

The Margins of Global Sourcing: Theory and Evidence from U.S. Firms *by* Pol Antràs, Teresa C. Fort and Felix Tintelnot

Online Theory Appendix (Not for Publication)

Equilibrium in the Complements-Pareto Case

In Proposition 2, we have established that whenever $\sigma - 1 > \theta$, the model delivers a ‘pecking order’ in the extensive margin of offshoring. For each country i , we can then rank foreign countries in terms of some index of sourcing appeal. We shall assume, for the time being, that this ranking is strict in the sense that the set of firms sourcing from any two distinct countries j and k do not coincide; more specifically, the measure of firms sourcing from the strictly more attractive country is necessarily larger. This assumption is fairly immaterial, as we shall show below.

Suppose also for simplicity that $\tilde{\varphi}_i = \tilde{\varphi}_{ii}$, so that all firms that source a positive amount (i.e., all firms that are active) do so, at least in part, from Home. Denote by r the r -th least appealing country from which firms from i source from, so Home is $r = 1$. Define also

$$\Theta_{ir} = \sum_{j=1}^r T_j (\tau_{ij} w_j)^{-\theta}.$$

Note that Proposition 2 implies that the set of productivity thresholds $\tilde{\varphi}_{ir}$ defined in the main text will be such that any firm with productivity above that threshold $\tilde{\varphi}_{ir}$ necessarily sources from country r , or in terms of the notation in equation (18), $I_{ir}(\varphi) = 1$ for all $\varphi > \tilde{\varphi}_{ir}$.

In light of the profit function in 9, these thresholds are given by

$$\begin{aligned} \tilde{\varphi}_{i1}^{\sigma-1} &= \frac{w_i f_{i1}}{\gamma^{(\sigma-1)/\theta} B_i \left(T_i (w_i)^{-\theta} \right)^{(\sigma-1)/\theta}}; \\ \tilde{\varphi}_{ir}^{\sigma-1} &= \frac{w_i f_{ir}}{\gamma^{(\sigma-1)/\theta} B_i \left(\Theta_{ir}^{(\sigma-1)/\theta} - \Theta_{ir-1}^{(\sigma-1)/\theta} \right)} \quad \text{for } r > 1. \end{aligned} \quad (29)$$

Consider now the industry equilibrium. Using the above notation, we can write the free entry condition (12) as

$$\gamma^{(\sigma-1)/\theta} B_i \sum_{r=1}^{J-1} \Theta_{ir}^{(\sigma-1)/\theta} \int_{\tilde{\varphi}_{ir}}^{\tilde{\varphi}_{ir+1}} \varphi^{\sigma-1} dG_i(\varphi) - w_i \sum_{r=1}^J f_{ir} \int_{\tilde{\varphi}_{ir}}^{\infty} dG_i(\varphi) = w_i f_e.$$

Next, invoking the Pareto distribution, $G_i(\varphi) = 1 - (\underline{\varphi}_i/\varphi)^\kappa$, and solving for the integrals, we obtain:

$$\gamma^{(\sigma-1)/\theta} B_i \sum_{r=1}^{J-1} \Theta_{ir}^{(\sigma-1)/\theta} \kappa \left(\underline{\varphi}_i \right)^\kappa \frac{(\tilde{\varphi}_{ir})^{\sigma-\kappa-1} - (\tilde{\varphi}_{ir+1})^{\sigma-\kappa-1}}{\kappa - \sigma + 1} - w_i \sum_{r=1}^J f_{ir} \left(\frac{\underline{\varphi}_i}{\tilde{\varphi}_{ir}} \right)^\kappa = w_i f_e.$$

