# From micro to macro: Demand and supply-side determinants of the trade elasticity*

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September 26, 2014

PRELIMINARY
AND INCOMPLETE

**Abstract**

This paper combines two firm-level customs datasets for French and Chinese exporters to estimate the trade elasticity of exports with respect to tariffs at the firm-level. This elasticity reveals the consumer's response to a change in trade cost: a demand side parameter. We then show that, when dropping the assumption of Pareto-distributed heterogeneity, this parameter is important to explain the *aggregate* reaction of bilateral exports to trade cost shocks. Furthermore, in this No-Pareto case, the trade elasticity is not constant, and varies across country pairs. Using our estimated demand-side parameter and a key supply-side parameter measuring the degree of dispersion of firms' productivity, we construct the predicted bilateral elasticities under the assumption of log-normally distributed productivity. The prediction on the aggregate elasticities, and its decomposition into different margins fits well with our aggregate estimates using French and Chinese data, suggesting that both demand and supply-side determinants matter in the reaction of trade patterns to trade costs variations, and that micro-data is a key element in the estimation of the macro-level elasticity.

**Keywords:** trade elasticity, firm-level data, heterogeneity, gravity, Pareto, Log-Normal.

**JEL Classification:** F1

*This research has received funding from the European Research Council under the European Community's Seventh Framework Programme (FP7/2007-2013) Grant Agreement No. 313522. We thank Swati Dhingra for useful comments on a very early version, and participants at seminars in Banque de France and ISGEP in Stockholm.

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# 1 Introduction

The response of trade flows to a change in trade costs, summarized as the aggregate trade elasticity, is a central element in any evaluation of the welfare impacts of trade liberalization. Arkolakis et al. (2012) recently showed that it is actually one of the (only) two sufficient statistics needed to calculate Gains From Trade (GFT), under a surprisingly large set of alternative modeling assumptions—the ones most commonly used by recent research in the field. Measuring those elasticities has therefore been the topic of a long-standing literature, with recent debates about the appropriate source of identification (exchange rate versus tariff changes in particular), aggregation issues (Imbs and Méjean (2014), Ossa (2012) for instance), and how those elasticities might vary according to the theoretical model at hand (Simonovska and Waugh (2012)). The most common usage is to estimate this elasticity in a *macro-level* bilateral trade equation that Head and Mayer (2014) label structural gravity, its specification being fully consistent with many different structural models of trade. While the estimation method is independent of the model, the interpretation of this elasticity is not. With a homogeneous firms model of the Krugman (1980) type in mind, the estimated elasticity turns out to reveal a demand-side parameter only. When instead considering heterogeneous firms à la Melitz (2003), the literature has proposed that the macro-level trade elasticity is driven solely by a supply-side parameter describing the dispersion of the underlying heterogeneity distribution of firms. This result has been shown with several demand systems (CES by Chaney (2008), linear by Melitz and Ottaviano (2008), translog by Arkolakis et al. (2010) for instance), but relies critically on the assumption of a Pareto distribution. The trade elasticity then provides an estimate of the dispersion parameter of the Pareto.[1]

Our paper shows that both existing interpretations of the estimated elasticities are too extreme: When the Pareto assumption is relaxed, the aggregate trade elasticity is a mix of demand and supply parameters. A second important consequence of abandoning Pareto is that the trade elasticity is no longer constant across country pairs. Estimating the aggregate trade elasticity with gravity hence becomes problematic because structural gravity does not apply anymore. We argue in this paper that quantifying trade elasticities at the aggregate level makes it necessary to use micro-level information when moving away from the Pareto assumption. We provide a method using firm-level export values for estimating all the components of the aggregate trade elasticity: i) the CES parameter that governs the intensive margin and ii) the supply side parameters that drive the extensive margin.

Our approach features several steps. The first one isolates the demand side parameter using firm-level exports by French and Chinese firms to destinations that confront those firms with different levels of tariffs. We maintain the traditional CES demand system combined with monopolistic competition, which yields a *firm-level* gravity equation specified as a ratio-type estimation so as to eliminate unobserved characteristics of both the exporting firm and the importer country. This method is called tetrads by Head et al. (2010) since it combines a set of four trade flows into an ratio of ratios called an export tetrad and regresses it on a corresponding tariff tetrad for the same product-country combinations.[2]

[1] In the ricardian Eaton and Kortum (2002) setup, the trade elasticity is also a supply side parameter reflecting heterogeneity, but this heterogeneity takes place at the national level, and reflects the scope for comparative advantage.

[2] Other work in the literature also relies on the ratio of ratios estimation. Romalis (2007) uses a similar method to estimate the effect of tariffs on trade flows at the product-country level. He estimates the effects of applied tariff changes within NAFTA countries (Canada and Mexico) on US imports at the product level. Hallak (2006) estimates a fixed effects gravity model and then uses a ratio of ratios method in a quantification exercise. Caliendo and Parro (2014) also use ratios of ratios and rely on asymmetries in tariffs to identify industry-level elasticities.

Our identification strategy relies on there being enough variation in tariffs applied by different destination markets to French and Chinese exporters. We therefore use the last year before the entry of China into WTO in 2001. We explore different sources of variance in the data with comparable estimates of the intensive margin trade elasticity that range between -5.3 and -2.3.

Our second step then combines those estimates with the central supply side parameter, the dispersion parameter of the productivity distribution, estimated on the same datasets, to obtain predicted aggregate bilateral elasticities of total export, number of exporters and average exports to each destination, before confronting those elasticities to estimated evidence. Without Pareto, those predictions require knowledge of the bilateral export productivity cutoff under which firms find export to be unprofitable. We emphasize a new observable, the ratio of average to minimum sales across markets, used to reveal those bilateral export cutoffs. A side result of our paper is to discriminate between Pareto and Lognormal as potential distributions for the underlying firm-level heterogeneity, suggesting that Lognormal does a better job at matching both the micro-level distribution of exports and the aggregate response of those exports to changes in trade costs.

Our paper clearly fits into the empirical literature estimating trade elasticities. Different approaches and proxies for trade costs have been used, with an almost exclusive focus on aggregate country or industry-level data. The gravity approach to estimating those elasticities, widely used and recommended by Arkolakis et al. (2012), mostly uses tariff data to estimate bilateral responses to variation in applied tariff levels. Most of the time, identification is in the cross-section of country pairs, with origin and destination determinants being controlled through fixed effects (Baier and Bergstrand (2001), Head and Ries (2001), Caliendo and Parro (2014), Hummels (1999), Romalis (2007) are examples). A related approach is to use the fact that most foundations of gravity have the same coefficient on trade costs and domestic cost shifters to estimate that elasticity from the effect on bilateral trade of exporter-specific changes in productivity, export prices or exchange rates (Costinot et al. (2012) is a recent example).[3] Baier and Bergstrand (2001) find a demand side elasticity ranging from -4 to -2 using aggregate bilateral trade flows from 1958 to 1988. Using product-level information on trade flows and tariffs, this elasticity is estimated by Head and Ries (2001), Romalis (2007) and Caliendo and Parro (2014) with benchmark average elasticities of -6.88, -8.5 and -4.45 respectively. Costinot et al. (2012) also use industry-level data for OECD countries, and obtains a preferred elasticity of -6.53 using productivity based on producer prices of the exporter as the identifying variable.

There are two related papers–the most related to ours–that estimate this elasticity at the firm-level. Berman et al. (2012) presents estimates of the trade elasticity with respect to real exchange rate variations across countries and over time using firm-level data from France. Fitzgerald and Haller (2014) use firm-level data from Ireland, real exchange rate and weighted average firm-level applied tariffs as price shifters to estimate the trade elasticity to trade costs. The results for the impact of real exchange rate on firms' export sales are of a similar magnitude, around 0.8 to 1. Applied tariffs vary at the product-destination-year level. Fitzgerald and Haller (2014) create a firm-level destination tariff as the weighted average over all hs6 products exported by a firm to a destination in a year using export sales as weights. Relying on this construction, they find a tariff elasticity of around -2.5 at the micro level. We depart from those papers by using an alternative methodology to identify the trade elasticity with respect to applied tariffs at a more disaggregated level (firm-product-destination).

[3] Other methodologies (also used for aggregate elasticities) use identification via heteroskedasticity in bilateral flows, and have been developed by Feenstra (1994) and applied widely by Broda and Weinstein (2006) and Imbs and Méjean (2014). Yet another alternative is to proxy trade costs using retail price gaps and their impact on trade volumes, as proposed by Eaton and Kortum (2002) and extended by Simonovska and Waugh (2011).

Our paper also contributes to the literature studying the importance of the distribution assumption of heterogeneity for trade patterns, trade elasticities and welfare. Head et al. (2014), Yang (2014), Melitz and Redding (2013) and Feenstra (2013) have recently argued that the simple gains from trade formula proposed by Arkolakis et al. (2012) relies crucially on the Pareto assumption, which kills important channels of gains in the heterogenous firms case. The alternatives to Pareto considered to date in welfare gains quantification exercises are i) the truncated Pareto by Helpman et al. (2008), Melitz and Redding (2013) and Feenstra (2013), and ii) the Lognormal by Head et al. (2014) and Yang (2014). A key simplifying feature of Pareto is to yield a constant trade elasticity, which is not the case for alternative distributions. Helpman et al. (2008) and Novy (2013) have produced gravity-based evidence showing substantial variation in the trade cost elasticity across country pairs. Our contribution to that literature is to use the estimated demand and supply-side parameters to construct predicted bilateral elasticities for aggregate flows under the Lognormal assumption, and compare their first moments to gravity-based estimates.

The next section of the paper describes our model and empirical strategy. The third section presents the different firm-level data and the product-country level tariff data used in the empirical analysis. The fourth section reports the baseline results. The fifth section describes additional results on the elasticity of tariffs with respect to different trade margins. Section 6 computes predicted macro-level trade elasticities and compares them with estimates from the Chinese and French aggregate export data. The final section concludes.

# 2 Empirical strategy for estimating the demand side parameter

## 2.1 A firm-level export equation

Consider a set of potential exporters, all located in the same origin country (omitting this index for now). We use the Melitz (2003) / Chaney (2008) theoretical framework of heterogeneous firms facing constant price elasticity demand (CES utility combined with iceberg costs) and exporting to several destinations. In this setup, firm-level exports to country $n$ depend upon the firm-specific unit input requirement ($\alpha$), wages ($w$), and discounted expenditure in $n$, $X_n P_n^{\sigma-1}$, with $P_n$ the ideal CES price index relevant for sales in $n$. There are trade costs associated with reaching market $n$, consisting of an observable iceberg-type part ($\tau_n$), and a shock that affects firms differently on each market, $b_n(\alpha)$:[4]

$$x_n(\alpha) = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} [\alpha w \tau_n b_n(\alpha)]^{1-\sigma} \frac{X_n}{P_n^{1-\sigma}} \tag{1}$$

Taking logs of equation (1), and noting with $\epsilon_n(\alpha) \equiv b_n^{1-\sigma}$ our unobservable firm-destination error term, and with $A_n \equiv X_n P_n^{\sigma-1}$ the "attractiveness" of country $n$ (expenditure discounted by the degree of competition on this market), a firm-level gravity equation can be derived:

$$\ln x_n(\alpha) = (1-\sigma)\ln\left(\frac{\sigma}{\sigma-1}\right) + (1-\sigma)\ln(\alpha w) + (1-\sigma)\ln\tau_n + \ln A_n + \ln\epsilon_n(\alpha) \tag{2}$$

[4]An example of such unobservable term would be the presence of workers from country $n$ in firm $\alpha$, that would increase the internal knowledge on how to reach consumers in $n$, and therefore reduce trade costs for that specific company in that particular market ($b$ being a mnemonic for barrier to trade). Note that this type of random shock is isomorphic to assuming a firm-destination demand shock in this CES-monopolistic competition model.

Our objective is to estimate the trade elasticity, $1 - \sigma$ identified on cross-country differences in applied tariffs (that are part of $\tau_n$). This involves controlling for a number of other determinants ("nuisance" terms) in equation (2). First, it is problematic to proxy for $A_n$, since it includes the ideal CES price index $P_n$, which is a complex non-linear construction that itself requires knowledge of $\sigma$. A well-known solution used in the gravity literature is to capture ($A_n$) with destination country fixed effects (which also solves any issue arising from omitted unobservable $n$-specific determinants). This is however not applicable here since $A_n$ and $\tau_n$ vary across the same dimension. To separate those two determinants, we use a second set of exporters, based in a country that faces different levels of applied tariffs, such that we recover a bilateral dimension on $\tau$.

A second issue is that we need to control for firm-level marginal costs ($\alpha w$). Again measures of firm-level productivity and wages are hard to obtain for two different source countries on an exhaustive basis. In addition, there might be a myriad of other firm-level determinants of export performance, such as quality of products exported, managerial capabilities... which will remain unobservable. We use a ratio-type estimation, inspired by Hallak (2006), Romalis (2007) and Head et al. (2010), that removes observable and unobservable determinants for both firm-level and destination factors. This method uses four individual export flows to calculate ratios of ratios: an approach referred to as *tetrads* from now on. We now turn to a presentation of this method.

## 2.2 Microfoundations of a ratio-type estimation

To implement tetrads at the micro level, we need firm-level datasets for two origin countries reporting exports by firm-product and destination country. Second, we also require information on bilateral trade costs faced by firms when selling their products abroad that differ across exporting countries. We combine French and Chinese firm-level datasets from the corresponding customs administration which report export value by firm at the hs6 level for all destinations in 2000. The firm-level customs datasets are matched with data on effectively applied tariffs to each exporting country (China and France) at the same level of product disaggregation by each destination. Focusing on 2000 allows us to exploit variation in tariffs applied to each exporter country (France/China) at the product level by the importer countries since it precedes the entry of China into WTO at the end of 2001.

Estimating micro-level tetrads implies dividing product-level exports of a firm located in France to country $n$ by the exports of the same product by that same firm to a reference country, denoted $k$. Then, calculate the same ratio for a Chinese exporter (same product and countries). Finally the ratio of those two ratios uses the multiplicative nature of the CES demand system to get rid of all the "nuisance" terms mentioned above.

Because there is quite a large number of exporters, taking all possible firm pair combinations is not feasible. We therefore concentrate our identification of the largest exporters for each product.[5] We rank firms based on export value for each hs6 product and reference importer country (Australia, Canada, Germany, Italy, Japan, New Zealand, Poland and the UK).[6] For a given product, taking the ratio of exports of a French firm with rank $j$ exporting to country $n$, over the flow to the reference importer country $k$, removes the need to proxy for firm-level characteristics in

[5] Section 4.3.2 presents an alternative strategy that keeps all exporters and explicitly takes into account selection issues.

