for differences across industries, we first demean the log of firm sales using the firm's four-digit

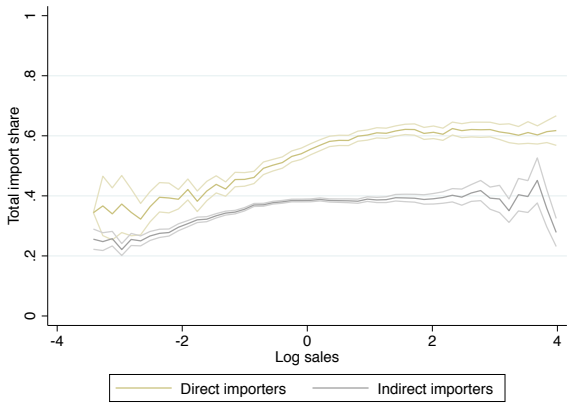
industry average. Thus, a firm with log sales of zero has the size of an average firm in its industry. Next, we use local polynomial regressions to non-parametrically estimate the relationships between firm size and trade. Panel (a) of Figure 3 reports estimates for firm size and direct and total import shares, while panel (b) presents estimates for firm size and direct and total export shares. By comparison, panels (c) and (d) display the relationships between firm size and the measures of total export and import for the firms that trade directly and those that only trade indirectly.

Figure 3: Relationship between firm size and direct and indirect trade

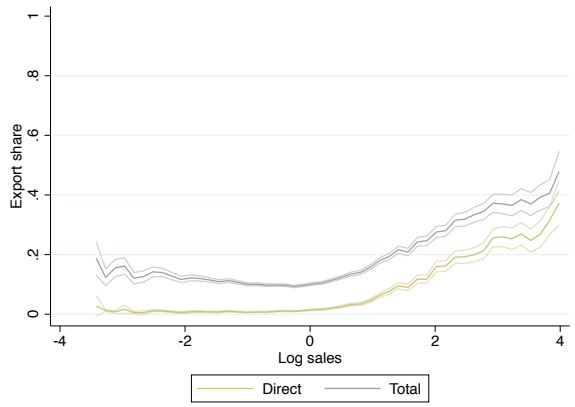
(a) Direct and total import shares



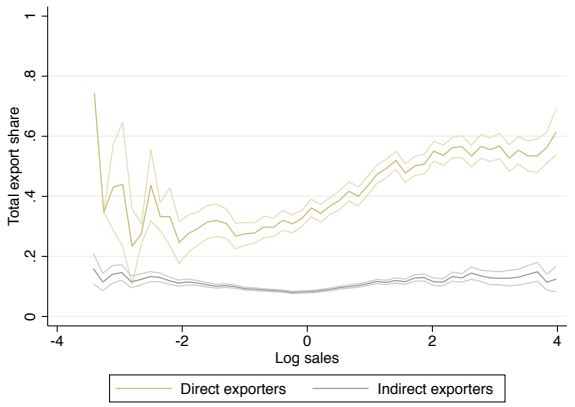
(c) Total import shares by participation status



(b) Direct and total export shares



(d) Total export shares by participation status



Notes: The figures display the smoothed values with 95 percent confidence intervals of kernel-weighted local polynomial regression estimates of the relationship between firms' levels of participation in foreign trade and their sales. We use the Epanechnikov kernel function with kernel bandwidth of 0.05, pilot bandwidth of 0.02, degree of polynomial smooth at 0, and smooth obtained at 50 points. Log sales are demeaned with four-digit industry fixed effects, and trimmed at the top and bottom 1 percentiles. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012.

The results in panels (a) and (b) of Figure 3 show that both the export and import shares are increasing in firm size regardless of whether we include or exclude indirect trade. As shown in panels (c) and (d), however, the positive relationships between firm size and total export and import shares are almost entirely driven by the firms that trade directly. Indeed, the small indirect exporters are selling as much of their output to foreign markets as the large indirect exporters.

The results in panels (c) and (d) of Figure 3 also suggest that firms that directly trade are systematically larger than firms that only trade indirectly; this finding holds true even if we look within industries and condition on the total import or export shares. This finding is consistent with the extensive margin estimates of the exporter premia in Table 2. In Online Appendix D.5, we investigate this finding more closely, assigning the firms into groups depending on the extent of their direct and indirect trade. As explained in that appendix, we consider three groups of importers: firms that directly import, firms that do not directly import but indirectly import a large share of their inputs, and the remaining firms that neither directly import nor import a lot indirectly. In the same fashion, we assign firms to three groups of exporters. We then plot the firm size distribution for the groups of importers and exporters. We find that direct exporters and importers are much larger than other firms. However, the firms that do not trade directly but indirectly export or import a lot are very similar in size to the firms that trade little if anything.

6 Persistence of Indirect Trade

So far, we have used the cross sections of the data to demonstrate that indirect trade is empirically important for many firms, especially those that are small and less productive. In this section, we take advantage of the panel nature of our data to examine the structure of the domestic production network and the persistence of the foreign trade behavior of firms.

Table 3: Persistence in trade behavior of firms

Importers				Exporters			
	Direct_{t+1}	non-HIP_{t+1}	HIP_{t+1}		Direct_{t+1}	non-HIP_{t+1}	HIP_{t+1}
Direct_t	0.89	0.09	0.02	Direct_t	0.82	0.13	0.05
non-HIP_t	0.04	0.90	0.05	non-HIP_t	0.04	0.91	0.05
HIP_t	0.04	0.25	0.70	HIP_t	0.05	0.18	0.77

Notes: The two panels report the one-year Markov matrices among the sets of three mutually exclusive and collectively exhaustive groups classified according to firms' direct and indirect foreign trade. On the importing side, for each two-digit sector we group firms as follows: The first group is the firms that directly import (Direct). Firms that do not directly import are classified as having high indirect import (HIP) if they are in the top quintile in the distribution of total import shares. The remainder of the firms that do not directly import are assigned to the group with low indirect import (non-HIP). We use the same criteria for the exporting side. The results are pooled from a balanced panel from 2002 to 2014.

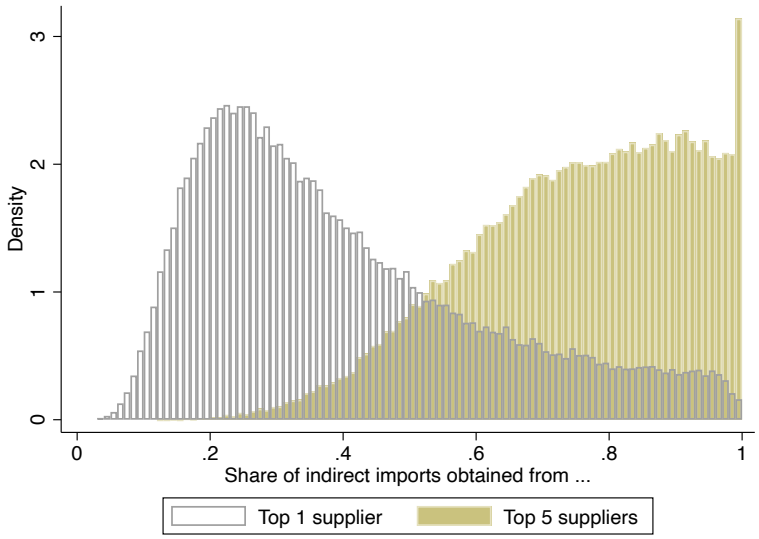
In Table 3, we explore the persistence of indirect and direct trade over time. In the left panel, we assign firms into three groups based on their import behavior in a given year. The groups are mutually exclusive and collectively exhaustive. One of the groups (Direct) consists of the firms that directly import. The other firms that do not directly import are classified as having high indirect import (HIP) if they are in the top quintile in the distribution of total import shares within their industry. The remainder of the firms that do not directly import are assigned to the group with low indirect import (non-HIP). We then compute the probability that a firm stays in the same group from one year to the next. The results show

that the way in which firms import is highly persistent: both firms that directly import and those that have high indirect imports are likely to continue to do so in the future.

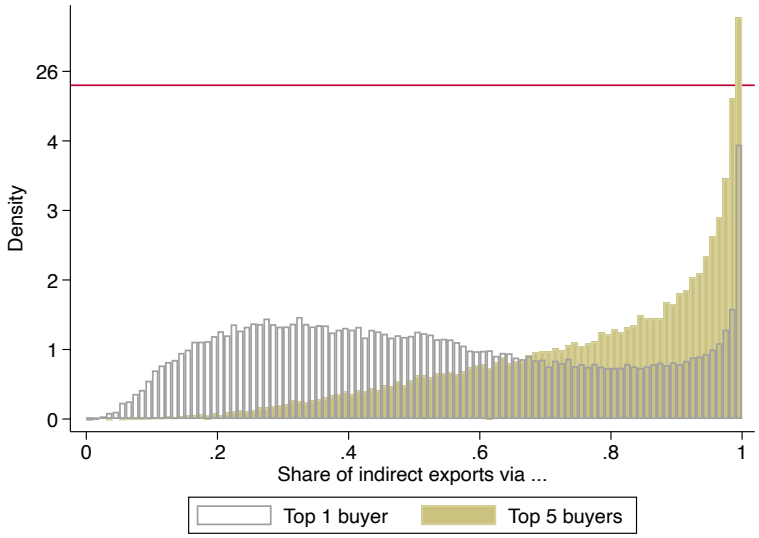
In the right panel of Table 3, we perform the same type of analysis for the persistence in export behavior. The results mirror those for import behavior: whether and how firms export are strongly persistent over time. As shown in Online Appendix D.6, the broad conclusions from Table 3 about the persistence of trade behavior also hold true if we look at persistence across five-year periods or across broad sectors.