Plugging the thresholds in (29) delivers

$$\begin{aligned} &\frac{\kappa}{\kappa - \sigma + 1} \left(\frac{\underline{\varphi}_i}{\tilde{\varphi}_{i1}} \right)^\kappa w_i f_{i1} - \frac{\kappa}{\kappa - \sigma + 1} \left(\frac{\underline{\varphi}_i}{\tilde{\varphi}_{i2}} \right)^\kappa \frac{\Theta_1^{(\sigma-1)/\theta}}{\left(\Theta_{i2}^{(\sigma-1)/\theta} - \Theta_1^{(\sigma-1)/\theta} \right)} w_i f_{i2} \\ &+ \kappa \left(\underline{\varphi}_i \right)^\kappa \sum_{r=2}^{J-1} \Theta_{ir}^{(\sigma-1)/\theta} \frac{(\tilde{\varphi}_{ir})^{-\kappa} \frac{w_i f_{ir}}{\left(\Theta_{ir}^{(\sigma-1)/\theta} - \Theta_{ir-1}^{(\sigma-1)/\theta} \right)} - (\tilde{\varphi}_{ir+1})^{-\kappa} \frac{w_i f_{ir+1}}{\left(\Theta_{ir+1}^{(\sigma-1)/\theta} - \Theta_{ir}^{(\sigma-1)/\theta} \right)}}{\kappa - \sigma + 1} \\ &- w_i \sum_{r=1}^J f_{ir} \left(\frac{\underline{\varphi}_i}{\tilde{\varphi}_{ir}} \right)^\kappa = w_i f_e. \end{aligned}$$

Expanding the summation involving the terms Θ_{ir} , canceling the terms in $\Theta_{ir}^{(\sigma-1)/\theta} - \Theta_{ir-1}^{(\sigma-1)/\theta}$, and simplifying, we finally obtain

$$\frac{\sigma-1}{\kappa-\sigma+1} \sum_{r=1}^J \left(\frac{\varphi_i}{\tilde{\varphi}_{ir}} \right)^\kappa f_{ir} = f_{ei}. \quad (30)$$

It is worth emphasizing that this equation holds regardless of the relative values of $\sigma-1$ and θ as long as these parameters and the degree of heterogeneity in fixed costs are such that a hierarchy in sourcing decisions exists. The key insight of Proposition 2 is that $\sigma-1 > \theta$ is a sufficient condition for this hierarchical structure to emerge regardless of the values of the fixed costs of offshoring f_{ij} .

In deriving equation (30), we have assumed that, from the point of view of firms in country i , the ranking of the appeal of the various source countries was strict. Whenever $\sigma-1 > \theta$, the complementarity in the sourcing decisions of firms implies, however, that the set of firms sourcing from two distinct countries j and k can in principle coincide. Intuitively, it could be the case that sourcing from country j can only be profitable when a firm in i also sources from country k , and viceversa. Fortunately, the above analysis can be readily adapted to deal with this sort of situations. More specifically, it suffices to define a *merged* country $j \cup k$ with a sourcing potential equal to the sum of j 's and k 's sourcing potential and with a sourcing fixed cost also equal to the sum of j 's and k 's sourcing fixed costs. This merged country can then be assigned a position r in the ranking of sourcing appeal across countries, and then it only suffices to be careful to run the summations in the expressions above replacing J with $J - \mathcal{M}$ where \mathcal{M} is the number of countries that have been *dropped* by being merged with other countries. It is then straightforward to see that one can again find its way to equation (30).

Note that equation (30) in turn implies that

$$\int_{\tilde{\varphi}_i}^{\infty} \sum_{j \in \mathcal{J}_i(\varphi)} f_{ij} dG_i(\varphi) + f_{ei} = \left(\frac{\sigma-1}{\kappa-\sigma+1} + 1 \right) f_{ei},$$

and thus plugging this expression in (13), we can conclude that

$$N_i = \frac{(\sigma-1)\eta L_i}{\sigma\kappa f_{ei}}, \quad (31)$$

as claimed in footnote 15.