[6] Those are among the main trading partners of France and China, and also have the key advantage for us of applying different tariff rates to French and Chinese exporters in 2000.

equation (2):

$$\frac{x_n(\alpha_{j,\mathrm{FR}})}{x_k(\alpha_{j,\mathrm{FR}})} = \left(\frac{\tau_{n\mathrm{FR}}}{\tau_{k\mathrm{FR}}}\right)^{1-\sigma} \times \frac{A_n}{A_k} \times \frac{\epsilon_n(\alpha_{j,\mathrm{FR}})}{\epsilon_k(\alpha_{j,\mathrm{FR}})} \tag{3}$$

To eliminate the aggregate attributes of importing countries $n$ and $k$, we require two sources of firm-level data to have information on export sales by destination country of firms located in at least two different exporting countries. This allows to take the ratio of equation (3) over the same ratio for a firm with rank $j$ located in China:

$$\frac{x_n(\alpha_{j,\mathrm{FR}})/x_k(\alpha_{j,\mathrm{FR}})}{x_n(\alpha_{j,\mathrm{CN}})/x_k(\alpha_{j,\mathrm{CN}})} = \left(\frac{\tau_{n\mathrm{FR}}/\tau_{k\mathrm{FR}}}{\tau_{n\mathrm{CN}}/\tau_{k\mathrm{CN}}}\right)^{1-\sigma} \times \frac{\epsilon_n(\alpha_{j,\mathrm{FR}})/\epsilon_k(\alpha_{j,\mathrm{FR}})}{\epsilon_n(\alpha_{j,\mathrm{CN}})/\epsilon_k(\alpha_{j,\mathrm{CN}})}. \tag{4}$$

Denoting tetradic terms with a $\sim$ symbol, one can re-write equation (4) as

$$\widetilde{x}_{\{j,n,k\}} = \widetilde{\tau}^{1-\sigma}_{\{n,k\}} \times \widetilde{\epsilon}_{\{j,n,k\}}, \tag{5}$$

which will be our main foundation for estimation.

## 2.3 Estimating equation

With equation (5), we can use tariffs to identify the firm-level trade elasticity, $1-\sigma$. Restoring the product subscript ($p$), and using $i$ = FR or CN as the origin country index, we specify bilateral trade costs as a function of applied tariffs, with ad valorem rate $t^p_{ni}$ and of a collection of other barriers, denoted with $D_{ni}$. Those include the classical gravity covariates such as distance, common language, colonial link and common border. Taking the example of a continuous variable such as distance for $D_{ni}$:

$$\tau^p_{ni} = (1 + t^p_{ni})D^{\delta}_{ni}, \tag{6}$$

which, once introduced in the logged version of (5) leads to our estimable equation

$$\ln \widetilde{x}^p_{\{j,n,k\}} = (1-\sigma)\ln\left(\widetilde{1 + t^p_{\{n,k\}}}\right) + (1-\sigma)\delta \ln \widetilde{D_{\{n,k\}}} + \ln \widetilde{\epsilon}^p_{\{j,n,k\}} \tag{7}$$

The dependent variable is constructed by the ratio of ratios of exports for $j = 1$ to 25, that is firms ranking from the top to the 25th exporter for a given product. Our procedure is the following: Firms are ranked according to their export value for each product and reference importer country $k$. We then take the tetrad of exports of the top French firm over the top Chinese firm exporting the same product to the same destination. The set of destinations for each product is therefore limited to the countries where both the top French and Chinese firm export that product. In order to have enough variation in the dependent variable, we complete the missing export values of each product-destination combination with the export tetrads of the top 2 to the top 25 firms.

It is apparent in equation (7) that the identification of the effect of tariffs is possible over several dimensions: essentially across i) destination countries and ii) products, both interacted with variance across reference countries. In our estimations, we investigate the various dimensions, by sequentially including product-reference or destination reference fixed effects to the baseline specification.

There might be unobservable destination country characteristics, such as political factors or uncertainty on trading conditions, that can generate a correlated error-term structure, potentially biasing downwards the standard error of our variable of interest. Hence, standard errors are clustered at the destination level in the baseline specifications.[7]

Finally, one might be worried by the presence of unobserved bilateral trade costs that might be correlated with our measure of applied tariffs. Even though it is not clear that the correlation with those omitted trade costs should be systematically positive, we use, as a robustness check, an a more inclusive measure of applied trade costs, the Ad Valorem Equivalent (AVE) tariffs from WITS and MAcMAp databases, described in the next section.

# 3 Data

- **Trade:** Our dataset is a panel of Chinese and French exporting firms in the year 2000. The French trade data comes from the French Customs, which provide annual export data at the product level for French firms.[8] The customs data are available at the 8-digit product level Combined Nomenclature (CN) and specify the country of destination of exports. The free on board (f.o.b) value of exports is reported in euros and we converted those to US dollars using the real exchange rate from Penn World Tables for 2000. The Chinese transaction data comes from the Chinese Customs Trade Statistics (CCTS) database which is compiled by the General Administration of Customs of China. This database includes monthly firm-level exports at the 8-digit HS product-level (also reported f.o.b) in US dollars. The data is collapsed to yearly frequency. The database also records the country of destination of exports. In both cases, export values are aggregated at the firm-hs6 digit product level and destination in order to match transaction firm-level data with applied tariffs information that are available at the hs6 product and destination country level.[9]

- **Tariffs:** Tariffs come from the WITS (World Bank) database for the year 2000.[10] We rely on the ad valorem rate effectively applied at the HS6 level by each importer country to France and China. In our cross-section analysis performed for the year 2000 before the entrance of China into the World Trade Organization (WTO), we exploit different sources of variation within hs6 products across importing countries on the tariff applied to France and China. The first variation naturally comes from the European Union (EU) importing countries that apply zero tariffs to trade with EU partners (like France) and a common external tariff to extra-EU countries (like China). The second source of variation in the year 2000 is that several non-EU countries applied the Most Favored Nation tariff (MFN) to France, while the effective tariff applied to Chinese products was different (since China was not yet a WTO member). We describe those countries and tariff levels below.

[7] Since the level of clustering (destination country) is not nested within the level of fixed effects and the number of clusters is quite small with respect to the size of each cluster, we also implement the solution proposed by Wooldridge (2006). He recommends to run country-specific random effects on pair of firms demeaned data, with a robust covariance matrix estimation. This methodology is also used by Harrigan and Deng (2010) who encounter a similar problem. The results, available upon request, are robust under this specification.

[8] This database is quite exhaustive. Although reporting of firms by trade values below 250,000 euros (within the EU) or 1,000 euros (rest of the world) is not mandatory, there are in practice many observations below these thresholds.

[9] The hs6 classification changes over time. During our period of analysis it has only changed once in 2002. To take into account this change in the classification of products, we have converted the HS-2002 into HS-1996 classification using WITS conversion tables.

[10] Information on tariffs is available at `http://wits.worldbank.org/wits/`

- **Gravity controls:** In all estimations, we include additional trade barriers variables that determine bilateral trade costs, such as distance, common language, colony and common border. Bilateral distances, common (official) language, colony and common border (contiguity) come from the CEPII distance database.[11]. We use the population-weighted great circle distance between the set of largest cities in the two countries.

## 3.1 Reference importer countries

The use of a reference country is crucial for a consistent identification of the trade elasticity. We choose reference importer countries with two criteria in mind. First, these countries should be those that are the main trade partners of France and China in the year 2000, since we want to minimize the number of zero trade flows in the denominator of the tetrad. The second criteria relies on the variation in the tariffs effectively applied by the importing country to France and China. Within the main trading partners, we keep Australia, Canada, Germany, Italy, Japan, New Zealand, Poland and the UK, those countries for which the average difference between the effectively applied ad valorem tariffs to France and China is greater.

In the interest of parsimony, we restrict our descriptive analysis of reference countries to the two main relevant trade partners of France and China in our sample. In the case of France, the main trade partner is Germany. The main trade partner of China is the US and the second one is Japan. Given that the US has applied the MFN tariff to China in several products before the entry of China in WTO, there is almost no variation in the difference in effectively applied ad valorem tariffs by the US to France and China in 2000. Hence, we use in the following descriptive statistics Germany and Japan as reference importer countries.

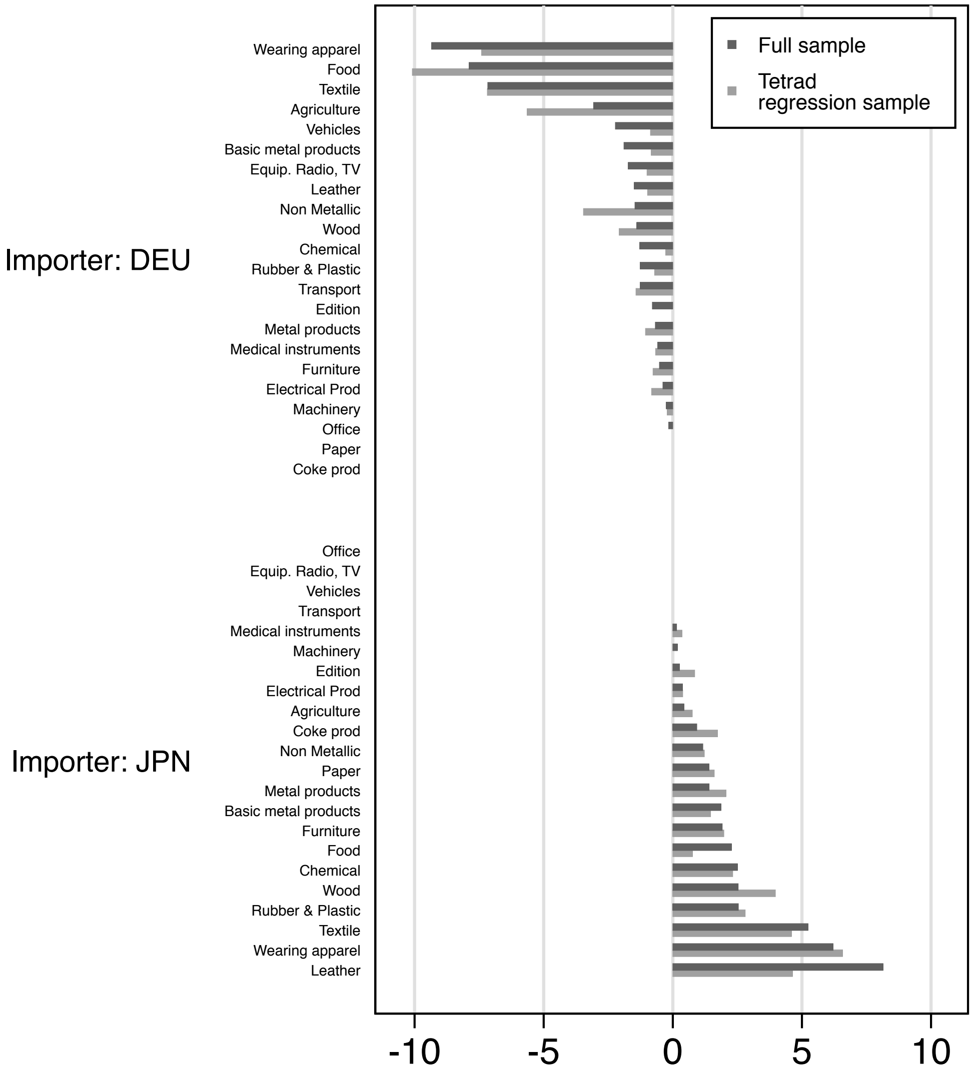
The difference in the effectively applied tariffs to France and China at the industry level by reference importer country (Germany and Japan) is presented in Table 1 and figure 1. As can be noticed, there is a significant variation across 2-digit industries in the average percentage point difference in applied tariffs to both exporting countries in the year 2000. This variation is even more pronounced at the hs6 product level. Our empirical strategy will exploit this variation within hs6 products and across destination countries.

[11]This dataset is available at `http://www.cepii.fr/anglaisgraph/bdd/distances.htm`

Table 1: Average percentage point difference between the applied tariff to France and China by reference importer country and industry (2000)

| Reference importer: | Germany | | Japan | |
|---|---|---|---|---|
| | Full sample | Tetrad regression sample | Full sample | Tetrad regression sample |
| Agriculture | -3.07 | -5.64 | .43 | .76 |
| Food | -7.89 | -10.09 | 2.27 | .76 |
| Textile | -7.17 | -7.18 | 5.24 | 4.6 |
| Wearing apparel | -9.34 | -7.41 | 6.21 | 6.57 |
| Leather | -1.5 | -.98 | 8.14 | 4.64 |
| Wood | -1.39 | -2.08 | 2.53 | 3.98 |
| Paper | 0 | 0 | 1.41 | 1.61 |
| Edition | -.79 | 0 | .26 | .85 |
| Coke prod | 0 | 0 | .93 | 1.73 |
| Chemical | -1.28 | -.28 | 2.51 | 2.32 |
| Rubber & Plastic | -1.27 | -.71 | 2.54 | 2.81 |
| Non Metallic | -1.47 | -3.46 | 1.17 | 1.22 |
| Basic metal products | -1.89 | -.84 | 1.86 | 1.47 |
| Metal products | -.68 | -1.06 | 1.41 | 2.06 |
| Machinery | -.25 | -.22 | .18 | 0 |
| Office | -.16 | 0 | 0 | 0 |
| Electrical Prod | -.38 | -.82 | .38 | .39 |
| Equip. Radio, TV | -1.73 | -1 | 0 | 0 |
| Medical instruments | -.58 | -.67 | .15 | .36 |
| Vehicles | -2.22 | -.87 | 0 | 0 |
| Transport | -1.27 | -1.43 | 0 | 0 |
| Furniture | -.52 | -.77 | 1.92 | 1.98 |

Figure 1: Average percentage point difference between the applied tariff to France and China by reference importer country and industry (2000)




Source: Authors' calculation based on Tariff data from WITS (World Bank).

## 3.2 Estimating sample

As explained in the previous section, we estimate the elasticity of exports with respect to tariffs at the firm-level relying on a ratio-type estimation. The dependent variable is the log of a double ratio of ratios of firm-level exports of firms with rank $j$ of product $p$ to destination $n$. The two ratios use the French/Chinese origin of the firm, and the reference country dimensions.

Firms are ranked according to their export value for each hs6 line and reference importer country. We first take the ratio of ratios of exports of the top 1 French and Chinese firms and then we complete the missing export values for hs6 product-destination pairs with the ratio of ratios of exports of the top 2 to the top 25 firms. The final estimating sample is composed of 61,310 (26,547 for the top 1 exporting firm) hs6-product, destination and reference importer country pairs observations in the year 2000.

The number of hs6 products and destination countries used in the estimations is lower than the ones available in the original French and Chinese customs datasets since to construct the ratio of ratios of exports we need that the top 1 (to top 25) French exporting firm exports the same hs6 product that the top 1 (to top 25) Chinese exporting firm to at least the reference country as well as the destination country. The total number of hs6 products in the estimating sample corresponds to 2439. The same restriction applies to destination countries. The number of destination countries is 68.

Table 2 present descriptive statistics on the main variables at the destination country level for the 68 countries present in the estimating sample. Columns (1) and (2) of Table 2 reports population and GDP for each destination country in 2000. Columns (3) to (5) display, for each destination country the ratio of total exports, average exports and total number of exporting firms between France and China to each market in 2000. The final column displays the ratio of distances separating our two exporters from each of the importing economies, and is used as the ranking variable. Only 12 countries in our estimating sample are closer to China than to France. In all of those, the number of Chinese exporters is larger than the number of French exporters, and the total value of Chinese exports largely exceeds the French one. On the other end of the spectrum, countries like Belgium and Switzerland witness much larger counts of exporters and total flows from France than from China.