Figure 4: Top links' shares in firms' indirect trade

(a) Top suppliers' shares in indirect imports



(b) Top buyers' shares in indirect exports



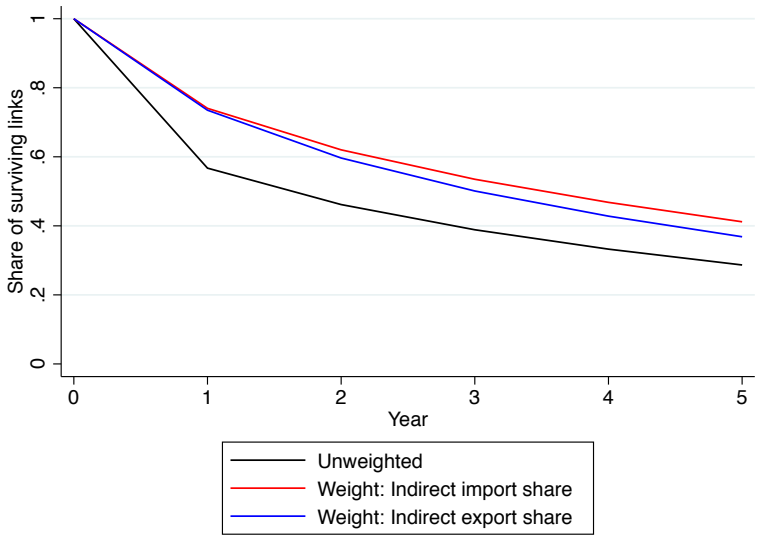
Notes: The figures plot the distributions of the shares that top suppliers and buyers account for in firms' indirect import and export shares. Supplier i's share in firm j's indirect imports is computed by $s_{ij}s_{Fi}^{Total}/\sum_k s_{kj}s_{Fk}^{Total}$. Buyer i's share in firm j's indirect exports is computed by $r_{ji}r_{iF}^{Total}/\sum_k r_{ji}r_{kF}^{Total}$. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012.

The strong persistence of the way in which firms trade does not necessarily imply that

individual buyer-supplier links are persistent over time. To examine this, it is useful to describe the structure of the production network and how it changes over time. As evident from Figure 6 in Appendix B.1, the Belgian economy can be described as a sparse production network in which firms have much fewer links than the possible maximum number. Indeed, a small set of individual buyer-supplier links explain most of the indirect trade, as shown in Figure 4. This finding is consistent with Kikkawa et al. (2018), who show that the largest supplier for the typical firm accounts for around 30 percent of the input purchases.

Another interesting finding from the Belgian network data is that the key buyer-supplier links are relatively persistent over time. To illustrate the persistence of the key buyer-supplier links, Figure 5 plots the share of firm-to-firm links that survive from one year to the next. Starting from the cross section of links in a given year, we show the fraction of links that survive over the subsequent five years. In addition to the unweighted share of surviving links, we also plot the weighted share of surviving links. The weights are given by the indirect import or export shares associated with the buyer-supplier links. While there is a significant amount of churning in the buyer-supplier relationships (only 57 percent of the links persist from one year to the next), we find that the links that are associated with a high share of indirect trade are much more persistent (74 percent of the weighted links persists from one year to the next). This finding is consistent with Huneeus (2018). Using Chilean data on domestic firm-to-firm transactions, he finds that key buyer-supplier links are much more important to persist over time.

Figure 5: Share of surviving firm-to-firm links



Notes: The figure reports the share of surviving firm-to-firm links over time. In addition to the unweighted fraction of surviving links, we also plot the weighted fraction of surviving links, using as weights the shares of indirect import or export associated with the buyer-supplier links. The weights are the buyer firm's indirect import share from the supplier at the initial year, $s_{ij}s_{Fi}^{Total}/\sum_k s_{kj}s_{Fk}^{Total}$, or, the supplier firm's indirect export share through the buyer at the initial year, $r_{ji}r_{iF}^{Total}/\sum_k r_{ji}r_{kF}^{Total}$, respectively. The results are pooled for all cross-sections of links from 2002 to 2009.

7 Transmission of Foreign Demand via Indirect Trade

We conclude the empirical analyses with an investigation of how indirect trade affects the transmission of foreign demand shocks. This analysis shows that what matters for the transmission of foreign demand shocks to a firm's revenue is how much the firm ultimately sells to foreign market, not whether these sales are from direct or indirect export.

Before we present the empirical results, we derive an estimating equation that relates changes in firm revenue to changes in foreign demand. We denote firm j's sales at time t by $X_{j,t}$. The goods the firm produces can be sold to three types of buyers: domestic firms, households at home, or direct export to foreign markets. Therefore, the first-order approximation of the change in firm j's sales can be written as

$$d\log X_{j,t} = \sum_i r_{ji,t-1} d\log X_{ji,t} + r_{jH,t-1} d\log X_{jH,t} + r_{jF,t-1} d\log X_{jF,t}, \tag{3}$$

where $X_{ji,t}$ denotes firm j's sales to domestic firm i, $X_{jH,t}$ denotes firm j's sales to households at home, $X_{jF,t}$ denotes firm j's direct export, and $r_{jH,t}$ denotes the share of revenue of firm j that comes from sales to households at home.

Assuming that each firm's inputs change proportionally to its output, $d\log X_{ji,t} = d\log X_{i,t}$, and that sales to households change proportionally to aggregate household expenditure, $d\log X_{jh,t} = d\log E_t$, we can obtain the following equation:[8]

$$d\log X_{j,t} = \sum_i \tilde{H}_{ji,t-1} r_{iH,t-1} d\log E_t + \sum_i \tilde{H}_{ji,t-1} r_{iF,t-1} d\log X_{iF,t}. \tag{4}$$

Equation (4) illustrates that a firm's sales are absorbed by one of two final destinations: direct or indirect sales to domestic households and direct or indirect export to foreign markets. Note that $\tilde{H}_{t-1} = (I - R_{t-1})^{-1}$ where the i,j element of matrix R_{t-1} is the share of revenue of firm i that is sold to firm j, $r_{ij,t-1}$. The term $\sum_i \tilde{H}_{ji,t-1} r_{iH,t-1}$ captures the share of firm j's sales that is exposed to changes in the demand from domestic households, $d\log E_t$, directly or indirectly. The term $\tilde{H}_{ji,t-1} r_{iF,t-1}$ captures firm j's total sales to foreign markets through firm i and is multiplied by firm i's change in exports, $d\log X_{iF,t}$.

Of course, it is difficult to draw causal inferences from a regression of firm sales on its its total export because of simultaneity bias and correlated unobservables (e.g. firm productivity). To obtain plausible exogenous variation in foreign demand, we instead follow Hummels et al. (2014) and construct changes in world import demand for each direct exporter j, $d\log X^{shock}_{jF,t}$,

$$d\log X^{shock}_{jF,t} = \sum_{c,p} r^{\text{EX}}_{j,c,p,t-1} d\log WID_{c,p,t}, \tag{5}$$

where c denotes countries, p denotes products, and $r^{\text{EX}}_{j,c,p,t-\tau}$ denotes the share of j's exports to

[8] The assumption of $d\log X_{ji,t} = d\log X_{i,t}$ is consistent with a model in which firms' production functions have a Cobb-Douglas structure. The assumption of $d\log X_{jh,t} = d\log E_t$ is consistent with a model in which there is a representative household with Cobb-Douglas preferences. See Appendix A.2 for related results.

country-product c, p in j's total exports at time $t-1$. The term $WID_{c,p,t}$ represents country c's imports of product p from all other countries excluding Belgium. To empirically examine how firm sales depend on foreign demand shocks, we estimate the following regression model:

$$d\log X_{j,t} = \alpha + \beta_{Et} \sum_i \tilde{H}_{ji,t-1} r_{iH,t-1} + \beta \sum_i \tilde{H}_{ji,t-1} r_{iF,t-1} d\log X_{iF,t}^{shock} + \varphi_{j,t}. \tag{6}$$

The estimating equation captures that foreign demand shocks may affect the firm's revenue through both direct and indirect export. Since firms may also be affected by changes in the demand from households at home, we control for the share of firms' sales that is exposed to household demand in every year. The change in household demand is captured by the time-varying coefficient β_{Et}. In addition, we include fixed effects for industry-year and a full set of firm fixed effects. Hence, our regression specification controls for industry-year-specific shocks and allows for firm-specific time trends.

Table 4 presents the estimation results from this regression model. The first two columns restrict the sample to direct exporters. The next column looks at the firms that only indirectly export. For completeness, the final column includes both direct and indirect exporters.

In the first column, we only take into account the foreign demand shocks that operate through direct export. Consistent with previous studies, we find a significant and sizable pass-through of direct export shocks to the firm's revenue.[9] In the second column, we continue to focus on direct exporters but now take into account both direct and indirect export when measuring the firm's exposure to foreign demand shocks. The exposure that occurs through the indirect export reflects the export of firm's domestic buyers, buyers' buyers, and so forth. These firms are themselves affected by foreign demand shocks through changes in world demand of country-product combinations with which the firms had previous trade relationships. When we combine these indirect shocks with the direct export shock in the measure of total export shock, we find that the pass-through to the firm's revenue increases from 0.20 to 0.3.