Some of the above expressions are useful in deriving the gravity equation in (17) characterizing bilateral manufacturing trade flows in the case of independent entry decisions (i.e., $\sigma-1 = \theta$). To see this, begin with equation (16) and plug the formula for the Pareto distribution to obtain

$$M_{ij} = (\sigma-1) N_i B_i \gamma T_j (\tau_{ij} w_j)^{-\theta} \kappa \underline{\varphi}_i^\kappa \frac{(\tilde{\varphi}_{ij})^{\sigma-1-\kappa}}{\kappa-\sigma+1}.$$

With independent entry decisions, the threshold in (29) simplifies to

$$\tilde{\varphi}_{ij}^{\sigma-1} = \frac{w_i f_{ij}}{\gamma B_i T_j (\tau_{ij} w_j)^{-\theta}}.$$

Plugging this expression for $\tilde{\varphi}_{ij}^{\sigma-1}$ into the previous one for M_{ij} , imposing $\theta = \sigma-1$, and manipulating the resulting expression in a manner analogous to the derivation of the benchmark Eaton-Kortum gravity equation in (15), we obtain

$$M_{ij} = N_i (B_i)^{\frac{\kappa}{\sigma-1}} (\tau_{ij})^{-\kappa} \underline{\varphi}_i^\kappa (w_i f_{ij})^{1-\frac{\kappa}{\sigma-1}} \frac{Q_j}{\sum_k N_k (B_k)^{\frac{\kappa}{\sigma-1}} (\tau_{kj})^{-\kappa} (\tilde{\varphi}_k)^\kappa (w_k f_{kj})^{1-\frac{\kappa}{\sigma-1}}}.$$

Using (3) and (31) and defining

$$\Psi_i = \frac{f_{ei}}{L_i} \underline{\varphi}_i^{-\kappa} P_i^{-\kappa} w_i^{\kappa/(\sigma-1)-1},$$

we thus obtain equation (17) in the main text.

In this section, we briefly outline two extensions of the model that illustrate how our framework can accommodate additional prominent patterns of the involvement of U.S. firms in international trade transactions. Because we will not incorporate these features into the structural estimation and quantitative analysis in the next sections, we will limit ourselves to studying the effects of these extensions on firm behavior, and not on the aggregate implications of the model.

Details on the Extensions in Section 3.5

A. Tradable Final Goods: Exporting and Importing

In the benchmark model in the main text, we have assumed that final-good varieties are prohibitively costly to trade across borders. We have done so to focus our analysis on the determinants and implications of selection into global sourcing. In this section, we briefly relax this assumption and demonstrate the existence of intuitive complementarities between the extensive margin of exporting and that of importing at the firm level.

Suppose then that trade in final-varieties is only partially costly and involves both iceberg trade costs τ_{ij}^X as well as fixed costs f_{ij}^X of exporting. Firm behavior conditional on a sourcing strategy is largely analogous to that in section 3.1. In particular, after observing the realization of its supplier-specific productivity shocks, each final-good producer will continue to choose the location of production for each input to minimize costs, which will lead to the same marginal cost function $c_i(\varphi)$ obtained above in equation (8). The main novelty is that the firm will now produce output not only for the domestic market but also for a set of endogenously chosen foreign markets, which constitute the firm's 'exporting strategy'. We can then express the problem of determining the optimal exporting and sourcing strategies of a firm from country i with core productivity φ as:

$$\begin{aligned} \max_{\substack{I_{ij}^M \in \{0,1\}_{j=1}^J \\ I_{ik}^X \in \{0,1\}_{k=1}^J}} \pi_i(\varphi, \mathbf{I}^M, \mathbf{I}^X) &= \varphi^{(\sigma-1)} \left(\gamma \sum_{j=1}^J I_{ij}^M T_j (\tau_{ij} w_j)^{-\theta} \right)^{(\sigma-1)/\theta} \sum_{k=1}^J I_{ik}^X (\tau_{ik}^X)^{1-\sigma} B_k \\ &\quad - w_i \sum_{j=1}^J I_{ij}^M f_{ij} - w_i \sum_{k=1}^J I_{ik}^X f_{ij}^X, \end{aligned}$$

Note that \mathbf{I}^M and \mathbf{I}^X denote the vector of extensive margin import and export decisions, respectively. It is straightforward to see that, whenever $(\sigma - 1)/\theta > 1$, this more general profit function continues to feature increasing differences in (I_j^M, I_k^M) for $j, k \in \{1, \dots, J\}$ with $j \neq k$, and also features increasing differences in (I_j^M, φ) for any $j \in \{1, \dots, J\}$. As a result, Proposition 2 continues to apply here and we obtain a 'pecking order' in the extensive margin of offshoring in the complements case.