# 4 Results

## 4.1 Graphical illustration

Before estimating the firm-level trade elasticity using the ratio type estimation, we turn to describing graphically the relationship between export flows and applied tariffs tetrads for different destination countries across products.

Using again the two main reference importer countries ($k$ is Germany or Japan), we calculate for each hs6 product $p$ the tetradic terms for exports of French and Chinese firms ranked $j = 1$ to 25th as $\ln \widetilde{x}^p_{\{j,n,k\}} = \ln x^p_n(\alpha_{j,\mathrm{FR}}) - \ln x^p_k(\alpha_{j,\mathrm{FR}}) - \ln x^p_n(\alpha_{j,\mathrm{CN}}) + \ln x^p_k(\alpha_{j,\mathrm{CN}})$ and the tetradic term for applied tariffs at the same level as $\ln \widetilde{(1 + t^p_{\{n,k\}})} = \ln(1 + t^p_{n\mathrm{FR}}) - \ln(1 + t^p_{k\mathrm{FR}}) - \ln(1 + t^p_{n\mathrm{CN}}) + \ln(1 + t^p_{k\mathrm{CN}})$, where $n$ is the destination country (Australia, Brazil, USA, Canada, Poland and Thailand) and $k$ the reference importer country (Germany or Japan). We use these tetrad terms to present raw (and unconditional) evidence of the effect of tariffs on exported values by individual firms. The graphs presented in Figure 4.1 also show the regression line and estimated coefficients of this simple regression of the logged export tetrad on the log of tariff tetrad for each of those six destination countries. Each point corresponds to a given hs6 product, and we highlight the cases where the export tetrad is calculated out of the largest ($j = 1$) French and Chinese exporters with a circle. The observations corresponding to Germany as a reference importer country are marked by a triangle, when the symbol is a square for Japan.

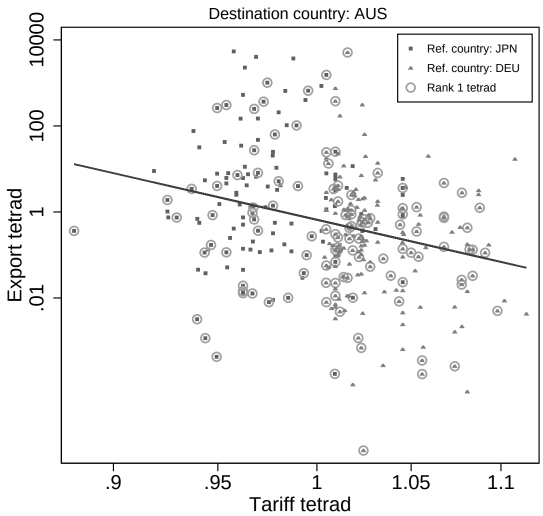
These estimations exploit the variation across products on tariffs applied by the destination country $n$ and reference importer country $k$ to China and France. In all cases, the estimated coefficient on tariff is negative and highly significant as shown by the slope of the line reported in each of each graphs. Those coefficients are quite large in absolute value, denoting a very steep response of consumers to differences in applied tariffs. Figure 4.1 takes a look at a different dimension of identification, by looking at the impact of tariffs for specific products. We graph, following the logic of Figure 4.1 the tetrad of export value against the tetrad of tariffs for six

Table 2: Destination countries characteristics in 2000

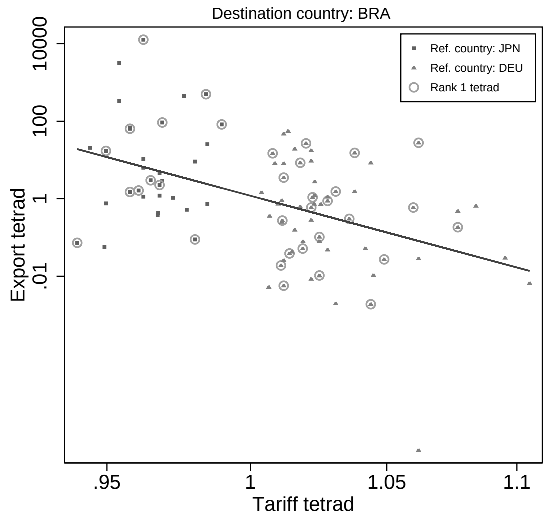
| | Population | GDP | Ratio France / China: Total exports | Average exports | Number exporters | Distance |
|---|---|---|---|---|---|---|
| CHE | 7 | 246 | 29.24 | 1.68 | 17.42 | .06 |
| BEL | 10 | 232 | 9.64 | 1.21 | 7.95 | .06 |
| NLD | 16 | 387 | 2.04 | 1.01 | 2.02 | .08 |
| GBR | 60 | 1443 | 4.89 | 2.37 | 2.06 | .09 |
| ESP | 40 | 581 | 14.38 | 3.82 | 3.76 | .1 |
| DEU | 82 | 1900 | 5.04 | 2.13 | 2.37 | .1 |
| ITA | 57 | 1097 | 7.33 | 2.7 | 2.71 | .11 |
| AUT | 8 | 194 | 10.73 | 1.84 | 5.84 | .12 |
| IRL | 4 | 96 | 8.52 | 1.37 | 6.2 | .12 |
| PRT | 10 | 113 | 18.05 | 1.99 | 9.09 | .13 |
| CZE | 10 | 57 | 5.47 | 2.46 | 2.22 | .13 |
| MAR | 28 | 33 | 11.34 | 1.54 | 7.35 | .16 |
| DNK | 5 | 160 | 3.15 | 1.07 | 2.94 | .16 |
| MLT | 0 | 4 | 17.03 | 9.17 | 1.86 | .18 |
| POL | 38 | 171 | 4.04 | 1.51 | 2.67 | .18 |
| NOR | 4 | 167 | 3.19 | 2.15 | 1.49 | .22 |
| SWE | 9 | 242 | 5.91 | 2.66 | 2.22 | .22 |
| BGR | 8 | 13 | 5.13 | 2.21 | 2.32 | .24 |
| GRC | 11 | 115 | 4.42 | 1.75 | 2.52 | .24 |
| MDA | 4 | 1 | 169.62 | 6.08 | 27.89 | .28 |
| BLR | 10 | 13 | 1.23 | .16 | 7.49 | .28 |
| EST | 1 | 6 | 1.33 | .43 | 3.13 | .3 |
| FIN | 5 | 121 | 1.9 | .86 | 2.2 | .32 |
| GHA | 20 | 5 | 1.23 | 1.79 | .69 | .38 |
| NGA | 125 | 46 | 1.39 | 2.4 | .58 | .38 |
| CYP | 1 | 9 | 2.73 | 2.33 | 1.17 | .39 |
| LBN | 4 | 17 | 3.3 | 2 | 1.65 | .43 |
| JOR | 5 | 8 | 1.15 | 2.37 | .49 | .45 |
| GAB | 1 | 5 | 117.02 | 2 | 58.6 | .46 |
| BRB | 0 | 3 | 2.38 | 1.95 | 1.22 | .47 |
| BRA | 174 | 644 | 1.83 | 1.86 | .99 | .5 |
| DOM | 9 | 20 | 2.8 | 2.44 | 1.15 | .52 |
| VEN | 24 | 117 | 1.4 | 2.58 | .54 | .52 |
| PRY | 5 | 7 | .33 | 1.15 | .29 | .54 |
| BOL | 8 | 8 | 3.47 | 2.44 | 1.42 | .55 |
| JAM | 3 | 8 | 1.93 | 6.06 | .32 | .56 |
| ARG | 37 | 284 | 1.72 | 2.95 | .58 | .57 |
| URY | 3 | 21 | .64 | 2.09 | .31 | .57 |
| COL | 42 | 84 | 1.7 | 2.29 | .74 | .57 |
| CUB | 11 | . | 1.35 | 1.6 | .84 | .58 |
| PAN | 3 | 12 | .18 | 1.1 | .16 | .6 |
| PER | 26 | 53 | .85 | 1.92 | .44 | .6 |
| CHL | 15 | 75 | 1.15 | 4.18 | .28 | .61 |
| UGA | 24 | 6 | 3.27 | 3.09 | 1.06 | .62 |
| CRI | 4 | 16 | 1.94 | 5.12 | .38 | .62 |
| CAN | 31 | 714 | .73 | 1.51 | .49 | .62 |
| SAU | 21 | 188 | 1.22 | 2.55 | .48 | .62 |
| HND | 6 | 6 | 1.38 | 2.86 | .48 | .64 |
| SLV | 6 | 13 | 8.78 | 18.54 | .47 | .65 |
| USA | 282 | 9765 | .54 | 1.12 | .48 | .67 |
| GTM | 11 | 19 | .54 | 1.46 | .37 | .67 |
| KEN | 31 | 13 | 1.37 | 2.31 | .59 | .68 |
| YEM | 18 | 9 | 1.12 | 3.23 | .35 | .7 |
| TZA | 34 | 9 | .36 | 1.24 | .29 | .71 |
| IRN | 64 | 101 | 1.29 | 1.37 | .93 | .72 |
| MEX | 98 | 581 | .93 | 1.3 | .72 | .75 |
| LKA | 19 | 16 | 1.35 | 8.12 | .17 | 1.72 |
| NZL | 4 | 53 | .55 | 1.95 | .28 | 1.84 |
| AUS | 19 | 400 | .38 | 1.73 | .22 | 1.98 |
| NPL | 24 | 5 | .13 | .34 | .38 | 2.24 |
| IDN | 206 | 165 | .11 | .89 | .12 | 2.47 |
| BGD | 129 | 47 | .15 | 1.94 | .08 | 2.7 |
| THA | 61 | 123 | .34 | 1.07 | .32 | 3.17 |
| BRN | 0 | 4 | .96 | 4.02 | .24 | 3.22 |
| LAO | 5 | 2 | .25 | .69 | .36 | 3.83 |
| PHL | 76 | 76 | .31 | 1.91 | .16 | 4.21 |
| JPN | 127 | 4650 | .12 | .6 | .19 | 4.96 |
| TWN | 22 | 321 | .38 | 1.3 | .29 | 6.69 |

Notes: Population is expressed in millions and GDP in billions of US dollars.

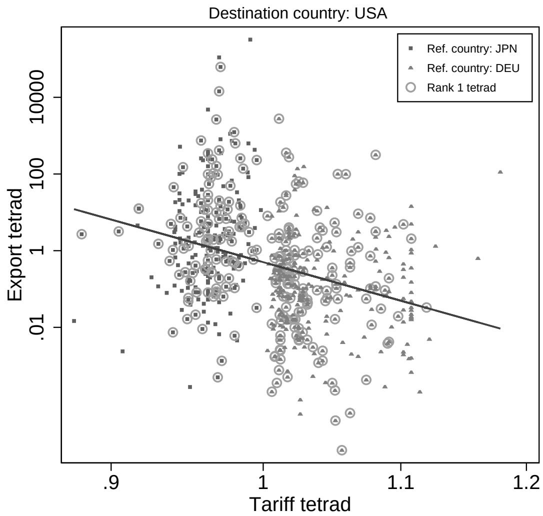
Figure 2: Unconditional tetrad evidence: by importer