In column (3), we estimate the same regression as in column (2), except we now consider the firms that do not directly export. These firms are exposed to foreign demand shocks only through their indirect export. For those firms, we find that the pass-through of indirect export shocks to their revenue is 0.31. Comparing the results in columns (2) and (3) reveals a new and interesting finding: when estimating the transmission of foreign demand shocks to revenues, two firms with the same total export shock are equally affected, regardless of whether the sales to foreign markets are from direct or indirect export. Finally, column (4) obtains a similar estimate for the sample of all firms, with a pass-through of 0.31. As shown in Online Appendix D.7, the findings in Table 4 are robust to a number of specification checks.

[9] Hummels et al. (2014) estimate a coefficient of similar magnitude when relating firms' exports to world import demand.

Table 4: Firms' response to foreign demand shocks

	(1) Δ ln Sales	(2) Δ ln Sales	(3) Δ ln Sales	(4) Δ ln Sales
Direct export shock	0.196***			
	(0.0265)			
Total export shock		0.300***	0.310***	0.311***
		(0.0323)	(0.0428)	(0.0261)
N	126539	126539	854930	992866
Sample	Direct exporter	Direct exporter	Indirect exporter	All firms
Ind.-Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

Notes: Standard errors are in parentheses. Variables are winsorized at the top and bottom 0.5 percentiles. The total export shock for firm j is defined as $\sum_i \tilde{H}_{ji,t-1} r_{iF,t-1} d\log X^{shock}_{iF,t}$, and the direct export shock for firm j is defined as $r_{jF,t-1} d\log X^{shock}_{jF,t}$. The assignment to the direct exporter or indirect exporter sample is made based on the export status in $t-1$. All specifications include the lagged share of firms' sales exposed to household demand, $\sum_i \tilde{H}_{ji,t-1} r_{iH,t-1}$, as a control, with a time-varying coefficient. Standard errors are clustered at the NACE four-digit level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

8 Conclusion

In this paper, we examined how many and what kind of firms ultimately rely on foreign inputs, sell to foreign markets, and are affected by trade shocks. To do so, it is necessary to capture that many firms access foreign markets indirectly by buying from or selling to domestic firms that trade internationally. To measure this notion of indirect trade, we used Belgian data with information on both the domestic firm-to-firm sales and the firms' foreign trade transactions.

Our findings may be summarized with five broad conclusions. First, most firms use a lot of foreign inputs, but only a small number of firms show that dependence through the direct imports observed in trade transaction data. Second, while direct exporters are rare, a majority of firms are indirectly exporting. In most firms, however, indirect export is quantitatively modest, and sales at home are the key source of revenue. Third, foreign trade is common not only at large and productive firms but also among those that are smaller and less productive. However, large firms differ in that they often enter foreign markets directly, whereas small firms tend to trade indirectly. Fourth, the way in which firms export and import is highly persistent over time. Both firms that trade directly and those that only trade indirectly are likely to continue to do so in the future. Fifth, what matters for the transmission of foreign demand shocks to a firm's revenue is how much the firm ultimately sells to foreign markets, not whether these sales are from direct or indirect export.

Taken together, our findings suggest that data on and modeling of domestic production networks are essential to understanding the role and behavior of different types of firms in international trade. Our empirical findings also raise a number of important questions: What determines how firms choose to access foreign markets? Are the gains from trade concentrated among the large and productive firms that access foreign markets directly? Or

are these gains shared with smaller and less productive firms that only indirectly import or export? How do demand and supply shocks transmit from one firm to the next in the domestic production network, and what are the effects of such shocks for workers, firms, and the economy? Is it necessary to observe firm-to-firm transactions to accurately estimate these effects?

To answer these questions, it is necessary to develop and estimate a model of production networks and international trade. In Appendix A, we develop such a model, assuming fixed firm-to-firm linkages and constant markups.[10] This simple model offers a justification for the way we measure total import and export shares, and it illustrates how data on firm-to-firm transactions can be used to draw inferences about the costs of and benefits from trade. At the same time, it is important to observe that the model we considered falls short of both explaining all our empirical findings and analyzing all the above questions. Doing so is an important task for future research.

[10] Assuming a fixed network structure prevents one from capturing how buyer-supplier relationships may respond to changes in the price of foreign prices. In an earlier version of this paper (Tintelnot, Kikkawa, Mogstad, and Dhyne, 2019), we therefore developed and estimated a model of trade with endogenous network formation. Other approaches to endogenous formation of the domestic production network include Oberfield (2018), Lim (2018), Huneeus (2018), and Taschereau-Dumouchel (2018).

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A Theoretical motivations for the measures of total trade

A.1 Theoretical motivation for s_{Fj}^{Total}

This section shows that, in a class of models, the firm-level cost changes and aggregate price changes in response to foreign price changes depend on the firms' total import shares, s_{Fj}^{Total}, not the direct import shares.

We consider a small open economy where the price of foreign goods, p_F, is taken as given. We assume fixed linkages between firms, fixed markups in firm-to-firm trade, and CRS production technologies. In their production, firms use domestic labor (with wage rate w) and inputs from their domestic suppliers. If they are directly importing from abroad, the imported inputs are also used as production inputs.

Denote firm j's cost function to produce y units of output with $c(\{p_{kj}\}_{k\in Z_j}, w, y)$, where Z_j denotes the set of firm j's domestic suppliers, and p_{kj} denotes the price that firm k charges firm j. Taking the total derivatives of the cost function yields:

$$\mathrm{d}c(\{p_{kj}\}_{k\in Z_j}, w, y) = \sum_{k\in Z_j} \frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial p_{kj}} \mathrm{d}p_{kj} + \frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial w} \mathrm{d}w + \frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial y} \mathrm{d}y.$$

Dividing both sides with $c(\{p_{kj}\}_{k\in Z_j}, w, y)$, we obtain:

$$\frac{\mathrm{d}c(\{p_{kj}\}_{k\in Z_j}, w, y)}{c(\{p_{kj}\}_{k\in Z_j}, w, y)} - \frac{y\frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial y}}{c(\{p_{kj}\}_{k\in Z_j}, w, y)} \frac{\mathrm{d}y}{y} = \sum_{k\in Z_j} \frac{p_{kj}\frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial p_{kj}}}{c(\{p_{kj}\}_{k\in Z_j}, w, y)} \frac{\mathrm{d}p_{kj}}{p_{kj}} + \frac{w\frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial w}}{c(\{p_{kj}\}_{k\in Z_j}, w, y)} \frac{\mathrm{d}w}{w}.$$

By Shephard's lemma, we also have $\frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial p_{kj}} = x_{kj}(\{p_{kj}\}_{k\in Z_j}, w, y)$ and $\frac{\partial c(\{p_{kj}\}_{k\in Z_j}, w, y)}{\partial w} = \ell_j(\{p_{kj}\}_{k\in Z_j}, w, y)$. In addition, from the constant returns to scale assumption, $c(\{p_{kj}\}_{k\in Z_j}, w, y) = yc(\{p_{kj}\}_{k\in Z_j}, w, 1)$. Rearrange and obtain:

$$\frac{\mathrm{d}c(\{p_{kj}\}_{k\in Z_j}, w, 1)}{c(\{p_{kj}\}_{k\in Z_j}, w, 1)} = \sum_{k\in Z_j} s_{kj} \frac{\mathrm{d}p_{kj}}{p_{kj}} + s_{Lj} \frac{\mathrm{d}w}{w}, \forall y.$$

That is, if the production function is CRS, the percentage change in the unit cost equals a weighted average of percentage change in factor prices, with a factor's weight equal to the expenditure share on the factor.

We can further arrange the equation by leveraging the fixed markup assumption, $\frac{\mathrm{d}p_{kj}}{p_{kj}} = \frac{\mathrm{d}c_k}{c_k}$, to obtain

$$\frac{\mathrm{d}c_j}{c_j} = \left(1 - s_{Fj}^{Total}\right) \frac{\mathrm{d}w}{w} + s_{Fj}^{Total} \frac{\mathrm{d}p_{F\cdot}}{p_{F\cdot}}. \tag{7}$$

Equation (7) implies that for small changes to the foreign price, the first-order approximated changes in the firm-level costs are a weighted aggregate of the change in the foreign price and

the change in the domestic wage. While one needs more structure to solve for the general equilibrium and obtain the change in the domestic wage, the weights are firm-specific and summarized by the firm's total import share.

One can obtain similar results for the aggregate price index changes. We now further assume a constant returns to scale utility function and describe it as $e(\{p_{jH}\}, U) = Ue(\{p_{jH}\}, 1)$. That is, the minimized expenditure to achieve utility level U equals U times the minimized expenditure to obtain a unit utility. Furthermore, with homothetic preferences, the ideal price index P is the minimized cost of buying one unit of utility, i.e., $P = e(\{p_{jH}\}, 1)$.