The key new feature of the above profit function $\pi_i(\varphi, \mathbf{I}^M, \mathbf{I}^X)$ is that it also exhibits increasing differences in (I_j^M, I_j^X) for any $j, k \in \{1, \dots, J\}$ and increasing differences in (I_j^X, φ) for any $j \in \{1, \dots, J\}$. This has at least two implications. First, regardless of whether $\sigma - 1 > \theta$ or $\sigma - 1 < \theta$, any change in parameters that increases the sourcing capability $\Theta_i(\varphi)$ of the firm – such as reduction in any τ_{ij} or an increase in any T_j – will necessarily lead to a (weak) increase in the vector \mathbf{I}^X , and thus (weakly) increase the export margin of exporting. Second, restricting attention to the complements case $(\sigma - 1)/\theta > 1$, the model delivers a complementarity between the exporting and importing margins of firms. For instance, holding constant the vector of residual demand parameters B_i , reductions in the costs of trading final goods across countries will not only increase the participation of firms in export markets, but will also increase the extensive margin of sourcing, in the sense that vector \mathbf{I}^M is non-increasing in τ_{ik}^X . Furthermore, as firm productivity increases, the participation of firms in both export and import markets increases, and at a faster rate than when one of these margins is shut down.

B. Endogenous Input Variety

Our benchmark model assumes that all final good producers use a measure one of inputs. We next briefly outline how our results extend and generalize to the case in which the final-good producer is allowed to choose the complexity of production, as captured by the measure of inputs used in production (see Acemoglu et al. (2007)). As we shall see, this ends up producing an equilibrium essentially identical to the one we have described above but with additional implications for how the measure of inputs purchased by firms changes with firm productivity.

The formal details of this extension are as follows. Final-good production continues to combine inputs according to a CES technology but we now let the measure of inputs be firm-specific and given by $n_i(\varphi)$. More specifically, we generalize the marginal cost function in (4) as follows:

$$c_i \left(\{j(v)\}_{v=0}^1, \varphi \right) = \frac{1}{\varphi} n_i(\varphi)^{1/(\rho-1)-\lambda} \left(\int_0^{n_i(\varphi)} (\tau_{ij(v)} a_{j(v)}(v, \varphi) w_{j(v)})^{1-\rho} dv \right)^{1/(1-\rho)}.$$

A higher value of $n_i(\varphi)$ enhances productivity via an input variety effect. As in Acemoglu et al. (2007), we introduce the term $n_i(\varphi)^{1/(\rho-1)-\lambda}$ in front of the integral in order to control the importance of variety effects for productivity via a parameter λ disentangled from the elasticity substitution between inputs ρ . In order to create a check on the optimal degree of complexity, we assume that firms face a fixed cost equal to $w_i n_i(\varphi) f_i^n$ when combining $n_i(\varphi)$ inputs in production. As in our benchmark model, in each of the countries in which the final-good producer incurred the fixed cost of sourcing, there is a competitive fringe of potential suppliers that can provide differentiated inputs to the firm with a firm-specific intermediate input efficiencies drawn from a Fréchet distribution.

With a continuum of inputs, the equilibrium measure of inputs used in production by a final-good producer has no implications for the distribution of input prices faced by that producer. Exploiting this feature, we can use derivations analogous to those in the benchmark model and in Eaton and Kortum (2002), to write the marginal cost of production as

$$c_i(\varphi) = \frac{1}{\varphi} (n_i(\varphi))^{-\lambda} (\gamma \Theta_i(\varphi))^{-1/\theta}, \quad (32)$$

and the firm's profits conditional on a sourcing strategy $\mathcal{J}_i(\varphi)$ as

$$\pi_i(\varphi) = \varphi^{\sigma-1} (n_i(\varphi))^{(\sigma-1)\lambda} (\gamma \Theta_i(\varphi))^{(\sigma-1)/\theta} B_i - w_i \sum_{j \in \mathcal{J}_i(\varphi)} f_{ij} - w_i n_i(\varphi) f_i^n,$$