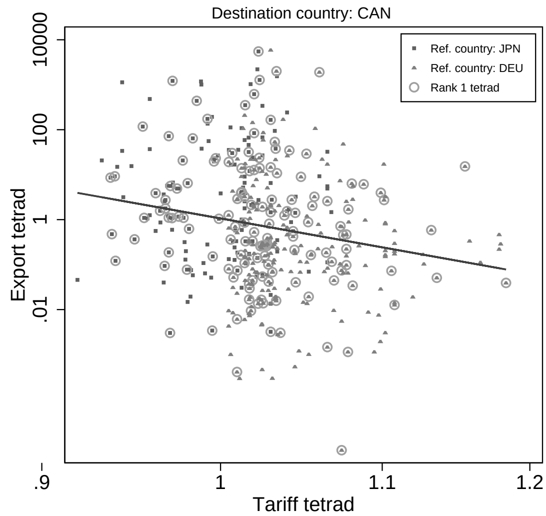

Note: The coefficient on tariff tetrad is -23.69 with a standard error of 4.76



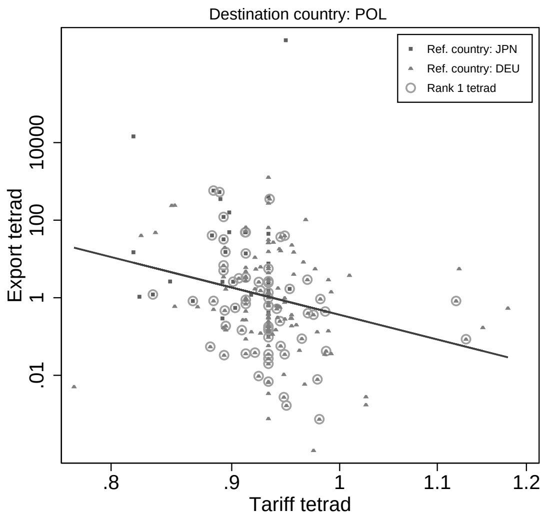

Note: The coefficient on tariff tetrad is -44.74 with a standard error of 9.05



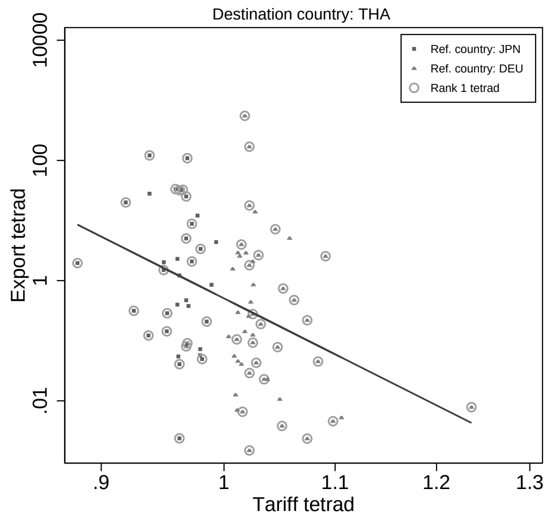

Note: The coefficient on tariff tetrad is -24.29 with a standard error of 2.93




Note: The coefficient on tariff tetrad is -15.52 with a standard error of 3.93




Note: The coefficient on tariff tetrad is -15.37 with a standard error of 4.38




Note: The coefficient on tariff tetrad is -22.47 with a standard error of 6.08

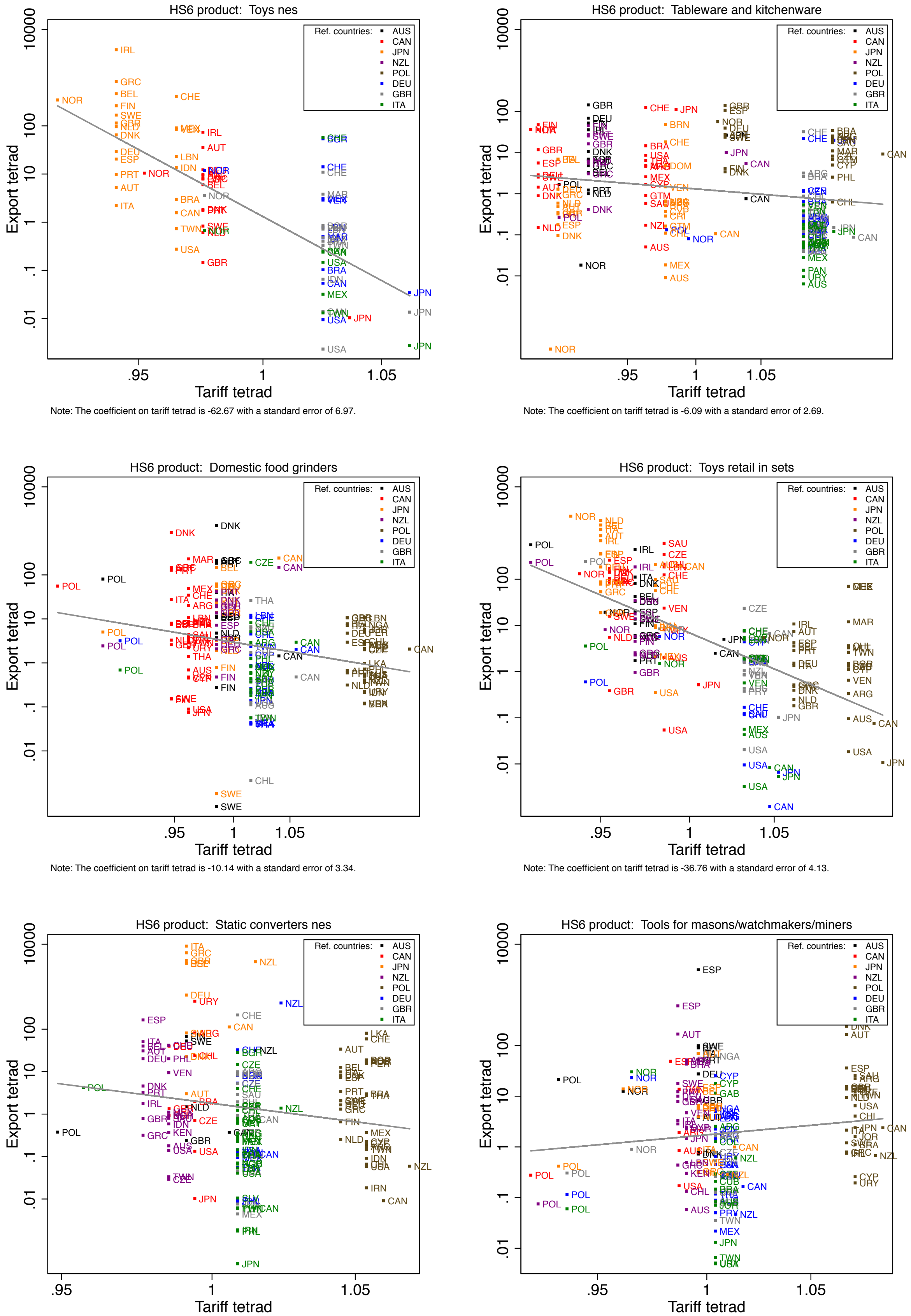
individual HS6 products, which are the ones for which we maximize the number of observations in the dataset. Again (apart from the tools sector, where the relationship is not significant), all those sectors exhibit strong reaction to tariff differences across importing countries. A synthesis of this evidence for individual sectors can be found by averaging tetrads over a larger set of products. We do that in Figure 4.1 for the 96 products that have at least 30 destinations in common in our sample for French and Chinese exporters. The coefficient is again very large in absolute value and highly significant. The next section presents regression results with the full sample, both dimensions of identification, and the appropriate set of gravity control variables which will confirm this descriptive evidence and, as expected reduce the steepness of the estimated response.

## 4.2 Baseline results

This section presents the estimates of the trade elasticity with respect to applied tariffs from equation (7) for all reference importer countries (Australia, Canada, Germany, Italy, Japan, New Zealand, Poland and the UK) pooled in the same specification. Standard errors are clustered by destination-reference importing country. Columns (1) to (3) of Table 3 show the results using as dependent variable the ratio of the top 1 exporting French and Chinese firm. Columns (2) presents estimations on the sample of positive tetraded tariffs and column (3) controls for the tetradic terms of Regional Trade Agreements (RTA). Columns (4) to (6) of Table 3 present the estimations using as dependent variable the ratio of firm-level exports of the top 1 to the top 25 French and Chinese firm at the hs6 product level. These estimations yield coefficients for the applied tariffs $(1-\sigma)$ that range between -4.8 and -1.74. Note that In both cases, the coefficients on applied tariffs are reduced when including the RTA, but that the tariff variable retains statistical significance, showing that the effect of tariffs is not restricted to the binary impact of going from positive to zero tariffs.

Estimations in Table 3 exploit the variation in tariffs applied to France and China across both products and destination countries. We now focus on the variation of tariffs within hs6-products across destination countries. To that effect, Table 4 includes hs6 product - reference importer country fixed effects and standard errors are clustered by destination-reference country pair. The coefficients for the applied tariffs $(1-\sigma)$ range from -4.8 to -1.7 for the pair of the top 1 exporting French and Chinese firms (columns (1) to (3)). Columns (4) to (6) present the results using as dependent variable the pair of the top 1 to the top 25 firms. In this case, the applied tariffs vary from -3.8 to -2.3. While RTA has a positive and significant effect, it again does not capture the whole effect of tariff variations across destination countries on export flows. Note also that distance and contiguity have the usual and expected signs and very high significance, while the presence of a colonial link and of a common language has a much more volatile influence.

Figure 3: Unconditional tetrad evidence: by product




Note: The coefficient on tariff tetrad is -62.67 with a standard error of 6.97.

Note: The coefficient on tariff tetrad is -6.09 with a standard error of 2.69.

Note: The coefficient on tariff tetrad is -10.14 with a standard error of 3.34.

Note: The coefficient on tariff tetrad is -36.76 with a standard error of 4.13.

Note: The coefficient on tariff tetrad is -20.46 with a standard error of 11.47.

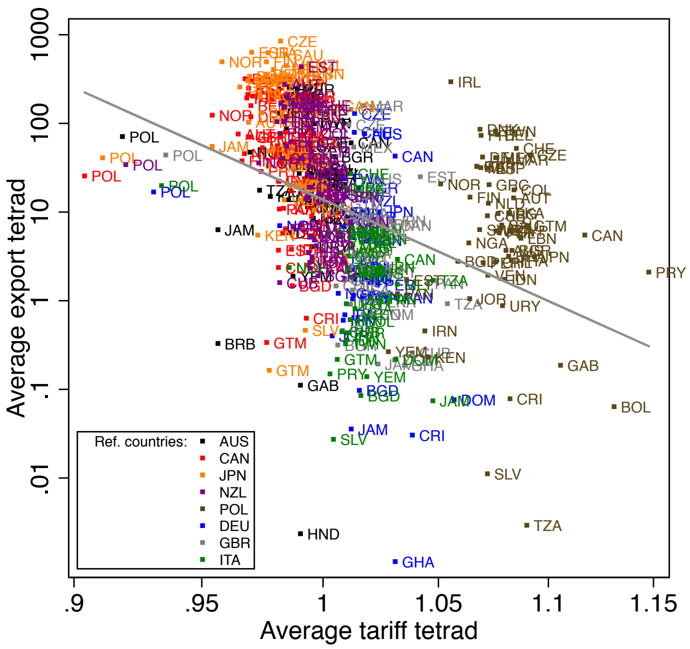
Note: The coefficient on tariff tetrad is 8.85 with a standard error of 6.21.

Table 3: Intensive margin elasticities.

| Dependent variable: | Top 1 firm-level exports | | | Top 1 to 25 firm-level exports | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Applied Tariff | -3.09$^a$ | -3.96$^a$ | -1.74$^b$ | -3.24$^a$ | -4.80$^a$ | -2.25$^a$ |
| | (0.76) | (0.81) | (0.79) | (0.61) | (0.66) | (0.60) |
| Distance | -0.46$^a$ | -0.41$^a$ | -0.23$^a$ | -0.51$^a$ | -0.43$^a$ | -0.33$^a$ |
| | (0.03) | (0.03) | (0.04) | (0.02) | (0.02) | (0.04) |
| Contiguity | 0.58$^a$ | 0.74$^a$ | 0.54$^a$ | 0.57$^a$ | 0.69$^a$ | 0.54$^a$ |
| | (0.08) | (0.08) | (0.07) | (0.07) | (0.08) | (0.07) |
| Colony | 0.16 | 0.14 | -0.23 | 0.17 | 0.00 | -0.11 |
| | (0.24) | (0.25) | (0.25) | (0.17) | (0.19) | (0.17) |
| Common language | -0.10$^c$ | -0.05 | 0.11$^c$ | -0.08 | -0.03 | 0.09 |
| | (0.06) | (0.08) | (0.06) | (0.05) | (0.07) | (0.06) |
| RTA | | | 0.79$^a$ | | | 0.60$^a$ |
| | | | (0.14) | | | (0.12) |
| Observations | 26547 | 10971 | 26547 | 61310 | 23015 | 61310 |
| $R^2$ | 0.123 | 0.162 | 0.126 | 0.139 | 0.183 | 0.141 |
| rmse | 3.00 | 3.00 | 3.00 | 2.98 | 2.98 | 2.98 |

Notes: Standard errors are clustered by destination-reference importing country. All estimations include a constant that is not reported. Applied tariff is the tetradic term of the logarithm of applied tariff plus one. Columns (2) and (5) present estimations on the sample of positive tetraded tariffs. $^a$, $^b$ and $^c$ denote statistical significance levels of one, five and ten percent respectively.

Figure 4: Unconditional tetrad evidence: averaged over top products




Note: Tetrads are averaged over the 96 products with at least 30 destinations in common.
The coefficient is -27.62 with a standard error of 3.09.

Table 4: Intensive margin elasticities. Within-product estimations.

| Dependent variable: | Top 1 firm-level exports | | | Top 1 to 25 firm-level exports | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Applied Tariff | -4.20[a] | -4.76[a] | -1.70 | -3.76[a] | -3.75[a] | -2.34[a] |
| | (1.06) | (1.54) | (1.08) | (0.71) | (0.93) | (0.64) |
| Distance | -0.48[a] | -0.44[a] | -0.16[a] | -0.45[a] | -0.45[a] | -0.24[a] |
| | (0.03) | (0.03) | (0.04) | (0.03) | (0.03) | (0.04) |
| Contiguity | 0.78[a] | 0.80[a] | 0.70[a] | 0.77[a] | 0.79[a] | 0.73[a] |
| | (0.07) | (0.09) | (0.06) | (0.07) | (0.09) | (0.07) |
| Colony | 0.22 | -0.25 | -0.31 | 0.12 | -0.16 | -0.21 |
| | (0.25) | (0.31) | (0.26) | (0.12) | (0.13) | (0.14) |
| Common language | -0.12[c] | 0.05 | 0.14[b] | 0.04 | 0.07 | 0.22[a] |
| | (0.06) | (0.08) | (0.07) | (0.05) | (0.07) | (0.07) |
| RTA | | | 1.06[a] | | | 0.68[a] |
| | | | (0.10) | | | (0.12) |
| Observations | 26547 | 10971 | 26547 | 61310 | 23015 | 61310 |
| $R^2$ | 0.116 | 0.108 | 0.124 | 0.098 | 0.101 | 0.101 |
| rmse | 2.04 | 1.94 | 2.03 | 2.30 | 2.09 | 2.29 |
| r2pos | | | | | | |

Notes: All estimations include hs6-reference importing country fixed effects Standard errors are clustered by destination-reference importing country. All estimations include a constant that is not reported. Applied tariff is the tetradic term of the logarithm of applied tariff plus one. Columns (2) and (5) present estimations on the sample of positive tetraded tariffs. [a], [b] and [c] denote statistical significance levels of one, five and ten percent respectively.

As a more demanding specification, still identifying trade elasticity across destinations, we now restrict the sample to countries applying non-MFN tariffs to France and China. The sample of such countries contains Australia, Canada, Japan, New Zealand and Poland.[12] Table 5 presents the results. Common language, contiguity and colony are excluded from the estimation since there is no enough variance in the non-MFN sample. Our non-MFN sample also does not allow for including a RTA dummy. In estimations reported in columns (1) and (2), standard errors are clustered by destination-reference country. Estimations in columns (3) and (4) include a fixed effect identifying the product-reference country and standard errors are clustered by destination-reference importer country as in the baseline specifications discussed in the previous section. Columns (2) and (4) present estimations on the sample non-MFN and positive tetraded tariffs.

Table 5: Intensive margin: non-MFN sample.

| Dependent variable: | Top 1 to 25 firm-level exports | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Applied Tariff | -1.50 | -2.72$^a$ | -3.68$^a$ | -5.06$^a$ |
| | (0.95) | (1.01) | (1.18) | (1.26) |
| Distance | -0.54$^a$ | -0.48$^a$ | -0.38$^a$ | -0.34$^a$ |
| | (0.02) | (0.03) | (0.05) | (0.06) |
| Observations | 7511 | 5389 | 7511 | 5389 |
| $R^2$ | 0.103 | 0.094 | 0.046 | 0.053 |
| rmse | 3.01 | 3.02 | 1.60 | 1.49 |

Notes: Estimations in columns (1) and (2) standard errors are clustered by destination and reference importing country. Estimations in columns (3) and (4) include a fixed effect identifying the hs6 product-reference importing country and standard errors are clustered by destination-reference importer country. All estimations include a constant that is not reported. Applied tariff is the tetradic term of the logarithm of applied tariff plus one. Columns (2) and (4) present estimations on the sample of positive tetraded tariffs. $^a$, $^b$ and $^c$ denote statistical significance levels of one, five and ten percent respectively.

## 4.3 Alternative specifications

### 4.3.1 Identification across products

Preceding section's estimations on the intensive margin trade elasticity exploit variation of applied tariffs within hs6 products across destination countries and exporters (firms located in France and China). This section presents a set of estimations on alternative specifications that exploits the variation of applied tariffs within destination countries across hs6-products.

Table 6 reports the results from estimations including a destination-reference importer country fixed effect. In this case, standard errors are clustered by hs6-reference importer country. Including

[12] We exclude EU countries from the sample of non-MFN destinations since those share many other dimensions with France that might be correlated with the absence of tariffs (absence of Non-Tariff Barriers, free mobility of factors, etc.). Poland only enters the EU in 2004.

these fixed effects implies that the source of identification comes from variations within destination countries across hs6-products in applied tariffs to both origin countries, France and China, by the reference importer countries. Columns (1) and (3) present estimations on the full sample, while columns (2) and (4) report estimations on the sample of positive tetraded tariffs. The trade elasticity ranges from -2.81 to -5.28 with an average value around -3.8. Estimations in columns (5) and (6) restrict the destination countries to be the ones applying non-MFN duties. The sample size drops radically, with the trade elasticities remaining of the expected sign and order of magnitude, but losing in statistical significance.