Take the total derivative of $e(\{p_{jH}\}, U)$ and obtain:

$$\frac{\mathrm{d}e(\{p_{jH}\}, U)}{e(\{p_{jH}\}, U)} = \sum_j \frac{p_{jH}\frac{\partial e(\{p_{jH}\}, U)}{\partial p_{jH}}}{e(\{p_{jH}\}, U)} \frac{\mathrm{d}p_{jH}}{p_{jH}} + \underbrace{\frac{U\frac{\partial e(\{p_{jH}\}, U)}{\partial U}}{e(\{p_{jH}\}, U)}}_{=1} \frac{\mathrm{d}U}{U}.$$

Then total differentiate $Ue(\{p_{jH}\}, 1)$:

$$\frac{\mathrm{d}e(\{p_{jH}\}, U)}{e(\{p_{jH}\}, U)} = \frac{\mathrm{d}P}{P} + \frac{\mathrm{d}U}{U}.$$

By Shephard's Lemma, $\frac{\partial e(\{p_{jH}\}, U)}{\partial p_{jH}} = x_{jH}(\{p_{jH}\}, U)$. Equating the previous two equations and dropping $\frac{\mathrm{d}U}{U}$, the first-order approximated change in the ideal price index for any level U is:

$$\frac{\mathrm{d}P}{P} = \sum_j s_{jH} \frac{\mathrm{d}p_{jH}}{p_{jH}}, \tag{8}$$

where s_{jH} denotes the share of household consumption that is produced by firm j. Leveraging the fixed markup assumption, $\frac{\mathrm{d}p_{jH}}{p_{jH}} = \frac{\mathrm{d}c_j}{c_j}$, the change in aggregate price index is a weighted average of firm-level cost changes, which in turn are functions of their total import share.

A.2 Theoretical motivation for r_{jF}^{Total}

This section shows that the response of firm-level total sales to domestic and foreign demand shocks depends on the total export shares, r_{jF}^{Total}, not the direct export shares.

We consider a class of models in which production functions are Cobb-Douglas in inputs (labor, intermediate goods supplied by domestic firms, and foreign inputs) and utility functions of domestic and foreign consumers are Cobb-Douglas in consumption goods made by domestic firms. As in Section A.1, we also assume fixed linkages between firms and fixed markups in firm-to-firm trade.

Denote firm j's total sales by X_j. Firms sell to domestic final consumers (X_{jH}), foreign

consumers (X_{jF}) and its downstream firms (X_{ji}):

$$X_j = \sum_{i \in W_j^D} X_{ji} + X_{jH} + X_{jF}.$$

Taking first difference and dividing both sides by X_j:

$$\frac{dX_j}{X_j} = \sum_{i \in W_j^D} r_{ji} \frac{dX_{ji}}{X_{ji}} + r_{jH} \frac{dX_{jH}}{X_{jH}} + r_{jF} \frac{dX_{jF}}{X_{jF}},$$

where r_{ji}, r_{jH}, and r_{jF} denote the share of sales to firm i, to domestic consumers, and to foreign consumers in firm j's total output, respectively.

Under the Cobb-Douglas assumption across firms' goods, we have $X_{ji} = \gamma_{ji} C_i$, $X_{jH} = \gamma_{jH} E$, and $X_{jF} = \gamma_{jF} E_F$, where C_i is the total cost of firm i, E is the aggregate domestic expenditure of households at home, and E_F is the aggregate foreign expenditure. We also have $\frac{dC_i}{C_i} = \frac{dX_i}{X_i}$ under fixed markups. The results in changes then follow: $\frac{dX_{ji}}{X_{ji}} = \frac{dX_i}{X_i}$, $\frac{dX_{jH}}{X_{jH}} = \frac{dE}{E}$, and $\frac{dX_{jF}}{X_{jF}} = \frac{dE_F}{E_F}$. Plugging these in to the above, we have:

$$\frac{dX_j}{X_j} = \sum_{i \in W_j^D} r_{ji} \frac{dX_i}{X_i} + r_{jH} \frac{dE}{E} + r_{jF} \frac{dE_F}{E_F}.$$

Rearranging this further, we obtain:

$$\frac{dX_j}{X_j} = (1 - r_{jF}^{Total}) \frac{dE}{E} + r_{jF}^{Total} \frac{dE_F}{E_F}.$$

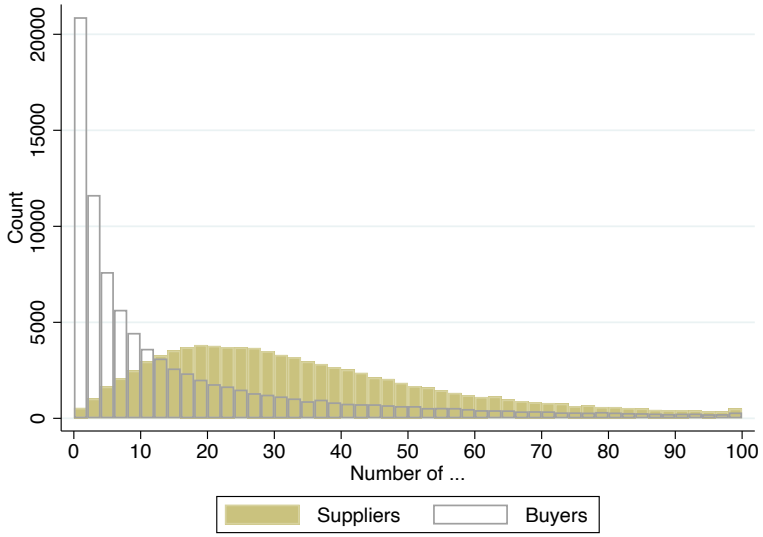
which shows that the change in a firm's sales is a weighted average of the changes in aggregate foreign and domestic expenditures, and the weight associated with the change in foreign demand is the total export share, r_{jF}^{Total}. With the Cobb-Douglas assumption, this result also holds globally for large changes in foreign demand.

B Additional empirical results

B.1 Firms' numbers of suppliers and buyers

Figure 6 plots the distributions of the number of domestic suppliers and buyers in year 2012. The domestic production network in Belgium can be characterized as a sparse network, as the median number of domestic suppliers is 33, and the median number of domestic buyers is 9.

Figure 6: Distributions of number of domestic suppliers and buyers



Notes: The figure plots the density distributions of firms' number of domestic suppliers and buyers in 2012. The distributions are truncated at 100. Out of the 98,745 private sector firms in 2012, we drop 9,034 firms with more than 100 domestic suppliers for the supplier distribution, and 10,052 firms with more than 100 domestic buyers for the buyer distribution.

B.2 Total import and export shares by participation status

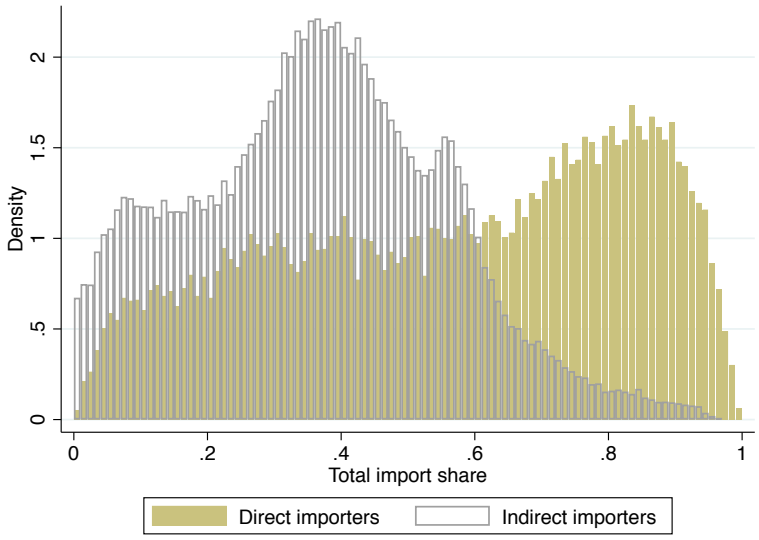
Figure 7 plots the distributions of firms' total import and export shares, separately for those that directly sell to and buy from foreign markets and for those that only trade indirectly.

We find that the distributions for the two sets of firms overlap to a large extent, especially for imports. For example, 27 percent of direct importers have s_{Fj}^{Total} that is below the median s_{Fj}^{Total} for indirect importers. On the export side, 32 percent of direct exporters have r_{jF}^{Total} that is below the 80th percentile r_{jF}^{Total} for indirect exporters.[11]

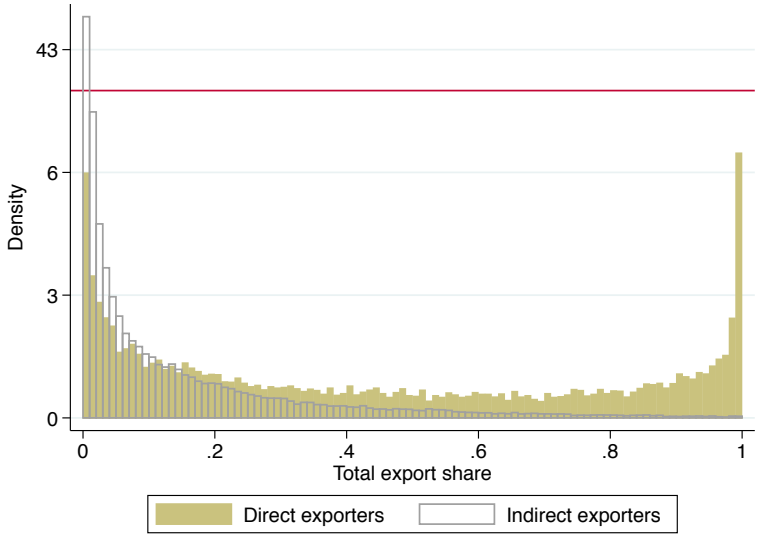
[11]These numbers do not change much even when we define the median s_{Fj}^{Total} and 80th percentile r_{jF}^{Total} at the two-digit level. We find that 26 percent of direct importers have s_{Fj}^{Total} that is below the median s_{Fj}^{Total} for indirect importers, and 36 percent of direct exporters have r_{jF}^{Total} that is below the 80th percentile r_{jF}^{Total} for indirect exporters.