where B_i is again given in (3). It is clear that conditional on a sourcing strategy $\mathcal{J}_i(\varphi)$ – and thus a value of $\Theta_i(\varphi)$ – this profit function is supermodular in productivity and the measure of inputs $n_i(\varphi)$.¹ Hence, a novel prediction from this extension is that more productive firms will tend to source more inputs from all sources combined (domestic and foreign) than less productive firms, even when these firms share a common sourcing strategy.² In the complements case with $\sigma - 1 > \theta$, this variant of the model also predicts that more productive firms will tend to buy (weakly) more inputs from *any* source than less productive firms.

As pointed out in the main text, it is important to emphasize that input-specific fixed costs do not serve as a substitute for country-specific fixed costs of sourcing. By this we mean that, in the absence of the latter type of fixed costs, our framework would not be able to account for the key facts motivating our benchmark model, since in such a case, all firms would source inputs from all countries, thus violating the patterns in Figure 1 and Table 1 in the Introduction.

¹For the choice of $n_i(\varphi)$ to satisfy the second-order conditions for a maximum, we need to impose that the efficiency gains from input variety are small enough to guarantee that $(\sigma - 1)\lambda < 1$ holds.

²Although our benchmark model is also consistent with more productive firms importing more inputs than less productive firms, with a common measure of inputs, this could only be rationalized by having more productive firms sourcing less inputs domestically than less productive firms.

Online Data Appendix (Not for Publication)

Sample

Table C.1 provides details of all firms in the Economic Censuses with positive sales and employment. The first row corresponds to firms that consist only of manufacturing establishments (“M” firms). The second row presents information for all firms with one or more manufacturing establishments and at least one establishment outside of manufacturing (“M+” firms). Together, these two types of firms comprise our sample.

Table C.1: Sample of firms

Firm Type	Firms	Imports \$millions	Empl \$millions	Sales \$billions	Fraction Importers
Manufacturing Only (M)	238,800	75,938	5,866	1,230	0.23
Manufacturing Plus (M+)	11,500	829,594	20,573	9,180	0.77
Other (O)	4,001,000	99,937	77,204	12,553	0.03
Wholesale Only (W)	300,000	240,654	3,484	2,300	0.31
Wholesale and Other (WO)	7,500	141,740	6,426	2,252	0.51
Total	4,561,700	1,387,863	113,553	27,515	0.06

Notes: Table provides information on firms in the Economic Census with positive sales and employment. Analysis in paper based on all M and M+ firms. Numbers rounded for disclosure avoidance. Imports exclude products classified under mining.

Premia and decomposition

Following Bernard et al. (2007), we report employment, sales, and productivity premia for firms that import in 2007. To do so, we regress the log each of these variables on an importer dummy and industry controls. Table C.2 reports the results. The top panel presents results using 2007 values of firm size and productivity and the bottom panel uses 2002 values. The first column of the table shows that firms importing in 2007 are larger and more productive than non-importers. In addition, these premia for 2007 import status were present in 2002. The magnitude of these import premia is similar to those typically found for exporters, with importers being on average about three times larger and about 6-7% more productive than non-importers.

We confirm the importance of the extensive margins of trade, both in terms of the number of imported products and the number of importing firms, first documented by Bernard et al. (2009). Following those authors, we decompose total U.S. imports $M_{US,j}$ from country j according to

$$\ln(M_{US,j}) = \ln(N_{US,j}^{firms}) + \ln(N_{US,j}^{prods}) + \ln\left(\frac{O_{US,j}}{N_{US,j}^{firms} \times N_{US,j}^{prods}}\right) + \ln\left(\frac{M_{US,j}}{O_{US,j}}\right),$$

where $O_{US,j}$ is the number of firm-product combinations with positive imports from j . The first two terms represent the unique numbers of firms ($N_{US,j}^{firms}$) importing and products ($N_{US,j}^{prods}$) imported from country j . The third term, referred to as the density, captures the fraction of firm-production combinations with positive import values. The final term captures the intensive margin. It measures the average import value per firm-product observation, for all combinations with positive imports. Table C.3 presents coefficients from OLS regressions of the logarithm of each margin on the logarithm of total trade. As is well known, these OLS coefficients sum to one, with each coefficient representing the share of overall variation explained by each margin. As in previous work, we find that variation in the extensive margins account for the majority