Table 6: Intensive margin elasticities. Within-country estimations.

| | Top 1 | | Top 1 to 25 | | | |
|---|---|---|---|---|---|---|
| Dependent variable: | firm-level exports | | firm-level exports | | | |
| Sample: | Full | | Full | | non-MFN | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Applied Tariff | -2.81[a] | -4.23[a] | -2.97[a] | -5.28[a] | -1.33 | -4.33[a] |
| | (0.80) | (0.97) | (0.51) | (0.63) | (1.26) | (1.46) |
| Observations | 26548 | 10972 | 61308 | 23015 | 7511 | 5389 |
| $R^2$ | 0.001 | 0.002 | 0.001 | 0.004 | 0.000 | 0.003 |
| rmse | 2.95 | 2.93 | 2.94 | 2.93 | 2.99 | 2.99 |

Notes: All estimations include destination-reference importing country fixed effects Standard errors are clustered by hs6-reference importing country. All estimations include a constant that is not reported. Applied tariff is the tetradic term of the logarithm of applied tariff plus one. Columns (5) and (6) present the estimations for the non-MFN sample. Columns (2), (4) and (6) present estimations on the sample of positive tetraded tariffs. [a], [b] and [c] denote statistical significance levels of one, five and ten percent respectively.

### 4.3.2 Selection bias

Not all firms export to all markets $n$, and the endogenous selection into different export destinations across firms is one of the core elements of the type of model we are using. To understand the potential selection bias associated with estimating the trade elasticity it is useful to recall the firm-level export equation (2), now accounting for the fact that we have exporters from both China and France, and therefore using the export country index $i$:

$$\ln x_{ni}(\alpha) = (1-\sigma)\ln\left(\frac{\sigma}{\sigma-1}\right) + (1-\sigma)\ln(\alpha w_i) + (1-\sigma)\ln\tau_{ni} + \ln A_n + \ln\epsilon_{ni}(\alpha). \quad (8)$$

In this model, selection is due to the presence of a fixed export cost $f_{ni}$ that makes some firms unprofitable in some markets. Assuming that fixed costs are paid using labor of the origin country, profits in this setup are given by $x_{ni}(\alpha)/\sigma - w_i f_{ni}$, which means that a firm is all the more likely to be present in market $n$ that its $(1-\sigma)\ln(\alpha w_i) + (1-\sigma)\ln\tau_{ni} + \ln A_n + \ln\epsilon_{ni}(\alpha)$ is high. Therefore a firm with a low cost $(\alpha w_i)$ can afford having a low draw on $\epsilon_{ni}(\alpha)$, creating a systematic bias on the cost variable. The same logic applies in attractive markets, (high $A_n$), which will be associated with lower average draws on the error term. Fortunately , our tetrad estimation technique removes the need to estimate $\alpha w_i$ and $A_n$, and therefore solves this issue.

However a similar problem arises with the trade cost variable, $\tau_{ni}$, which is used to estimate the trade elasticity. Higher tariff countries will be associated with firms having drawn higher

$\epsilon_{ni}(\alpha)$, thus biasing downwards our estimate of the trade elasticity. Our approach of tetrads that focuses on highly ranked exporters for each hs6-market combination should however not be too sensitive to that issue, since those are firms that presumably have such a large productivity that their idiosyncratic destination shock is of second order. In order to verify that intuition, we follow Eaton and Kortum (2001), applied to firm-level data by Crozet et al. (2012), who assume a normally distributed $\ln \epsilon_{ni}(\alpha)$, yielding a generalized structural tobit. This procedure uses the theoretical equation for minimum sales, $x_{ni}^{\texttt{MIN}}(\alpha) = \sigma w_i f_{ni}$, which provides a natural estimate for the truncation point for each desination market. This method (EK tobit) keeps all individual exports to all possible destination markets (including zeroes).[13] When estimating equation (8), we proxy for $\ln A_n$ with $\text{GDP}_n$ and $\text{population}_n$, and for firm-level determinants $\alpha$ with the count of markets served by the firm. An origin country dummy for Chinese exporters account for all differences across the two groups, such as wages, $w_i$. Last, we ensure comparability by i) keeping the same sample of product-market combinations as in previous estimations using tetrads, ii) running the estimation with the same dimension of fixed effects (hs6). Each column of Tables 7 and 8 show the simple OLS (biased) estimates or the EK-tobit method run in the sample of product-market combinations by reference importing country. As in previous usages of that method, the OLS seems very severely biased, probably due to the extremely high selection levels observed (with all reference countries, slightly less than 14% of possible flows are observed). Strikingly, the EK tobit estimates are very comparable to the tetrad estimates shown until now , giving us further confidence in an order of magnitude of the firm-level trade elasticity around located between -3 and -5.[14]

# 5 From micro- to macro- elasticities

We now turn to aggregate consequences of our estimates of firm-level response to trade cost shocks. The objective of this section is to provide a theory-consistent methodology for inferring, from firm-level data, the *aggregate* elasticity of trade with respect to trade costs. Given this objective, our methodology requires to account for the full distribution of firm-level productivity, i.e. we now need to add supply-side determinants of the trade elasticity to the demand-side aspects developed in previous sections. Following Head et al. (2014), we consider two alternative distributions—Pareto, as is standard in the literature, and log-normal—and we provide two sets of estimates, one for each considered distribution. The Pareto assumption has this unique feature that the aggregate elasticity is constant, and depends only on the dispersion parameter of the Pareto, that is on supply only, a result first emphasized in Chaney (2008). Without Pareto, things are notably more complex, as the trade elasticity varies across country pairs. In addition, calculating this elasticity requires knowledge of the bilateral cost cutoff under which the considered country is unprofitable.

To calculate this bilateral cutoff, we combine our estimate of the demand side parameter $\hat{\sigma}$ with a dyadic micro-level observable, the *mean-to-min* ratio, that corresponds to the ratio of average over minimum sales of firms for a given country pair. In the model, this ratio measures the endogenous dispersion of cross-firm performance on a market, and more precisely the relative

[13]For each product, we fill in with zero flows destinations that a firm found unprofitable to serve in reality. The set of potential destinations for that product is given all countries where at least one firm exported that good.

[14]Pooling over all the reference countries gives tariff elasticities of 1.893 for OLS and -4.925 for the EK tobit, both very significant. This pattern and those values are very much in line with detailed results from Tables 7 and 8.

Table 7: Correcting for the selection bias.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref. country: | Australia | | Brazil | | Canada | | Germany | | UK | |
| | OLS | EK Tobit | OLS | EK Tobit | OLS | EK Tobit | OLS | EK Tobit | OLS | EK Tobit |
| Applied Tariff | $1.35^a$ | $-6.19^a$ | $1.13^a$ | $-5.80^a$ | $2.67^a$ | $-4.51^a$ | $2.87^a$ | $-2.42^a$ | $2.44^a$ | $-4.11^a$ |
| | (0.25) | (1.33) | (0.27) | (1.40) | (0.24) | (1.34) | (0.21) | (0.88) | (0.22) | (1.09) |
| RTA | $-0.55^a$ | $1.86^a$ | $-0.56^a$ | $2.95^a$ | $-0.56^a$ | $2.57^a$ | $-0.82^a$ | $2.48^a$ | $-0.81^a$ | $2.97^a$ |
| | (0.07) | (0.46) | (0.09) | (0.46) | (0.08) | (0.40) | (0.07) | (0.34) | (0.06) | (0.36) |
| Distance | 0.01 | -0.16 | $0.06^c$ | 0.16 | 0.01 | 0.25 | -0.03 | -0.14 | -0.00 | 0.02 |
| | (0.02) | (0.17) | (0.03) | (0.17) | (0.03) | (0.15) | (0.03) | (0.13) | (0.02) | (0.14) |
| Common language | $0.15^a$ | $3.98^a$ | $0.20^a$ | $4.42^a$ | $0.30^a$ | $5.45^a$ | $0.08^b$ | $4.42^a$ | $0.18^a$ | $5.07^a$ |
| | (0.05) | (0.27) | (0.08) | (0.35) | (0.05) | (0.26) | (0.04) | (0.18) | (0.03) | (0.18) |
| Contiguity | $0.07^b$ | $1.52^a$ | $0.10^b$ | $1.33^a$ | $0.08^b$ | $0.89^a$ | $0.19^a$ | $1.62^a$ | $0.21^a$ | $0.92^a$ |
| | (0.03) | (0.15) | (0.04) | (0.20) | (0.03) | (0.15) | (0.03) | (0.10) | (0.03) | (0.12) |
| Colony | $0.39^b$ | $3.22^a$ | $0.79^a$ | $1.87^a$ | $0.35^a$ | $1.58^b$ | $0.63^a$ | $2.24^a$ | $0.84^a$ | $2.86^a$ |
| | (0.17) | (0.67) | (0.14) | (0.72) | (0.12) | (0.63) | (0.11) | (0.55) | (0.12) | (0.59) |
| $\text{GDP}_n$ | $0.14^a$ | $1.63^a$ | $0.15^a$ | $1.44^a$ | $0.19^a$ | $1.76^a$ | $0.19^a$ | $1.60^a$ | $0.18^a$ | $1.63^a$ |
| | (0.02) | (0.08) | (0.02) | (0.08) | (0.02) | (0.08) | (0.02) | (0.07) | (0.01) | (0.06) |
| $\text{Population}_n$ | $0.05^b$ | $0.84^a$ | $0.06^a$ | $0.99^a$ | 0.01 | $0.73^a$ | -0.01 | $0.83^a$ | -0.00 | $0.85^a$ |
| | (0.02) | (0.09) | (0.02) | (0.11) | (0.02) | (0.10) | (0.02) | (0.07) | (0.02) | (0.07) |
| Chinese exporter dummy | $0.40^a$ | $1.14^a$ | $0.19^a$ | $1.04^a$ | $0.47^a$ | $0.76^a$ | $0.46^a$ | $1.45^a$ | $0.51^a$ | $1.49^a$ |
| | (0.04) | (0.21) | (0.05) | (0.24) | (0.04) | (0.20) | (0.03) | (0.15) | (0.04) | (0.17) |
| # of dest. by firm | $0.20^a$ | $2.17^a$ | $0.23^a$ | $2.24^a$ | $0.17^a$ | $2.06^a$ | $0.15^a$ | $2.14^a$ | $0.16^a$ | $2.14^a$ |
| | (0.01) | (0.05) | (0.01) | (0.05) | (0.01) | (0.04) | (0.01) | (0.03) | (0.01) | (0.03) |
| Observations | 445979 | 3066253 | 256043 | 1672328 | 460467 | 2822200 | 731259 | 5045119 | 686051 | 4672816 |
| $R^2$ | 0.045 | | 0.046 | | 0.053 | | 0.078 | | 0.064 | |
| Pseudo $R^2$ | | 0.081 | | 0.089 | | 0.085 | | 0.074 | | 0.074 |

Notes: All estimations include fixed effects for each hs6 product level. Standard errors are clustered at the hs6-destination-origin country level. All estimations include a constant that is not reported. Applied tariff is the logarithm of applied tariff plus one at the hs6 product level and destination country. a, b and c denote statistical significance levels of one, five and ten percent respectively.

Table 8: Correcting for the selection bias.(cont.)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref. country: | Italy | | Japan | | Mexico | | Poland | | Thailand | |
| | OLS | EK Tobit | OLS | EK Tobit | OLS | EK Tobit | OLS | EK Tobit | OLS | EK Tobit |
| Applied Tariff | $2.59^a$ | $-3.29^a$ | $0.83^a$ | $-3.16^b$ | $0.60^b$ | $-4.78^a$ | $1.65^a$ | $-2.46^b$ | $1.05^a$ | $-3.40^b$ |
| | (0.21) | (0.87) | (0.28) | (1.59) | (0.29) | (1.67) | (0.28) | (1.19) | (0.31) | (1.61) |
| RTA | $-0.94^a$ | $2.01^a$ | $-0.17^c$ | $3.54^a$ | $-0.46^a$ | $2.02^a$ | $-0.39^a$ | $2.38^a$ | $-0.55^a$ | $2.38^a$ |
| | (0.07) | (0.37) | (0.10) | (0.53) | (0.10) | (0.49) | (0.11) | (0.47) | (0.11) | (0.59) |
| Distance | $-0.07^b$ | -0.20 | $0.18^a$ | $0.58^a$ | $0.08^b$ | -0.06 | 0.07 | -0.06 | 0.00 | 0.01 |
| | (0.03) | (0.15) | (0.04) | (0.19) | (0.03) | (0.18) | (0.04) | (0.16) | (0.04) | (0.19) |
| Common language | 0.05 | $4.36^a$ | $0.36^a$ | $4.18^a$ | $0.21^a$ | $4.11^a$ | $0.16^b$ | $4.32^a$ | $0.24^a$ | $4.23^a$ |
| | (0.04) | (0.18) | (0.06) | (0.31) | (0.07) | (0.33) | (0.06) | (0.30) | (0.08) | (0.41) |
| Contiguity | $0.14^a$ | $1.64^a$ | 0.02 | $1.32^a$ | 0.07 | $1.42^a$ | 0.05 | $1.59^a$ | -0.01 | $1.51^a$ |
| | (0.03) | (0.10) | (0.05) | (0.17) | (0.05) | (0.20) | (0.04) | (0.16) | (0.05) | (0.25) |
| Colony | $0.73^a$ | $2.79^a$ | $0.57^a$ | $3.46^a$ | $0.71^a$ | $2.91^a$ | $0.67^a$ | $2.42^a$ | $0.54^a$ | $3.89^a$ |
| | (0.13) | (0.53) | (0.14) | (0.97) | (0.14) | (0.66) | (0.15) | (0.69) | (0.15) | (0.89) |
| $GDP_n$ | $0.19^a$ | $1.55^a$ | $0.14^a$ | $2.02^a$ | $0.13^a$ | $1.85^a$ | $0.18^a$ | $1.49^a$ | $0.16^a$ | $1.73^a$ |
| | (0.01) | (0.06) | (0.02) | (0.11) | (0.02) | (0.09) | (0.02) | (0.09) | (0.02) | (0.11) |
| $Population_n$ | -0.02 | $0.82^a$ | $0.07^a$ | $0.48^a$ | $0.07^a$ | $0.47^a$ | 0.02 | $0.77^a$ | $0.06^b$ | $0.64^a$ |
| | (0.02) | (0.07) | (0.02) | (0.12) | (0.03) | (0.12) | (0.02) | (0.10) | (0.03) | (0.11) |
| Chinese exporter dummy | $0.44^a$ | $1.25^a$ | $0.39^a$ | $0.98^a$ | $0.32^a$ | $0.80^a$ | $0.53^a$ | $1.83^a$ | $0.31^a$ | $1.34^a$ |
| | (0.04) | (0.16) | (0.04) | (0.29) | (0.05) | (0.23) | (0.06) | (0.26) | (0.05) | (0.26) |
| # of dest. by firm | $0.17^a$ | $2.15^a$ | $0.21^a$ | $2.06^a$ | $0.23^a$ | $2.31^a$ | $0.23^a$ | $2.23^a$ | $0.28^a$ | $2.26^a$ |
| | (0.01) | (0.03) | (0.01) | (0.05) | (0.01) | (0.06) | (0.01) | (0.05) | (0.01) | (0.06) |
| Observations | 719485 | 4839867 | 320329 | 1742412 | 280489 | 1922465 | 270022 | 1699798 | 186694 | 1224907 |
| $R^2$ | 0.076 | | 0.043 | | 0.049 | | 0.055 | | 0.045 | |
| Pseudo $R^2$ | | 0.073 | | 0.090 | | 0.091 | | 0.081 | | 0.089 |

Notes: All estimations include fixed effects for each hs6 product level. Standard errors are clustered at the hs6-destination-origin country level. All estimations include a constant that is not reported. Applied tariff is the logarithm of applied tariff plus one at the hs6 product level and destination country. a, b and c denote statistical significance levels of one, five and ten percent respectively.

performance of entrants in this market following a change in our variable of interest: variable trade costs.