Figure 7: Total import and export shares by participation status

(a) Direct versus indirect importers



(b) Direct versus indirect exporters



Notes: The figures show the densities of total import shares, s_{Fj}^{Total}, and total export shares, r_{jF}^{Total}, for direct importers and exporters, as well as for indirect importers and exporters. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012.

B.3 Variance decompositions of import and export shares

In Table 5 we calculate how much of the variation in the total participation in foreign trade is within versus between industries. We find that even at the four-digit industry level, within-industry variation in the total import share accounts for 64 percent of the variation, and the number—68 percent—is even higher for the total export share. We obtain similar results when decomposing the variance of the indirect import and export shares, where we define firm j's indirect import share as $s_{Fj}^{Total} - s_{Fj}$, and its indirect export share as $r_{jF}^{Total} - r_{jF}$. We also investigate to what extent the import (export) content within domestic purchases (sales) varies within and between industries. Industry input-output tables assume homogeneity in the import content of domestic intermediate purchases within industries. Our calculations suggest, however, that more than 70 percent of the variation in the import content of firms' domestic input purchases arises within industries.

Table 5: Variance decomposition of indirect participation to foreign trade

Aggregation	Two-digit		Four-digit	
	within	between	within	between
Total import share	0.71	0.29	0.64	0.36
Total export share	0.77	0.23	0.68	0.32
Indirect import share	0.76	0.24	0.67	0.33
Indirect export share	0.80	0.20	0.70	0.30
Import share in domestic network inputs	0.77	0.23	0.70	0.30
Export share in domestic network sales	0.84	0.16	0.76	0.24

Notes: This table reports the results of a variance decomposition analysis for various measures of total and indirect participation in foreign trade, in year 2012. See equations (1) and (2) for variable definitions. Firm j's indirect import share is defined as $s_{Fj}^{Total} - s_{Fj}$, and its indirect export share is defined as $r_{jF}^{Total} - r_{jF}$. The import share in domestic network inputs is calculated as $\left(s_{Fj}^{Total} - s_{Fj}\right) / \sum_{i \in Z_j^D} s_{ji}$. The export share in domestic network sales is calculated as $\left(r_{jF}^{Total} - r_{jF}\right) / \sum_{i \in W_j^D} r_{ji}$.

C Data Appendix

C.1 Definition and construction of variables

We describe how we compute each variable that we use in the analyses in the paper. Firms' variable inputs consist of their labor costs reported in the annual accounts, their imports reported in the international trade dataset, and the goods purchased from other Belgian firms that are reported in the B2B dataset. Note that we do not include goods purchased from firms that do not meet the sample selection criteria. Firms' sales consist of their sales to other Belgian firms that meet the sample selection criteria, their exports reported in the international trade dataset, and their sales to domestic final demand. A firm's sales to domestic final demand is computed as the residual of the firm's total turnover reported in the annual accounts, after subtracting exports and the firm's sales to other Belgian firms, including those to firms not in the selected sample.

These procedures essentially exclude firms' sales to, and purchases from other firms that do not meet the sample selection criteria.

C.2 Reporting thresholds of the international trade dataset

There are different reporting thresholds for the international trade dataset, depending on if the trade occurred with an extra-EU country or within the EU. The dataset covers all extra-EU exports and imports by firms with values higher than 1,000 euro or with weights bigger than 1,000kg. Nevertheless, we also observe values less than 1,000 euro as more firms use electronic reporting procedures. For intra-EU trade prior to 2006, the dataset covers all exports and imports by firms whose combined imports from intra-EU countries that are more than 250,000 euro a year. For intra-EU trade from 2006 onward, the thresholds for exports and imports changed to 1,000,000 euro and 400,000 euro, respectively. Import reporting thresholds became 700,000 euro per year in 2010. While these reporting threshold for intra-EU trade imply we miss some trade transaction, they are set to capture at least 93 percent of aggregate Belgian trade in the micro-data, hence our data still contains the overwhelming majority of the value of Belgian trade.

C.3 Mapping CN codes into NACE codes

Our international trade dataset records products in Combined Nomenclature (CN) codes, up to eight digits. On the other hand, all other datasets that we use record the enterprise's primary sector in NACE Rev.2 code. To align the two classifications, we convert the CN eight-digit codes into NACE Rev.2 codes. As the first six digits of CN codes are identical to the contemporary Harmonized System (HS) codes, we first convert those HS six-digit codes to Classification of Products by Activity (CPA) codes. We then convert CPA codes to NACE codes, using the fact that CPA 2008 codes are identical to NACE Rev.2 codes up

to four digits. This conversion allows us to convert more than 98 percent of all international trade recorded in our dataset, in terms of values (in 2012).

C.4 Grouping VAT identifiers into firms

As mentioned in the main text, all our datasets are recorded at the VAT identifier level. We utilize ownership filings in the annual accounts and information from the Balance of Payments survey in order to aggregate multiple VAT identifiers into firms. In the ownership filings, each enterprise reports a list of all other enterprises of which it has an ownership share of at least 10 percent and the value of the share. In the Balance of Payments survey, Belgian enterprises with international financial linkages have to report their stock and flows of financial links. They have to report both the international participation they own and the foreign owners of financial participation in their capital if the participation represents at least 10 percent of the capital. The survey is designed to cover the population of Belgian enterprises involved in international financial transactions.

We group all VAT identifiers into firms if they are linked with more than or equal to 50 percent of ownership. In addition, we group all VAT identifiers into firms if they share the same foreign parent firm that holds more than or equal to 50 percent of their shares. We use a "fuzzy string matching" method to determine whether they share the same foreign parent firm, by obtaining similarity measures of all possible pairs of foreign firms' names. Lastly, in order to correct for misreportings, we also add links to the VAT identifier pairs if the two were linked one year before and one year after. We define a firm as the group of VAT identifiers that are directly and indirectly linked.

Given these groupings of VAT identifiers, we then choose the "most representative" VAT identifier for each firm. We use this "head VAT identifier" as the identifier of the firm.[12] Then, in order to make the identifiers consistent over time, we make the following adjustment: We take firms whose head VAT identifier was not an identifier of any firm in the previous year. For such firms, if there exists a VAT identifier within the firm which was a head VAT identifier in the previous year, then we switch the firm identifier to that former head VAT identifier.[13]

Having determined the head VAT identifier for each firm with multiple VAT identifiers, we aggregate all the variables up to the firm level. For variables such as total sales and inputs, we adjust the aggregated variables with the amount of B2B trade that occurred within the firm, correcting for double counting. For other non-numeric variables such as firms' primary sector, we take the value of its head VAT identifier.

[12]The criteria for determining the head VAT identifier are as follows: (i) If there is only one VAT identifier in the firm that filed all the full annual accounts, the VAT declarations, and the B2B filings, then this VAT identifier is chosen as the head. (ii) If there are no such VAT identifiers or multiple of them, then we choose the VAT identifier that has the largest total assets reported. (iii) If there are no VAT identifier that filed the annual accounts, then we choose the VAT identifier that has the largest amount of total inputs, which is the sum of labor costs, B2B inputs, and imports.

[13]If there are multiple such VAT identifier, then we choose the "most representative" VAT identifier, using the same criteria described in footnote 12.

The number of VAT identifiers for firms with multiple VAT identifiers are shown in Table C1. The majority of multiple VAT firms consist of only two VAT identifiers.

Table C1: Number of VAT identifiers in firms with multiple VAT identifiers

	Mean	10%	25%	50%	75%	90%	max
Number of VAT identifier	3	2	2	2	3	5	372

Notes: This table reports the distribution of the number of VAT identifiers, for firms that consist of two or more VAT identifiers in year 2012.

C.5 Firm selection

Table C2 reports the coverage of the selected firms among all Belgian firms in the dataset. Our sample selection reduces the number of selected firms drastically, but the selected sample covers most of the value added, sales, imports, and exports of all Belgian firms in the dataset.

Table C2: Coverage of all Belgian firms and selected sample

Year	All Belgian Firms					Selected sample				
	Count	V.A.	Sales	Imports	Exports	Count	V.A.	Sales	Imports	Exports
2002	714,469	134	812	204	217	88,301	119	564	175	185
2007	782,006	176	1080	294	282	95,941	152	728	277	265
2012	860,373	195	1244	320	317	98,745	164	796	292	292

Notes: All numbers except for count are denominated in billion euro in current prices. Firms' value added in the selected sample is computed as their sales minus imports and their purchases from other Belgian firms that are in the selected sample. Firms' value added is from the reported values from the annual accounts.

C.6 Sectoral composition

Table C3 shows the sectoral composition of our selected sample.