Table C.2: Premia for 2007 Importers

	All Firms	Non-2002 Importers
2007 Log employment	1.552***	1.269***
2007 Log sales	1.737***	1.399***
2007 Log value-added per worker	0.060***	0.039***
2002 Log employment	1.466***	1.154***
2002 Log sales	1.638***	1.270***
2002 Log value-added per worker	0.074***	0.052***

Notes: All results are from OLS regressions of the variable listed on the left on an indicator equal to one if the firm imported in 2007. The first column includes all firms. The second column is based on the subset of firms that did not import in 2002. Results with 2002 variables are based only on the subset of firms that existed in 2002. All regressions include four digit industry controls.

of the variation in aggregate import volume across countries. The extensive margins account for a total of 65 percent, while the intensive margin explains just 35 percent of the total variation.

Table C.3: Extensive and Intensive Margin Decomposition

	Log of number of importing firms	Log of number of imported products	Log of Density	Log of average import value per product per firm
	0.541*** (0.016)	0.535*** (0.015)	-0.426*** (0.014)	0.350*** (0.018)
Adj. R ²	0.85	0.84	0.81	0.64
Observations	221	221	221	221

Notes: Each column corresponds to results from regressing the log of each margin on the log of total import values. The coefficients are a measure of the fraction of variation in aggregate import volumes across countries explained by that margin. Density represents the fraction of all possible firm-product combinations with positive import values. The estimated coefficients sum to one.

Premia figures

In the introduction, we plot the relationship between the log of firm sales and the minimum number of countries from which a firm sources. To construct the figure, we regress the log of firm sales on cumulative dummies for the number of countries from which a firm sources and industry controls. The omitted category is non-importers, so the premia are interpreted as the difference in size between non-importers and firms that import from at least one country, at least two countries, etc. The horizontal axis denotes the number of countries from which a firm sources, with 1 corresponding to firms that use only domestic inputs. The introduction figure controls for firm industry with variables that measure the share of a firm's employment in four-digit NAICS industries. (These are simply industry fixed effects for all firms that span only one

industry.) Here we show that the patterns depicted in the introduction are robust when considering a firm's size prior to importing and when controlling for the products that a firm imports or exports. Figure C.1 plots the relationship between a firm's log sales in 2002 and the number of countries from which it sources in 2007, for firms that did *not* import in 2002. Figure C.2 depicts the relationship when controlling for the number of products a firm imports (left panel) and the number of products the firm exports (right panel). In additional undisclosed results, available upon request, we show similar patterns when using firm employment and the log of value-added labor productivity.

Figure C.1: Importer premia for firm's 2002 sales, limited to firms that do not import in 2002,