Under Pareto, the mean-to-min ratio, for a given origin, should be constant and independent of the size of the destination market. This pattern of scale-invariance is not observed in the data where we see that mean-to-min ratios increase massively in big markets—a feature consistent with a log-normal distribution of firm-level productivity. In the last step of the section we compare our micro-based predicted elasticities to those estimated with a gravity-like approach based on macro-data.

## 5.1 Inferring aggregate trade elasticity from firm-level data

In order to obtain the theoretical predictions on aggregate trade elasticities, we start by summing, for each country pair, the sales equation (1) across all active firms:

$$X_{ni} = V_{ni} \times \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} (w_i \tau_{ni})^{1-\sigma} A_n M_i^e, \tag{9}$$

where $M_i^e$ is the mass of entrant firms and $V_{ni}$ denotes a cost-performance index of exporters located in country $i$ and selling in $n$. This index is characterized by

$$V_{ni} \equiv \int_0^{a_{ni}^*} a^{1-\sigma} g(a) da, \tag{10}$$

where $a \equiv \alpha \times b(\alpha)$ corresponds to the unitary labor requirement *rescaled* by the firm-destination shock. In equation (10), $g(.)$ denotes the pdf of the rescaled unitary labor requirement and $a_{ni}^*$ is the rescaled labor requirement of the cutoff firm. The solution for the cutoff is the cost satisfying the zero profit condition, i.e., $x_{ni}(a_{ni}^*) = \sigma w_i f_{ni}$. Using (1), this cutoff is characterized by

$$a_{ni}^* = \frac{1}{\tau_{ni} f_{ni}^{1/(\sigma-1)}} \left(\frac{1}{w_i}\right)^{\sigma/(\sigma-1)} \left(\frac{A_n}{\sigma}\right)^{1/(\sigma-1)}. \tag{11}$$

We are interested in the (partial) elasticity of aggregate trade value with-respect to variable trade costs, $\tau_{ni}$. Partial means here holding constant origin-specific and destination-specific terms (income and price indices). In practical terms, the use of importer and exporter fixed effects in gravity regressions (the main source of estimates of the aggregate elasticity) hold $w_i$, $M_i$ and $A_n$ constant, so that, using (9), we have[15]

$$\frac{d \ln X_{ni}}{d \ln \tau_{ni}} = 1 - \sigma - \gamma_{ni}, \tag{12}$$

where $\gamma_{ni}$ is a very useful term, studied by Arkolakis et al. (2012), describing how $V_{ni}$ varies with an increase in the cutoff cost $a_{ni}^*$, that is an easier access of market $n$ for firms in $i$:

$$\gamma_{ni} \equiv \frac{d \ln V_{ni}}{d \ln a_{ni}^*} = \frac{a_{ni}^{*2-\sigma} g(a_{ni}^*)}{V_{ni}}. \tag{13}$$

[15] While this is literally true under Pareto because $w_i$, $M_i$ and $A_n$ enter $a_{ni}^*$ multiplicatively, deviating from Pareto adds a potentially complex interaction term through a non-linear in logs effect of monadic terms on the dyadic cutoff. We expect this effect to be of second order, and neglect it for now.

Equation (12) means that the aggregate trade elasticity may not be constant across country pairs because of the $\gamma_{ni}$ term. In order to evaluate those bilateral trade elasticities, combining (13) with (10) reveals that we need to know the value of bilateral cutoffs $a^*$. In order to obtain those, we define the following function

$$\mathcal{H}(a^*) \equiv \frac{1}{a^{*1-\sigma}} \int_0^{a^*} a^{1-\sigma} \frac{g(a)}{G(a^*)} da, \tag{14}$$

a monotonic, invertible function which has a straightforward economic interpretation in this model. It is the ratio of average over minimum performance (measured as $a^{*1-\sigma}$) of firms located in $i$ and exporting to $n$. Using equations (1) and (9), this ratio also corresponds to the observed mean-to-min ratio of sales:

$$\frac{\bar{x}_{ni}}{x_{ni}(a^*_{ni})} = \mathcal{H}(a^*_{ni}). \tag{15}$$

For our two origin countries (France and China), we observe the ratio of average to minimum trade flows for each destination country $n$. Using equation (15), one can calibrate $\hat{a}^*_{n,\texttt{FRA}}$ and $\hat{a}^*_{n,\texttt{CHN}}$ the estimated value of the export cutoff for French and Chinese firms exporting to $n$ as a function of the mean-to-min ratio of French and Chinese sales on each destination market $n$

$$\hat{a}^*_{n,\texttt{FRA}} = \mathcal{H}^{-1}\left(\frac{\bar{x}_{n,\texttt{FRA}}}{x^{\texttt{MIN}}_{n,\texttt{FRA}}}\right), \qquad \text{and} \qquad \hat{a}^*_{n,\texttt{CHN}} = \mathcal{H}^{-1}\left(\frac{\bar{x}_{n,\texttt{CHN}}}{x^{\texttt{MIN}}_{n,\texttt{CHN}}}\right). \tag{16}$$

Equipped with the dyadic cutoffs we combine (12), (13) and (10) to obtain the aggregate trade elasticities

$$\frac{d \ln X_{n\texttt{FRA}}}{d \ln \tau_{n\texttt{FRA}}} = 1 - \hat{\sigma} - \frac{x^{\texttt{MIN}}_{n,\texttt{FRA}}}{\bar{x}_{n,\texttt{FRA}}} \times \frac{\hat{a}^*_{n,\texttt{FRA}} g(\hat{a}^*_{n,\texttt{FRA}})}{G(\hat{a}^*_{n,\texttt{FRA}})}, \tag{17}$$

$$\frac{d \ln X_{n\texttt{CHN}}}{d \ln \tau_{n\texttt{CHN}}} = 1 - \hat{\sigma} - \frac{x^{\texttt{MIN}}_{n,\texttt{CHN}}}{\bar{x}_{n,\texttt{CHN}}} \times \frac{\hat{a}^*_{n,\texttt{CHN}} g(\hat{a}^*_{n,\texttt{CHN}})}{G(\hat{a}^*_{n,\texttt{CHN}})}, \tag{18}$$

where $\hat{\sigma}$ is our estimate of the intensive margin (the demand-side parameter) from previous sections. Our inference procedure is characterized by equations (16), (17) and (18). We can also calculate two other trade margins: the elasticity of the number of active exporters $N_{ni}$ (the so-called extensive margin) and the elasticity of average shipments $\bar{x}_{ni}$. The number of active firms is closely related to the cutoff as: $N_{ni} = M^e_i \times G(a^*_{ni})$ where $M^e_i$ represents the mass of entrants (also absorbed by importer fixed effects in gravity regressions). Differentiating the previous relationship and using (17) and (18) we can estimate the dyadic extensive margin of trade

$$\frac{d \ln N_{n\texttt{FRA}}}{d \ln \tau_{n\texttt{FRA}}} = -\frac{\hat{a}^*_{n,\texttt{FRA}} g(\hat{a}^*_{n,\texttt{FRA}})}{G(\hat{a}^*_{n,\texttt{FRA}})}, \qquad \text{and} \qquad \frac{d \ln N_{n,\texttt{CHN}}}{d \ln \tau_{n,\texttt{CHN}}} = -\frac{\hat{a}^*_{n,\texttt{CHN}} g(\hat{a}^*_{n,\texttt{CHN}})}{G(\hat{a}^*_{n,\texttt{CHN}})}, \tag{19}$$

From the accounting identity $X_{ni} \equiv N_{ni} \times \bar{x}_{ni}$, we obtain the (partial equilibrium) elasticity of average shipments to trade simply as the difference between the estimated aggregate elasticities, (17) and (18), and the estimated extensive margins, (19).

$$\frac{d \ln \bar{x}_{n\texttt{FRA}}}{d \ln \tau_{n\texttt{FRA}}} = \frac{d \ln X_{n\texttt{FRA}}}{d \ln \tau_{n\texttt{FRA}}} - \frac{d \ln N_{n\texttt{FRA}}}{d \ln \tau_{n\texttt{FRA}}} \qquad \text{and} \qquad \frac{d \ln \bar{x}_{n,\texttt{CHN}}}{d \ln \tau_{n,\texttt{CHN}}} = \frac{d \ln X_{n,\texttt{CHN}}}{d \ln \tau_{n,\texttt{CHN}}} - \frac{d \ln N_{n,\texttt{CHN}}}{d \ln \tau_{n,\texttt{CHN}}}, \tag{20}$$

For the sake of interpreting the role of the mean-to-min, we combine (17) and (20) to obtain a relationship linking the aggregate elasticities to the (intensive and extensive) margins and to the mean-to-min ratio

$$\frac{d\ln X_{n\texttt{FRA}}}{d\ln \tau_{n\texttt{FRA}}} = \underbrace{1-\hat{\sigma}}_{\text{intensive margin}} + \underbrace{\frac{1}{\bar{x}_{n,\texttt{FRA}}/x^{\texttt{MIN}}_{n,\texttt{FRA}}}}_{\text{min-to-mean}} \times \underbrace{\frac{d\ln N_{n\texttt{FRA}}}{d\ln \tau_{n\texttt{FRA}}}}_{\text{extensive margin}}, \tag{21}$$

This decomposition shows that the aggregate trade elasticity is the sum of the intensive margin and the (weighted) extensive margin. The weight on the extensive margin depends only on the mean-to-min ratio, our observable measuring the dispersion of relative firm performance. Intuitively, the weight of the extensive margin should be decreasing when the market gets easier. Indeed easy markets have larger rates of entry, $G(a^*)$, and therefore increasing presence of weaker firms which augments dispersion measured as $\mathcal{H}(a^*_{ni})$. The marginal entrant in an easy market will therefore have less of an influence on aggregate exports, a smaller impact of the extensive margin. In the limit, the weight of the extensive margin becomes negligible and the whole of the aggregate elasticity is due to the intensive margin / demand parameter. In the Pareto case however this mechanism is not operational since $\mathcal{H}(a^*_{ni})$ and therefore the weight of the extensive margin is constant. We now turn to implementing our method with Pareto as opposed to an alternative distribution yielding non-constant dispersion of sales across destinations.

## 5.2 Mean-to-min ratios and micro-based estimates of trade elasticities

A crucial step for our inference procedure consists in specifying the distribution of rescaled labor requirement, $G(a)$, which is necessary to inverse the $\mathcal{H}$ function, reveal the bilateral cutoffs and therefore obtain the bilateral trade elasticities. The literature has almost exclusively used the Pareto. Head et al. (2014) show that a credible alternative, which seems favored by firm-level export data, is the log-normal distribution. Pareto-distributed rescaled productivity $\varphi \equiv 1/a$ translates into a power law CDF for $a$, with shape parameter $\theta$. A log-normal distribution of $a$ retains the log-normality of productivity (with location parameter $\mu$ and dispersion parameter $\nu$) but with a change in the log-mean parameter from $\mu$ to $-\mu$. The CDFs for $a$ are therefore given by

$$G^{\mathrm{P}}(a) = \left(\frac{a}{\bar{a}}\right)^{\theta}, \qquad \text{and} \qquad G^{\mathrm{LN}}(a) = \Phi\left(\frac{\ln a + \mu}{\nu}\right), \tag{22}$$

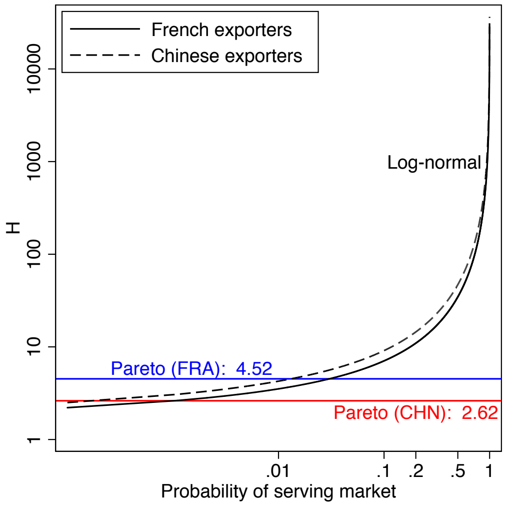
where we use $\Phi$ to denote the CDF of the standard normal. Simple calculations using (22) in (14), and detailed in the appendix, show that the resulting formulas for $\mathcal{H}$ are

$$\mathcal{H}^{\mathrm{P}}(a^*_{ni}) = \frac{\theta}{\theta-\sigma+1}, \qquad \text{and} \qquad \mathcal{H}^{\mathrm{LN}}(a^*_{ni}) = \frac{h[(\ln a^*_{ni}+\mu)/\nu]}{h[(\ln a^*_{ni}+\mu)/\nu+(\sigma-1)\nu]}, \tag{23}$$

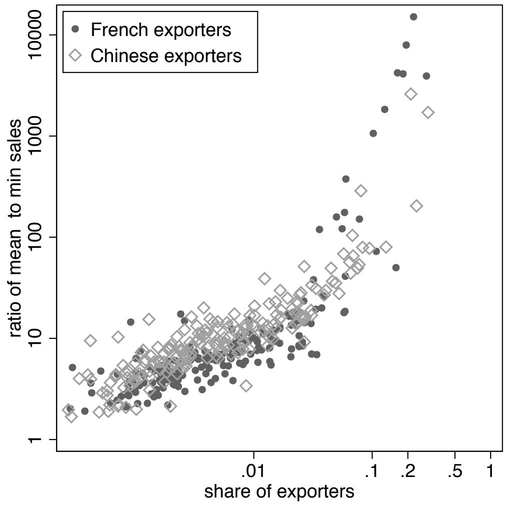
where $h(x) \equiv \phi(x)/\Phi(x)$, the ratio of the PDF to the CDF of the standard normal.

The left panel of Figure 5 depicts the theoretical behavior of the dyadic mean-to-min ratio as a function of the probability of serving the destination market $G(a^*_{ni})$ for all possible values of $a^*_{ni}$. Calculating those $\mathcal{H}^{\mathrm{P}}(a^*_{ni})$ and $\mathcal{H}^{\mathrm{LN}}(a^*_{ni})$ requires knowledge of underlying key supply-side distribution parameters $\theta$ and $\nu$. For those, we use estimates from the Quantile-Quantile (QQ) regressions in Head et al. (2014). This method, based on a regression of empirical against theoretical quantiles of log sales, is applied on the same samples of exporters (Chinese and French) as here, and requires an estimate of the CES. We choose $\hat{\sigma} = 5$, which corresponds to a central value in our findings on the intensive margin above (where $1 - \hat{\sigma} \simeq -4$). Under Pareto heterogeneity, the mean-to-min is constant but this property of scale invariance is specific to the Pareto : Indeed it is increasing in $G(a^*_{ni})$ under log-normal.