Table C3: Sectoral composition in 2012

Sector	Count	V.A.	Sales	Network Sales	Labor cost	Imports	Exports
Agriculture and Mining	2,805	4.37	45.1	12.6	1.54	16.9	10.9
Manufacturing	16,577	54.9	318	66.0	32.5	146	193
Utility and Construction	20,421	25.4	80.0	26.8	14.9	27.8	17.5
Wholesale and Retail	31,117	30.7	233	74.8	18.4	84.1	53.4
Service	27,825	48.4	120	45.2	32.7	17.6	16.9
Total	98,745	164	796	225	100	292	292

Notes: Agriculture and Mining corresponds to NACE two-digit codes 01 to 09, Manufacturing corresponds to NACE two-digit codes 10 to 33, Utility and Construction corresponds to NACE two-digit codes 35 to 43, Wholesale and Retail corresponds to NACE two-digit codes 45 to 47, and Service corresponds to NACE two-digit codes 49 to 63, 68 to 82, and 94 to 96. Values except for count are in billion euro.

D Additional empirical results

D.1 Direct and total import shares, by broad sectors

We investigate the direct and total import and export shares by firms' broad sectors. Figure D1 plots the distributions of the import and export shares for each broad sector. Tables D4 and D5 report the summary statistics of direct and total shares, for each broad sector.

Table D4: Distribution of direct and total import share by firms' broad sector

Sector	Direct import share, s_{Fj}			Total import share, s_{Fj}^{Total}		
	Mean	Weighted Mean	Median	Mean	Weighted Mean	Median
Agriculture and Mining	0.05	0.73	0	0.46	0.86	0.45
Manufacturing	0.12	0.61	0	0.44	0.76	0.42
Utility and Construction	0.02	0.33	0	0.39	0.61	0.39
Wholesale and Retail	0.12	0.45	0	0.52	0.76	0.55
Service	0.01	0.20	0	0.25	0.40	0.24
Total	0.07	0.47	0	0.40	0.69	0.39

Notes: The numbers for the weighted mean are calculated using total input purchases of firms as the weights. The table is based on the analysis of 98,745 private sector firms in Belgium in 2012.

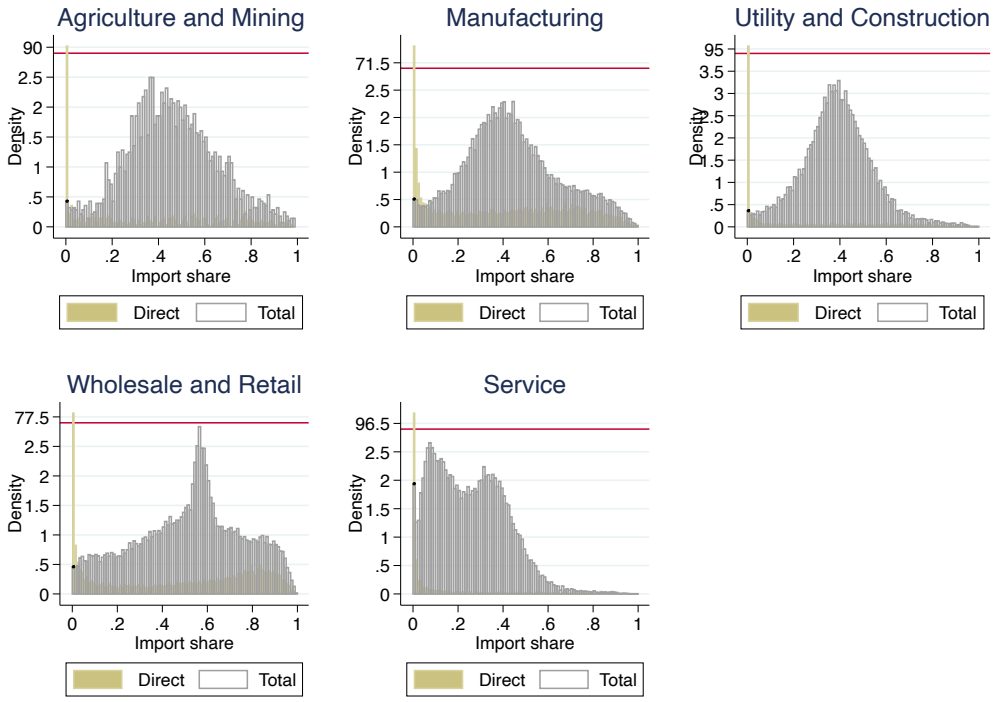
Table D5: Distribution of direct and total export share by firms' sector

Sector	Direct export share, r_{jF}			Total export share, r_{jF}^{Total}		
	Mean	Weighted Mean	Median	Mean	Weighted Mean	Median
Agriculture and Mining	0.06	0.24	0	0.33	0.34	0.25
Manufacturing	0.12	0.61	0	0.28	0.68	0.13
Utility and Construction	0.01	0.22	0	0.09	0.31	0.02
Wholesale and Retail	0.05	0.23	0	0.11	0.30	0.01
Service	0.01	0.14	0	0.10	0.27	0.02
Total	0.04	0.37	0	0.14	0.45	0.03

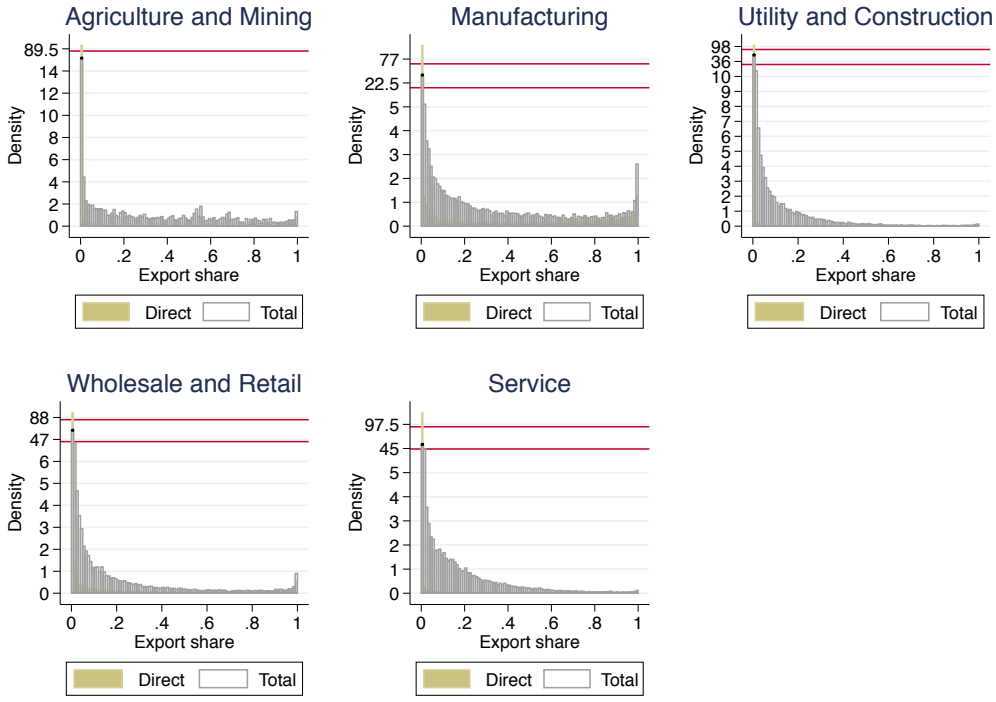
Notes: The numbers for the weighted mean are calculated using total sales of firms as the weights. The table is based on the analysis of 98,745 private sector firms in Belgium in 2012.

Figure D1: Direct and total shares, by firms' broad sector

(a) Direct and total import share



(b) Direct and total export share

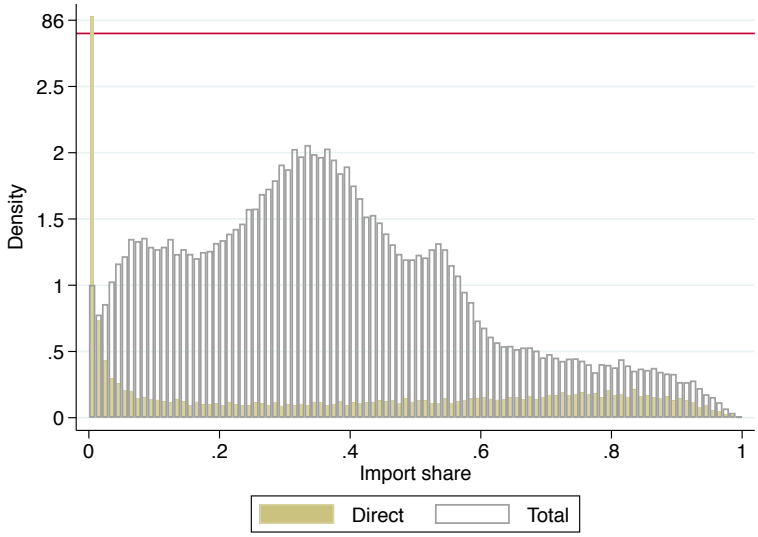


Notes: The black dot indicates the ending of the bar for the total import shares and the total export shares. The horizontal lines represent scale breaks on the vertical axis. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012.

D.2 Taking capital usage into account

In Figure D2, we show a figure analogous to panel (a) of Figure 1, but taking firms' capital usage into account. Following Dhyne, Petrin, Smeets, and Warzynski (2017), we set the yearly depreciation rate as 8 percent and set the interest rate as the long-term interest rate in Belgium. We compute the user cost of capital using fixed tangible assets reported in the annual accounts, and add them to the denominators of the input shares in equation (1).