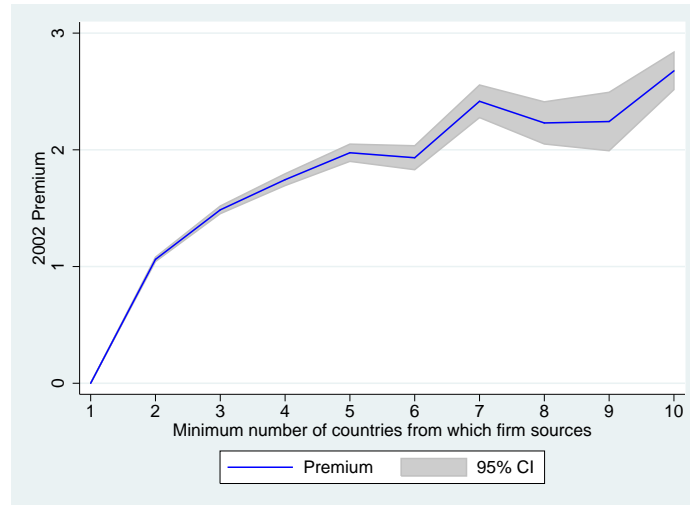
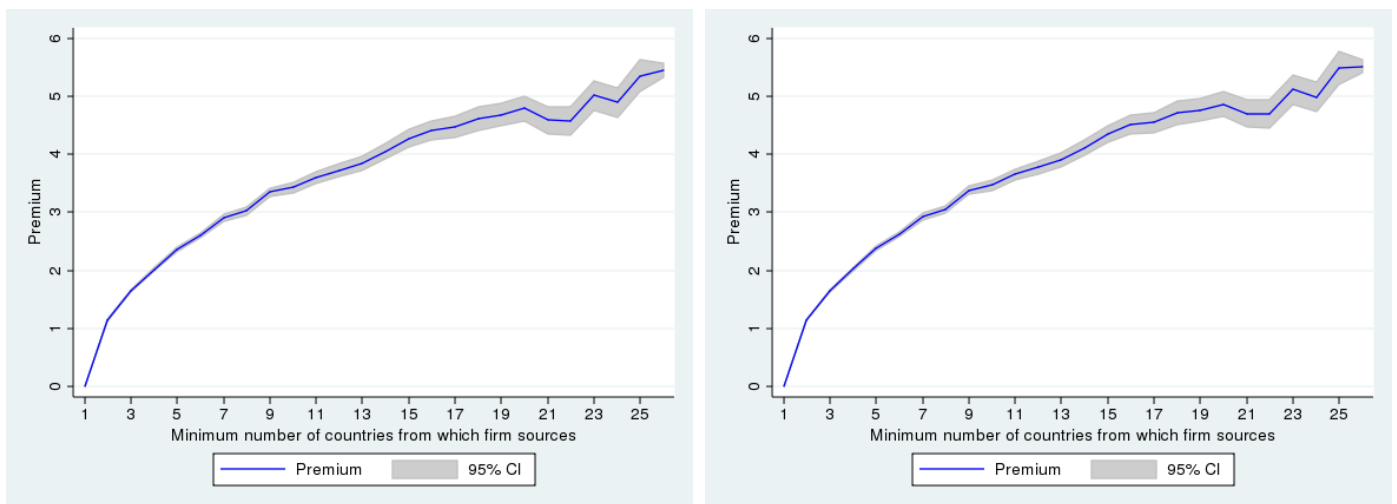


Figure C.2: Importer premia with product controls



(a) Controlling for number of products imported by the firm (b) Controlling for number of products exported by the firm

Countries per product counts

In section 4.2.2, we show that most firms source most products from a single location. Table C.4 shows that this pattern persists for firms that source from at least three foreign countries. We also compare these firm-level statistics to the same numbers for exporting. To make a valid comparison, we must first aggregate to the HS6 level. This ensures the same number of product categories for imports and exports. Table C.5 shows that, even at the HS6 level, most firms source most products from one location. This is in contrast to firms' exporting decisions, where we see that the median firm sells at least one product to three destinations and the 95th percentile sells to 21 countries.

Table C.4: Number of countries from which a firm imports the same HS10 product, for firms that import from at least 3 countries

	Firm Level		
	Mean	Median	Max
Mean	1.28	1.05	3.18
Median	1.19	1.00	2.00
95%tile	1.96	1.00	9.00

Notes: Table reports statistics on the firm-level mean, median, and maximum of the number of countries from which a firm imports the same HS10 product.

Table C.5: Number of countries per HS6 product traded by a firm

	Firm Level Imports			Firm Level Exports		
	Mean	Median	Max	Mean	Median	Max
Mean	1.15	1.00	1.92	1.76	1.00	4.26
Median	1.05	1.00	1.00	1.33	1.00	3.00
95%tile	1.92	1.00	5.00	4.87	2.00	21.00

Notes: Table reports statistics on the firm-level mean, median, and maximum of the number of countries from which a firm imports or exports the same HS6 product.