Figure 5: Theoretical and Empirical Mean-to-Min ratios




(a) theory

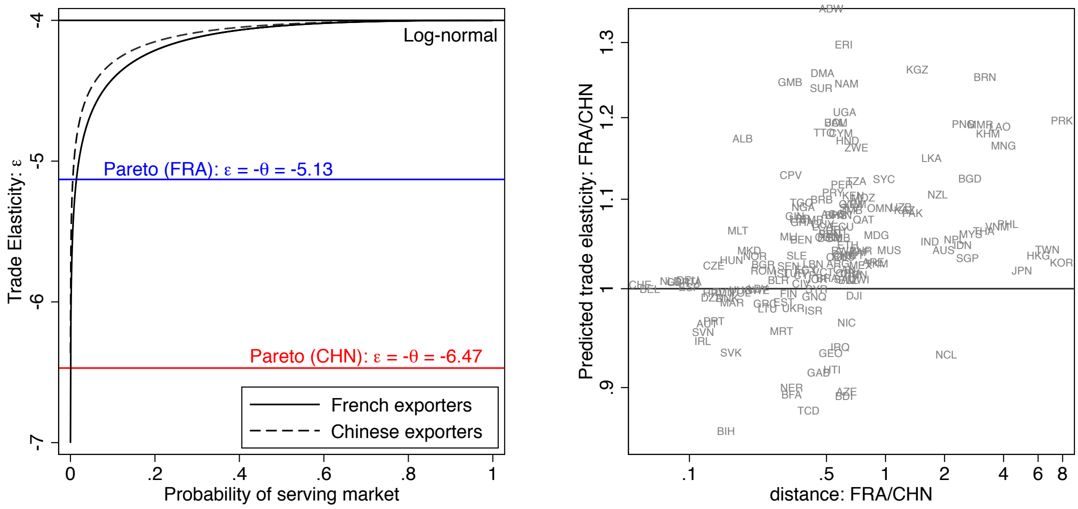



(b) data

Panel (b) of figure 5 depicts the empirical application of the $\mathcal{H}$ value for French and Chinese exporters in 2000 for all countries in the world. On the x-axis is the share of exporters serving each of those markets. Immediately apparent is the non-constant nature of the mean-to-min ratio in the data, contradicting the Pareto prediction. This finding is very robust when considering alternatives to the minimum sales (which might be noisy if only because of statistical threshold effects) for the denominator of $\mathcal{H}$, that is different quantiles of the export distribution.

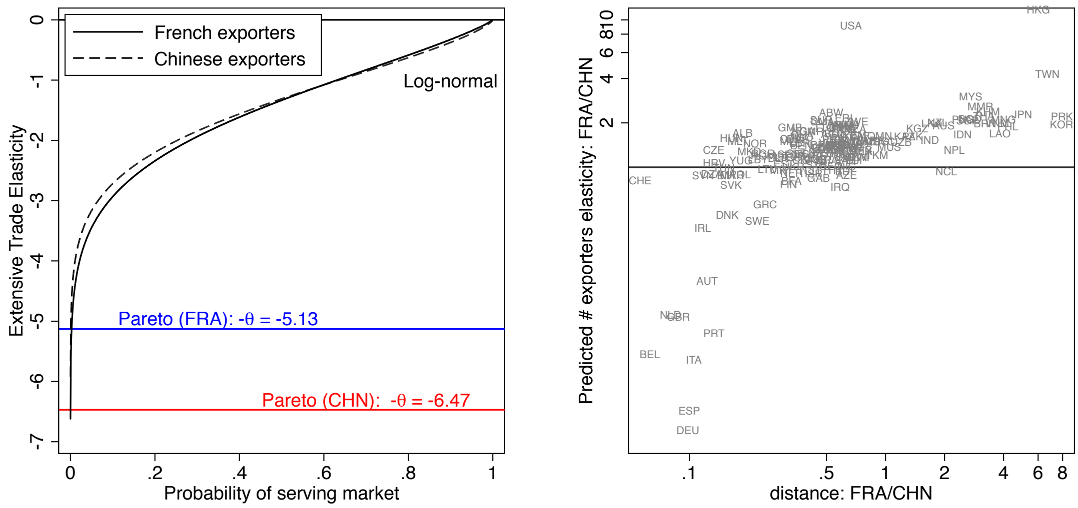
Figure 6 turns to the predicted trade elasticities in its panel (a). Those are calculated for each destination country for both Chinese and French exporters using the cutoff equations revealed from empirical values of $\mathcal{H}$ and using equation (16). Again, the Pareto case has a constant prediction (one for each exporter), while log normal predicts a trade elasticity that is declining (in absolute value) with easiness of the market. Panel (b) takes those predicted aggregate trade elasticities and plots them against actual physical distance. The two axes are taken as ratios of France over China, in order to eliminate destination specific factors ($A_n$) in those elasticities. Distance is the simplest determinant of $\tau_{ni}$ and acts exactly as expected: more difficult (distant) markets exhibit larger predicted trade elasticities (which empirically corresponds to smaller mean-to-min sales ratios). The predicted elasticity on the extensive margin is also rising with market toughness in the theory (relative distance in the data) as shown in figure 7. The inverse relationship is true for average exports. When a market is very easy and most exporters make it there, the extensive margin goes to zero, and the response of average exports goes to the value of the intensive margin (the firm-level response), $1-\sigma$, as shown in panel (a) of figure 8. While this should intuitively be true in general, Pareto does not allow for this change in elasticities across markets, since the response of average exports should be uniformly 0, while the total response is entirely due to the (constant) extensive margin.

Figure 6: Predicted trade elasticities: $\varepsilon_{n\text{FRA}}/\varepsilon_{n\text{CHN}}$



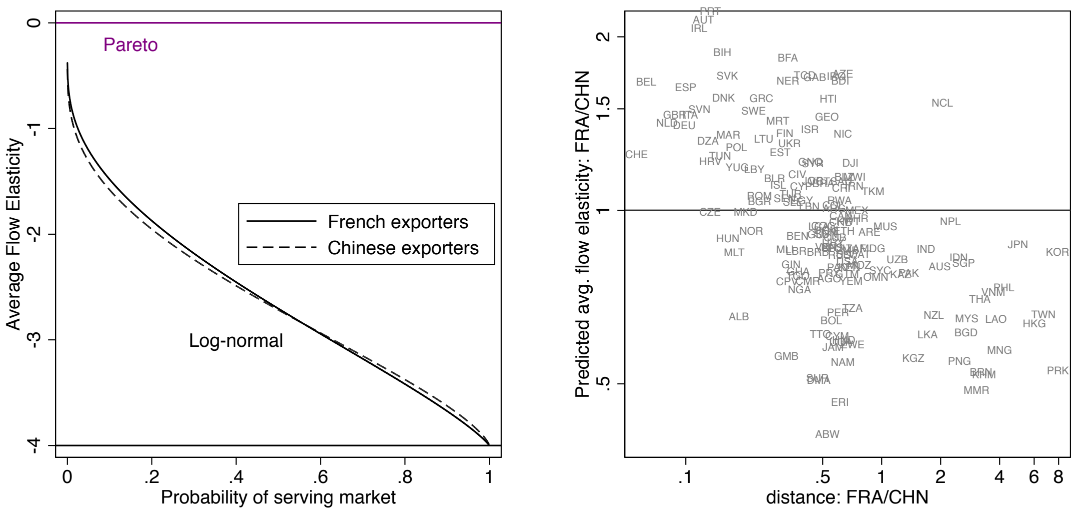

(a) theory (b) predicted elas. vs distance

Figure 7: Predicted elasticities: extensive margin




(a) theory (b) predicted elas. vs distance

Figure 8: Predicted elasticities: average exports




(a) theory

(b) predicted elas. vs distance

### 5.3 Comparison with macro-based estimates of trade elasticities

We now can turn to empirical estimates of aggregate elasticities to be compared with our predictions. Those are obtained using aggregate versions of our estimating tetrad equations presented above, which is very comparable to the traditional method used: a gravity equation with country fixed effects and a set of bilateral trade costs covariates, on which a constant trade elasticity is assumed. Column (1) of Table 9 uses the same sample of product-markets as in our benchmark firm-level estimations and runs the regression on the tetrad of aggregate rather than individual exports. Column (2) uses the same covariates but on the count of exporters, and column (3) completes the estimation by looking at the effects on average flows. An important finding is that the effect on average trade flow is estimated at -1.67, and is significant at the 5% level, contrary to the Pareto prediction (in which no variable trade cost should enter the equation for average flows).[16] This finding is robust to controlling for RTA (column 6) or constraining the sample to positive tariffs (column 9). The estimated median trade elasticity on total flows over all specifications at -5.63, is very close from the -5.03 found as the median estimate in the literature by Head and Mayer (2014).

Under Pareto, the aggregate elasticity should reflect fully the one on the number of exporters, and there should be no impact of tariffs on average exports. This prediction of the Pareto distribution is therefore strongly contradicted by our results. Does the data support the log-normal predictions? In order to compare with the average elasticities obtained in Table 9, we compute in Table 10 the average value and standard deviation of bilateral trade elasticities calculated using log-normal, and presented in the preceding sub-section. The first column presents the figures for the French exporters sample, the second one is the Chinese exporters case, and the last column averages those. The numbers obtained are quite comparable to the empirical estimates of the average elasticity presented in Table 9, when the effects of RTAs are taken into account, in columns

[16]Note that the three dependent variables are computed for each hs6 product-destination, and therefore that the average exports do not contain an extensive margin where number of products would vary across destinations.

Table 9: Elasticites of total flows, count of exporters and average trade flows.

| | Tot. (1) | # exp. (2) | Avg. (3) | Tot. (4) | # exp. (5) | Avg. (6) | Tot. (7) | # exp. (8) | Avg. (9) |
|---|---|---|---|---|---|---|---|---|---|
| Applied Tariff | -7.11$^a$ | -5.44$^a$ | -1.67$^b$ | -4.27$^a$ | -2.98$^a$ | -1.28$^b$ | -5.63$^a$ | -2.85$^a$ | -2.79$^a$ |
| | (0.83) | (0.71) | (0.65) | (0.69) | (0.71) | (0.59) | (0.91) | (0.50) | (0.66) |
| Distance | -0.83$^a$ | -0.57$^a$ | -0.26$^a$ | -0.40$^a$ | -0.20$^a$ | -0.20$^a$ | -0.80$^a$ | -0.55$^a$ | -0.25$^a$ |
| | (0.04) | (0.03) | (0.02) | (0.06) | (0.03) | (0.04) | (0.04) | (0.03) | (0.03) |
| Contiguity | 0.61$^a$ | 0.28$^a$ | 0.33$^a$ | 0.53$^a$ | 0.21$^a$ | 0.32$^a$ | 0.69$^a$ | 0.38$^a$ | 0.31$^a$ |
| | (0.13) | (0.09) | (0.06) | (0.12) | (0.08) | (0.06) | (0.13) | (0.09) | (0.06) |
| Colony | 0.86$^a$ | 0.62$^a$ | 0.24$^a$ | 0.21 | 0.06 | 0.15 | 1.03$^a$ | 0.83$^a$ | 0.19$^c$ |
| | (0.13) | (0.11) | (0.08) | (0.14) | (0.10) | (0.10) | (0.19) | (0.13) | (0.10) |
| Common language | 0.17$^c$ | 0.28$^a$ | -0.11$^c$ | 0.52$^a$ | 0.58$^a$ | -0.06 | 0.11 | 0.15$^c$ | -0.04 |
| | (0.09) | (0.09) | (0.06) | (0.09) | (0.08) | (0.07) | (0.09) | (0.09) | (0.06) |
| RTA | | | | 1.36$^a$ | 1.18$^a$ | 0.18$^b$ | | | |
| | | | | (0.12) | (0.06) | (0.08) | | | |
| Observations | 61310 | 61310 | 61310 | 61310 | 61310 | 61310 | 23015 | 23015 | 23015 |
| $R^2$ | 0.347 | 0.552 | 0.076 | 0.365 | 0.598 | 0.076 | 0.351 | 0.534 | 0.084 |
| rmse | 1.60 | 0.72 | 1.31 | 1.58 | 0.68 | 1.31 | 1.46 | 0.67 | 1.19 |

Notes: All estimations include fixed effects for each product-reference importer country combination. Standard errors are clustered at the destination-reference importer level. All estimations include a constant that is not reported. The dependent variable is the tetradic term of the logarithm of total exports at the hs6-destination-origin country level in columns (1), (4) and (7); of the number of exporting firms by hs6-destination and origin country in columns (2), (5) and (8) and of the average exports at the hs6-destination-origin country level in columns (3), (6) and (9). Applied tariff is the tetradic term of the logarithm of applied tariff plus one. Columns (7) to (9) present the estimations on the sample of positive tetraded tariffs and non-MFN tariffs. $^a$, $^b$ and $^c$ denote statistical significance levels of one, five and ten percent respectively.

(4), (5) and (6). Although this is not a definitive validation of the heterogenous firms model with log-normal distribution, our results clearly favor this distributional assumption over Pareto, and provides support for the empirical relevance of non-constant trade elasticties where both demand and supply determinants matter.

Table 10: Predicted bilateral trade elasticities (LN distribution)

| LHS | France | China | Average |
|---|---|---|---|
| Total flows | -4.613 | -4.515 | -4.564 |
| | (.626) | (.867) | (.595) |
| Number of exporters | -3.029 | -2.824 | -2.926 |
| | (1.307) | (1.425) | (1.166) |
| Average flows | -1.584 | -1.691 | -1.638 |
| | (.777) | (.68) | (.652) |

Notes: This table presents the predicted elasticities (mean and s.d.) on total exports, the number of exporting firms, and average export flows. Required parameters are $\sigma$, the CES, and $\nu$, the dispersion parameter of the log normal distribution.

# 6 Conclusion

We have argued in this paper that knowledge of the firm-level response to trade costs is a central element to our understanding of aggregate export reaction. In other words, we need micro-level data to understand the macro-level impacts of trade costs, a central element in any trade policy evaluation. This need for micro data is presumably true with the vast majority of possible heterogeneity distribution assumptions. There is one exception however where micro data is not needed to estimate the aggregate elasticity: the Pareto distribution. It is an exception the literature has been concentrating on for reasons of tractability that are perfectly legitimate, but the evidence presented in our paper points to systematic variation in bilateral aggregate trade elasticities that is both substantial and compatible with Lognormal heterogeneity (in addition to be strongly preferred when looking at the micro-level distribution of export sales). We therefore call for a "micro approach" to estimating those elasticities as opposed to the "macro approach" using gravity specified so as to estimate a constant elasticity.