Figure D2: Panel (a) of Figure 1, accounting for firms' user cost of capital



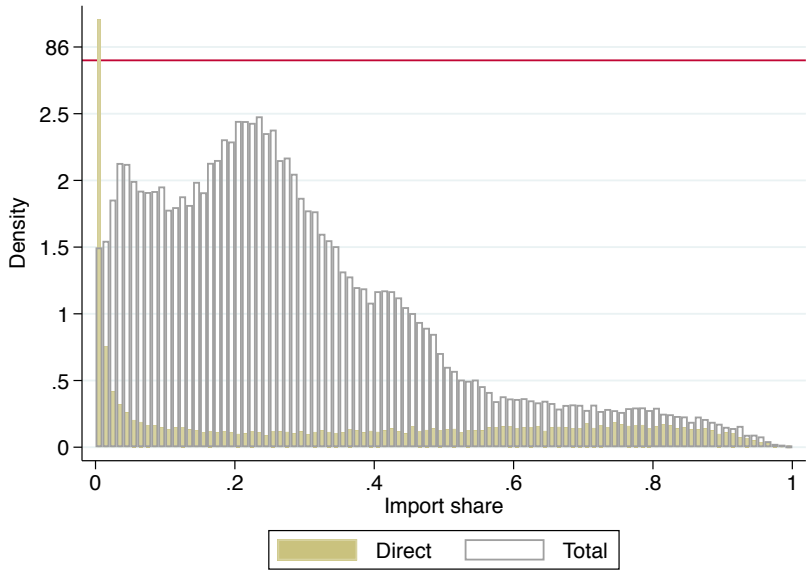
Notes: The figure plots the distributions of direct import shares, s_{Fj}, and total import shares, s_{Fj}^{Total}, with firms' user cost of capital added to their input costs. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012. The horizontal line represents a scale break on the vertical axis.

D.3 Taking into account purchases from and sales to firms outside the sample set

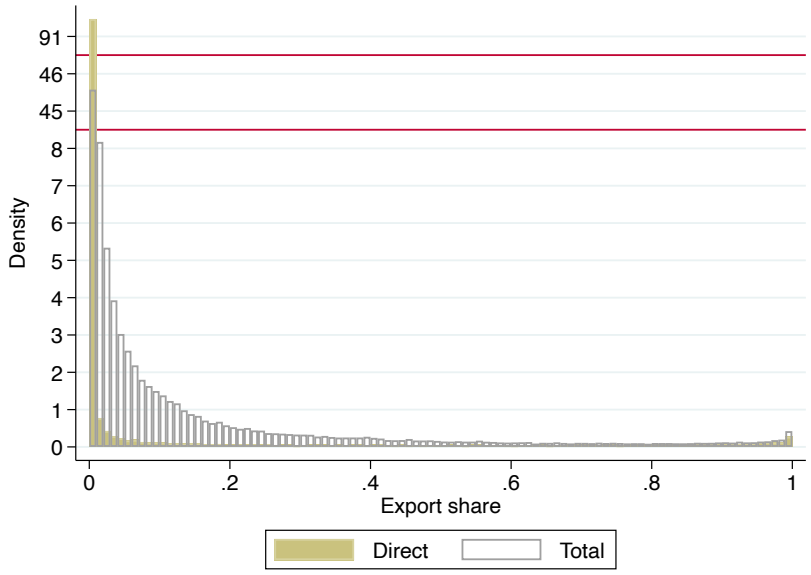
In the main text we only considered transactions among firms that are in the selected sample. Figure D3 plots the distributions of direct and total shares when we account for purchases from and sales to firms outside the sample set. In particular, Panel (a) considers the direct and total import shares with firms' purchases from suppliers not in the selected sample added to their input costs. Panel (b) considers the direct and total export shares with firms' sales to buyers not in the selected sample added to their sales.

Figure D3: Direct and total shares, with sales from and to non-selected firms

(a) Panel (a) of Figure 1, accounting for purchases from firms not in the selected sample



(b) Panel (b) of Figure 1, accounting for sales to firms not in the selected sample



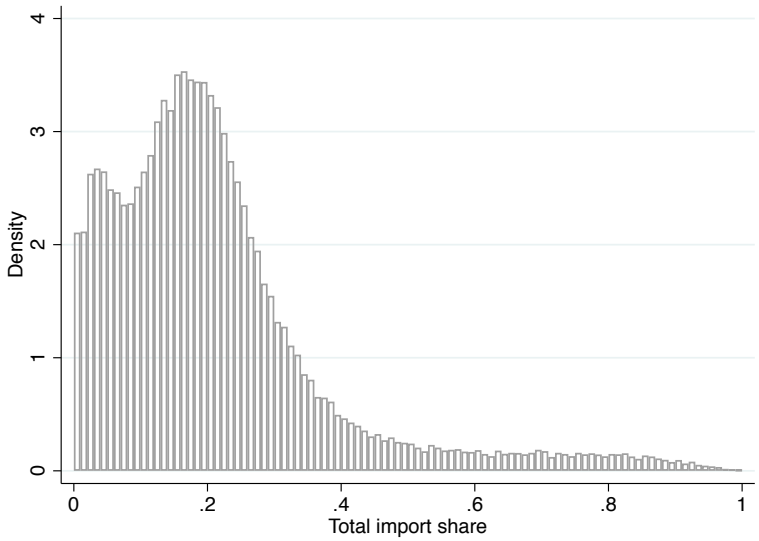
Notes: The top figure plots the distributions of the direct import shares, s_{Fj}, and total import shares, s_{Fj}^{Total}, with firms' purchases from suppliers not in the selected sample added to their input costs. The bottom figure plots the distributions of the direct and total export shares, with firms' sales to buyers not in the selected sample added to their sales. The horizontal lines represent scale breaks on the vertical axis. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012.

D.4 Total participations in foreign trade when excluding wholesale and retail sectors

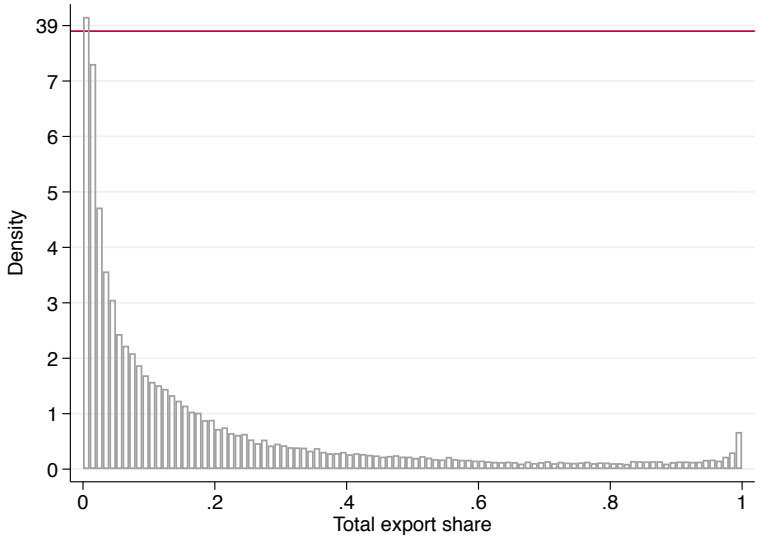
Panel (a) of Figure D4 plots the distribution of total import shares for firms outside the wholesale and retail sectors, where the total import shares are computed by setting the direct import shares for firms in the wholesale and retail sectors as 0. 15 percent of firms outside the wholesale and retail sectors were importers. Analogously, panel (b) of Figure D4 plots the distribution of total export shares for firms outside the wholesale and retail sectors, where the total export shares are computed by setting the direct export shares for firms in the wholesale and retail sectors as 0. 10 percent of firms outside the wholesale and retail sectors were exporters.

Figure D4: Total import and export shares, when excluding direct imports and exports by the wholesale and retail sector

(a) Total import share



(b) Total export share



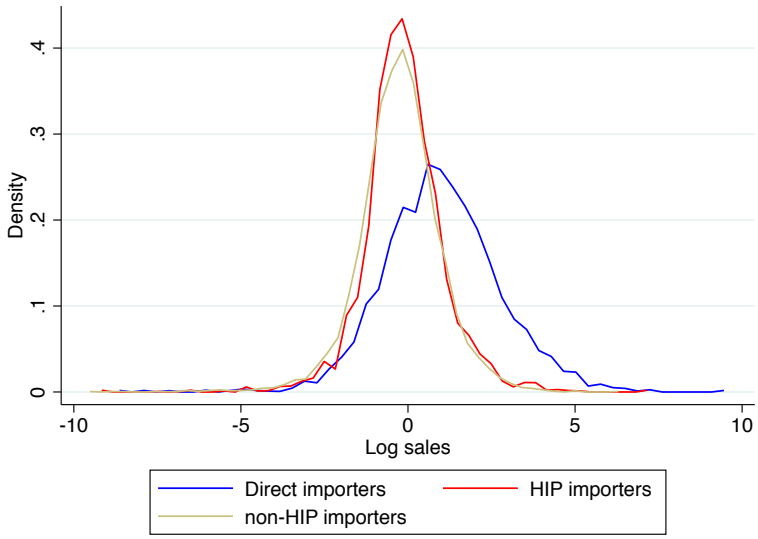
Notes: The figures plot the distributions of total import shares and total export shares for firms not in the wholesale or retail sectors in year 2012. The total import share of firm j, s_{Fj}^{Total} is calculated by solving $s_{Fj}^{Total} = s_{Fj} + \sum_{i \in Z_j^D} s_{ij} s_{Fi}^{Total}$ where s_{Fj} is firm j's direct import share, and s_{ij} is firm i's share among firm j's inputs. s_{Fj} for firms in the wholesale and retail sectors are set to be 0. The total export share of firm j, r_{jF}^{Total} is calculated by solving $r_{jF}^{Total} = r_{jF} + \sum_{i \in W_j^D} r_{ji} r_{jF}^{Total}$ where r_{jF} is firm j's direct export share and r_{ji} is the share of firm j's revenue that arises from sales to firm i. r_{jF} for firms in the wholesale and retail sectors are set to be 0.

D.5 Size distribution across groups with different extent of direct and indirect trade

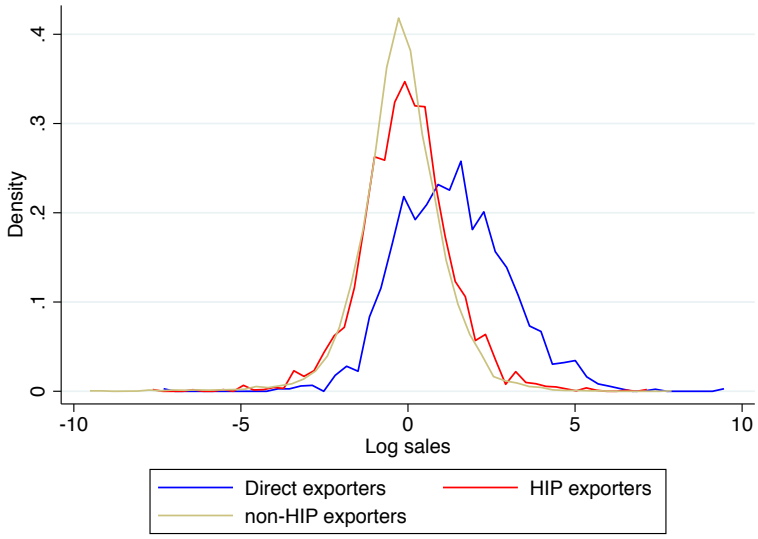
Figure D5 plots the size distribution of firms across groups that are assigned according to their extent of direct and indirect trade. We consider three groups of importers: firms that directly import (Direct importers); firms that do not directly import but are in the top quintile in the distribution of total import shares within their industry (HIP importers), and the remaining firms that neither directly import nor import a lot indirectly (non-HIP importers). In the same fashion, we assign firms to three groups of exporters.

Figure D5: Size distribution of firms across the three groups

(a) Imports



(b) Exports



Notes: The figure plots the size distribution of firms across groups that are split according to their direct and indirect exposures to foreign trade. Firms on the importing side are split into direct importers, HIP importers that are in the top quintile distribution of indirect exposure to foreign inputs among firms not directly importing, and non-HIP importers that are the rest of the firms that do not directly import. Firms on the exporting side are split into direct exporters, HIP exporters that are in the top quintile distribution of indirect exposure to foreign exports among firms not directly exporting, and non-HIP exporters that are the rest of the firms that do not directly export. We use the Epanechnikov kernel function with kernel bandwidth of 0.01, and smooth obtained at 50 points. Log sales are demeaned with four-digit industry fixed effects. The figures are based on the analysis of 98,745 private sector firms in Belgium in 2012.

D.6 Additional Markov transition matrices

As in the main text, we assign firms into three mutually exclusive and collectively exhaustive groups based on their import and export behavior in a given year. On the importing side, we assign one of the groups (Direct) with firms that directly import. The other firms that do not directly import are classified as either having high indirect import (HIP), or as having low indirect import (non-HIP). We assign firms in the same way on the exporting side. We then compute the five-year Markov transition probabilities across these groups and report the results in Table D6. We also compute one-year Markov transition probabilities for each broad sector and report the results in Table D7.

Table D6: Five-year transition matrices

Importers

	Direct_{t+5}	non-HIP_{t+5}	HIP_{t+5}
Direct_t	0.82	0.14	0.03
non-HIP_t	0.07	0.85	0.08
HIP_t	0.08	0.38	0.54

Exporters

	Direct_{t+5}	non-HIP_{t+5}	HIP_{t+5}
Direct_t	0.71	0.21	0.08
non-HIP_t	0.05	0.88	0.08
HIP_t	0.07	0.26	0.67

Notes: The two panels report the five-year Markov matrices among the sets of three mutually exclusive groups classified according to firms' extent to direct and total trade. On the importing side, for each two-digit sector we group firms as follows: firms that directly import (direct importers), firms that are in the top quintile distribution of indirect participation to foreign inputs among firms not directly importing (HIP importers), and the rest of the firms that do not directly import (non-HIP importers). We use the same criteria for the exporting side. The results are pooled from a balanced panel from year 2002 to 2014.

Table D7: Transition matrices across broad sectors

Agriculture and Mining

Importers				Exporters			
	Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$		Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$
Direct$_t$	0.86	0.11	0.03	Direct$_t$	0.86	0.12	0.03
non-HIP$_t$	0.04	0.90	0.06	non-HIP$_t$	0.03	0.91	0.05
HIP$_t$	0.05	0.26	0.69	HIP$_t$	0.03	0.21	0.76

Manufacturing

Importers				Exporters			
	Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$		Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$
Direct$_t$	0.91	0.07	0.02	Direct$_t$	0.89	0.08	0.03
non-HIP$_t$	0.07	0.88	0.05	non-HIP$_t$	0.05	0.90	0.04
HIP$_t$	0.07	0.23	0.71	HIP$_t$	0.07	0.15	0.78

Utility and Construction

Importers				Exporters			
	Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$		Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$
Direct$_t$	0.80	0.16	0.04	Direct$_t$	0.66	0.23	0.12
non-HIP$_t$	0.02	0.93	0.05	non-HIP$_t$	0.01	0.92	0.07
HIP$_t$	0.02	0.30	0.68	HIP$_t$	0.03	0.26	0.71

Retail and Wholesale

Importers				Exporters			
	Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$		Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$
Direct$_t$	0.91	0.07	0.02	Direct$_t$	0.80	0.15	0.05
non-HIP$_t$	0.05	0.91	0.05	non-HIP$_t$	0.06	0.91	0.03
HIP$_t$	0.05	0.16	0.79	HIP$_t$	0.08	0.12	0.80

Service

Importers				Exporters			
	Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$		Direct$_{t+1}$	non-HIP$_{t+1}$	HIP$_{t+1}$
Direct$_t$	0.72	0.24	0.04	Direct$_t$	0.66	0.26	0.08
non-HIP$_t$	0.04	0.89	0.07	non-HIP$_t$	0.02	0.92	0.06
HIP$_t$	0.04	0.36	0.60	HIP$_t$	0.03	0.19	0.78

Notes: The five panels report the one-year Markov matrices among the sets of three mutually exclusive groups, for each broad sector. Firms are classified according to their extent to direct and total trade. On the importing side, for each two-digit sector we group firms as follows: firms that directly import (direct importers), firms that are in the top quintile distribution of indirect participation to foreign inputs among firms not directly importing (HIP importers), and the rest of the firms that do not directly import (non-HIP importers). We use the same criteria for the exporting side. The results are pooled from a balanced panel from year 2002 to 2014.

D.7 Additional results on the transmission of foreign demand shocks

Table D8 presents additional results on the firms' responses to foreign demand shocks. Columns (1), (3), (5), and (7) show that the results in Table 4 are robust when taking out firm fixed effects. Columns (2), (4), (6), and (8) also show that the main results are robust when adding firms' lagged direct export shares as control.

Table D8: Additional regression results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Δ ln Sales	Δ ln Sales	Δ ln Sales	Δ ln Sales	Δ ln Sales	Δ ln Sales	Δ ln Sales	Δ ln Sales
Direct export shock	0.194***	0.219***						
	(0.0243)	(0.0258)						
Total export shock			0.304***	0.298***	0.313***	0.295***	0.329***	0.298***
			(0.0295)	(0.0322)	(0.0370)	(0.0420)	(0.0227)	(0.0264)
N	136102	126539	136102	126539	877309	854930	1014092	992866
Sample	Direct exporter	Direct exporter	Direct exporter	Direct exporter	Indirect exporter	Indirect exporter	All firms	All firms
Ind.-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	Yes	No	Yes	No	Yes	No	Yes
Lagged export share $r_{iF,t-1}$ control	No	Yes	No	Yes	No	Yes	No	Yes

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Variables are winsorized at the top and bottom 0.5 percentiles. The total export shock for firm j is defined as $\sum_i \tilde{H}_{ji,t-1} r_{iF,t-1} d \log X_{iF,t}^{shock}$ and the direct export shock for firm j is defined as $r_{jF,t-1} d \log X_{jF,t}^{shock}$. The assignment to the direct exporter or indirect exporter sample is made based on the export status in $t-1$. All specifications include lagged share of firms' sales exposed to household demand, $\sum_i \tilde{H}_{ji,t-1} r_{iH,t-1}$, as control, with time-varying coefficient. Standard errors are clustered at the NACE four-digit level.