Note that the micro- and macro- approaches differ radically in several respects. On the one hand, gravity is a more direct and parsimonious route for estimating aggregate elasticities: (i) parametric assumptions are reduced to a minimum while our micro-based procedure depends on the calibration of the productivity distribution; (ii) gravity relies on a less rich informational structure that makes possible the use of easily accessible dataset of bilateral aggregate trade flows. On the other hand, gravity provides, for each origin country, only a cross-destination average of elasticities while the micro-based approach provides the full cross-dyadic distribution of elasticities. Given this last limitation, we use our gravity estimates of averaged elasticities as a benchmark for discriminating between the two distributional assumptions made in our micro-based quantifications. We find that average value of bilateral trade elasticities obtained under a log-normal calibration is very close to the empirical gravity estimate which constrains the elasticity to be constant across country pairs. By contrast, the Pareto-based calibration leads to elasticities that are further away from empirical estimates.

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# A Empirical Appendix

Table 11: Average difference between applied tariffs to France and China by destination country. Full sample

| | France < | China | France = | China | France > | China |
|---|---|---|---|---|---|---|
| | Tariff | # HS6 | Tariff | # HS6 | Tariff | # HS6 |
| ARG | . | 0 | 0 | 5113 | . | 0 |
| AUS | . | 0 | 0 | 4188 | 1.91 | 905 |
| AUT | -5.71 | 2134 | 0 | 2799 | . | 0 |
| BEL | -5.71 | 2134 | 0 | 2799 | . | 0 |
| BGD | . | 0 | 0 | 5106 | . | 0 |
| BGR | . | 0 | 0 | 5059 | . | 0 |
| BLR | . | 0 | 0 | 4559 | . | 0 |
| BOL | . | 0 | 0 | 5113 | . | 0 |
| BRA | . | 0 | 0 | 5113 | . | 0 |
| BRB | . | 0 | 0 | 2020 | . | 0 |
| BRN | . | 0 | 0 | 5079 | . | 0 |
| CAN | -3.87 | 15 | 0 | 2877 | 3.07 | 2178 |
| CHE | . | 0 | 0 | 3938 | . | 0 |
| CHL | . | 0 | 0 | 5113 | . | 0 |
| COL | . | 0 | 0 | 5113 | . | 0 |
| CRI | . | 0 | 0 | 5113 | . | 0 |
| CUB | . | 0 | 0 | 5112 | . | 0 |
| CYP | . | 0 | 0 | 4929 | . | 0 |
| CZE | . | 0 | 0 | 5113 | . | 0 |
| DEU | -5.71 | 2134 | 0 | 2799 | . | 0 |
| DNK | -5.71 | 2134 | 0 | 2799 | . | 0 |
| DOM | . | 0 | 0 | 5008 | . | 0 |
| ESP | -5.71 | 2134 | 0 | 2799 | . | 0 |
| EST | . | 0 | 0 | 5113 | . | 0 |
| FIN | -5.71 | 2134 | 0 | 2799 | . | 0 |
| GAB | . | 0 | 0 | 5108 | . | 0 |
| GBR | -5.71 | 2134 | 0 | 2799 | . | 0 |
| GHA | . | 0 | 0 | 5019 | . | 0 |
| GRC | -5.71 | 2134 | 0 | 2799 | . | 0 |
| GTM | . | 0 | 0 | 5113 | . | 0 |
| HND | . | 0 | 0 | 5113 | . | 0 |
| IDN | . | 0 | 0 | 5110 | . | 0 |
| IRL | -5.71 | 2134 | 0 | 2799 | . | 0 |
| IRN | . | 0 | 0 | 5113 | . | 0 |
| ITA | -5.71 | 2134 | 0 | 2799 | . | 0 |
| JAM | . | 0 | 0 | 5113 | . | 0 |
| JOR | . | 0 | 0 | 5085 | . | 0 |
| JPN | -.18 | 3 | 0 | 2771 | 4.06 | 2256 |
| KEN | . | 0 | 0 | 4554 | . | 0 |
| LAO | . | 0 | 0 | 4977 | . | 0 |
| LBN | . | 0 | 0 | 5067 | . | 0 |
| LKA | . | 0 | 0 | 5090 | . | 0 |
| MAR | . | 0 | 0 | 5113 | . | 0 |
| MDA | . | 0 | 0 | 5068 | . | 0 |
| MEX | . | 0 | 0 | 5084 | . | 0 |
| MLT | . | 0 | 0 | 5109 | . | 0 |
| NGA | . | 0 | 0 | 5113 | . | 0 |
| NLD | -5.71 | 2134 | 0 | 2799 | . | 0 |
| NOR | . | 0 | 0 | 4770 | . | 0 |
| NPL | . | 0 | 0 | 5096 | . | 0 |
| NZL | . | 0 | 0 | 3220 | 1.15 | 1876 |
| PAN | . | 0 | 0 | 5110 | . | 0 |
| PER | . | 0 | 0 | 5113 | . | 0 |
| PHL | . | 0 | 0 | 5112 | . | 0 |
| POL | -9.51 | 4234 | 0 | 485 | 7.14 | 388 |
| PRT | -5.71 | 2134 | 0 | 2799 | . | 0 |
| PRY | . | 0 | 0 | 5113 | . | 0 |
| SAU | . | 0 | 0 | 4799 | . | 0 |
| SLV | . | 0 | 0 | 5113 | . | 0 |
| SWE | -5.7 | 2136 | 0 | 2800 | . | 0 |
| THA | . | 0 | 0 | 5056 | . | 0 |
| TWN | . | 0 | 0 | 5113 | . | 0 |
| TZA | . | 0 | 0 | 5113 | . | 0 |
| UGA | . | 0 | 0 | 5110 | . | 0 |
| URY | . | 0 | 0 | 4829 | . | 0 |
| USA | . | 0 | 0 | 4768 | . | 0 |
| VEN | . | 0 | 0 | 5109 | . | 0 |
| YEM | . | 0 | 0 | 5111 | . | 0 |

Notes: The table reports the average difference across hs6 products of applied tariffs by destination country $n$ to France and China and the corresponding number of hs6 products when the tariff applied to France is lower than to China (columns (1) and (2)), when the applied tariff to both origin countries is the equal (columns (3) and (4)) and when the tariff applied to France is higher than to China (columns (5) and (6)).

Table 12: Average difference between applied tariffs to France and China by destination country. Tetrad sample.

| | France < China Tariff | # HS6 | France = China Tariff | # HS6 | France > China Tariff | # HS6 |
|---|---|---|---|---|---|---|
| ARG | . | 0 | 0 | 359 | . | 0 |
| AUS | . | 0 | 0 | 611 | 1.87 | 180 |
| AUT | -6.04 | 294 | 0 | 297 | . | 0 |
| BEL | -5.44 | 584 | 0 | 662 | . | 0 |
| BGD | . | 0 | 0 | 35 | . | 0 |
| BGR | . | 0 | 0 | 57 | . | 0 |
| BLR | . | 0 | 0 | 3 | . | 0 |
| BOL | . | 0 | 0 | 3 | . | 0 |
| BRA | . | 0 | 0 | 408 | . | 0 |
| BRB | . | 0 | 0 | 1 | . | 0 |
| BRN | . | 0 | 0 | 2 | . | 0 |
| CAN | . | 0 | 0 | 312 | 2.77 | 427 |
| CHE | . | 0 | 0 | 480 | . | 0 |
| CHL | . | 0 | 0 | 235 | . | 0 |
| COL | . | 0 | 0 | 98 | . | 0 |
| CRI | . | 0 | 0 | 18 | . | 0 |
| CUB | . | 0 | 0 | 10 | . | 0 |
| CYP | . | 0 | 0 | 133 | . | 0 |
| CZE | . | 0 | 0 | 255 | . | 0 |
| DEU | -5.56 | 731 | 0 | 881 | . | 0 |
| DNK | -5.73 | 368 | 0 | 383 | . | 0 |
| DOM | . | 0 | 0 | 21 | . | 0 |
| ESP | -5.41 | 628 | 0 | 759 | . | 0 |
| EST | . | 0 | 0 | 24 | . | 0 |
| FIN | -5.28 | 275 | 0 | 295 | . | 0 |
| GAB | . | 0 | 0 | 11 | . | 0 |
| GBR | -5.51 | 709 | 0 | 839 | . | 0 |
| GHA | . | 0 | 0 | 9 | . | 0 |
| GRC | -4.98 | 350 | 0 | 440 | . | 0 |
| GTM | . | 0 | 0 | 17 | . | 0 |
| HND | . | 0 | 0 | 2 | . | 0 |
| IDN | . | 0 | 0 | 268 | . | 0 |
| IRL | -5.34 | 177 | 0 | 196 | . | 0 |
| IRN | . | 0 | 0 | 76 | . | 0 |
| ITA | -5.5 | 651 | 0 | 761 | . | 0 |
| JAM | . | 0 | 0 | 9 | . | 0 |
| JOR | . | 0 | 0 | 116 | . | 0 |
| JPN | . | 0 | 0 | 490 | 4.04 | 429 |
| KEN | . | 0 | 0 | 32 | . | 0 |
| LAO | . | 0 | 0 | 1 | . | 0 |
| LBN | . | 0 | 0 | 231 | . | 0 |
| LKA | . | 0 | 0 | 64 | . | 0 |
| MAR | . | 0 | 0 | 221 | . | 0 |
| MDA | . | 0 | 0 | 1 | . | 0 |
| MEX | . | 0 | 0 | 328 | . | 0 |
| MLT | . | 0 | 0 | 51 | . | 0 |
| NGA | . | 0 | 0 | 59 | . | 0 |
| NLD | -5.59 | 633 | 0 | 766 | . | 0 |
| NOR | . | 0 | 0 | 338 | . | 0 |
| NPL | . | 0 | 0 | 3 | . | 0 |
| NZL | . | 0 | 0 | 120 | 1.03 | 195 |
| PAN | . | 0 | 0 | 65 | . | 0 |
| PER | . | 0 | 0 | 52 | . | 0 |
| PHL | . | 0 | 0 | 237 | . | 0 |
| POL | -9.42 | 366 | 0 | 25 | 9.3 | 7 |
| PRT | -4.75 | 321 | 0 | 341 | . | 0 |
| PRY | . | 0 | 0 | 22 | . | 0 |
| SAU | . | 0 | 0 | 310 | . | 0 |
| SLV | . | 0 | 0 | 14 | . | 0 |
| SWE | -5.92 | 379 | 0 | 412 | . | 0 |
| THA | . | 0 | 0 | 440 | . | 0 |
| TWN | . | 0 | 0 | 590 | . | 0 |
| TZA | . | 0 | 0 | 6 | . | 0 |
| UGA | . | 0 | 0 | 1 | . | 0 |
| URY | . | 0 | 0 | 105 | . | 0 |
| USA | . | 0 | 0 | 1550 | . | 0 |
| VEN | . | 0 | 0 | 150 | . | 0 |
| YEM | . | 0 | 0 | 25 | . | 0 |

Notes: The table reports the average difference across hs6 products of applied tariffs by destination country $n$ to France and China and the corresponding number of hs6 products when the tariff applied to France is lower than to China (columns (1) and (2)), when the applied tariff to both origin countries is the equal (columns (3) and (4)) and when the tariff applied to France is higher than to China (columns (5) and (6)).

# B Theoretical Mean-to-Min ratios under Pareto and Log-Normal distributions

In general, the shape of the distribution of firms' productivity matters for the aggregate trade elasticity, generating heterogeneous responses across country pairs to the same trade costs shock In this Appendix we consider two different distributions of the (rescaled) productivity: i) Pareto, which turns out to be a quite special case where heterogeneity washes out, and ii) Log-normal which maintains the mapping between heterogeneous productivity and heterogeneous trade elasticities.

More precisely, the central relationship (12) makes it clear that the heterogeneity of aggregate trade elasticity comes entirely from the term $\gamma_{ni}$ that stems from endogenous selection of firms into export markets (see equation 13). In turn, $\gamma_{ni}$ depends on the cost-performance index $V_{ni}$ as defined by (10). We therefore need to understand how these $\gamma$ and $V$ terms behave under alternative distribution assumptions.

If productivity is Pareto then the rescaled unit input requirement $a$ has PDF $g(a) = \theta a^{\theta-1}/\bar{a}^{\theta}$, which translates into

$$V_{ni}^{\mathrm{P}} = \frac{\theta a_{ni}^{*\theta-\sigma+1}}{\bar{a}^{\theta}(\theta-\sigma+1)}. \tag{24}$$

The elasticity of $V_{ni}$ with respect to $a^*$ is

$$\gamma_{in}^{\mathrm{P}} = \theta - \sigma + 1 > 0. \tag{25}$$

Hence, Pareto makes all the $\gamma_{in}$ terms be the same, and therefore transforms an expression generally yielding heterogeneous trade elasticities into a one-parameter elasticity $\frac{d\ln X_{ni}}{d\ln \tau_{ni}} = \theta$, that is related to the supply side of the economy only.

When productive efficiency is distributed log-normally, things are very different. For $\varphi \sim$log-$\mathcal{N}(\mu,\nu)$, the distribution of rescaled unit input requirements is $a \sim$log-$\mathcal{N}(-\mu,\nu)$, and we can write

$$V_{ni}^{\mathrm{LN}} = \exp[(\sigma-1)\mu + (\sigma-1)^2\nu^2/2]\Phi[(\ln a_{ni}^* + \mu)/\nu + (\sigma-1)\nu], \tag{26}$$

where $\Phi()$ denotes the CDF of the standard normal distribution. Differentiating $\ln V_{ni}$ with respect to $\ln a_{ni}^*$,

$$\gamma_{ni}^{\mathrm{LN}} = \frac{1}{\nu} h\left(\frac{\ln a_{ni}^* + \mu}{\nu} + (\sigma-1)\nu\right), \tag{27}$$

where $h(x) \equiv \phi(x)/\Phi(x)$, the ratio of the PDF to the CDF of the standard normal. Thus $\gamma_{ni}$ is no longer the constant $1-\sigma+\theta$ which obtains for productivity distibuted Pareto with shape parameter $\theta$.

The $\mathcal{H}$ function is a central element of our calibration procedure, as summarized by relationship (15) , that reveals cutoffs and therefore aggregate bilateral elasticities. Comparing (10), (13) and (14) we see that $\mathcal{H}$ and $\gamma$ are closely related

$$\gamma_{ni} \times \mathcal{H}(a_{ni}^*) = a_{ni}^* \frac{g(a_{ni}^*)}{G(a_{ni}^*)} \tag{28}$$

With Pareto, we make use of (25) to obtain

$$\mathcal{H}^{\mathrm{P}}(a_{ni}^*) = \frac{\theta}{\theta-\sigma+1}, \tag{29}$$

With a lognormal productivity, equation (27) leads to

$$\mathcal{H}^{\text{LN}}(a_{ni}^*) = \frac{h[(\ln a_{ni}^* + \mu)/\nu]}{h[(\ln a_{ni}^* + \mu)/\nu + (\sigma - 1)\nu]}, \tag{30}$$

An attractive feature of our quantification procedure relates to the small number of relevant parameters to be calibrated. Under Pareto, equations (25) and (29) show that only the shape parameter $\theta$ matters. Similarly, under a Lognormal, only the calibration of the second-moment of the distribution, $\nu$, is necessary for inverting the $\mathcal{H}$ function to reveal the cutoff and for quantifying the aggregate elasticity: This last point stems from the fact that shifting the first moment, $\mu$, affects (27) and (30) in an identical way and so has no impact on the quantification.