Tariff-Based Product-Level Trade Elasticities*

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Abstract

Trade elasticity which varies widely across products is a crucial parameter in evaluating the welfare impacts of changes in trade frictions. We estimate trade elasticities at the product level by exploiting the variation in bilateral tariffs for each product category for the universe of country pairs over the 2001 to 2016 period. The predicted trade flows using the product-specific trade elasticities estimated here match the observed post-EPA import between the US and Chile, confirming the accuracy of our estimates.

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Introduction

The global economy is currently confronted with an unprecedented resurgence of trade frictions due to the trade war initiated in 2018 and the Covid-19 outbreak crisis of 2020. The quantification of the welfare impacts of these higher trade costs for economies at different levels of economic development, and characterized by different sectoral specialization and degree of openness, requires the sound parametrization of the trade model that is used. Trade elasticity is one of these key parameters, especially when it comes to providing an order of magnitude of the trade and welfare impacts of a change in trade costs: changes in welfare are a function of the change in the share of domestic expenditure and the trade elasticity to variable trade costs (Arkolakis, Costinot & Rodriguez-Clare 2012).[1] As a tariff is a variable trade cost imposed by the importer country, the elasticity of trade values to changes in tariffs becomes the key parameter for many researchers and practitioners interested in evaluating the welfare effects of trade policies – see the approach coined as "trade theory with numbers" popularized by Costinot & Rodriguez-Clare (2014). But while the first statistic – how much does a country trade with itself as a proportion of its total expenditures – is directly observable, the current estimates of trade elasticities diverge widely. Even restricting the comparison to the gravity estimates controlling for multilateral resistance terms leads to a wide range of values, as shown by Head & Mayer (2014) in their review of 435 elasticities from 32 papers: they obtain a median figure of 5.03 with a standard deviation of 9.3.

Reasons for such divergence pertain to methods and data. The trade elasticity can be estimated *via* a demand system (Feenstra 1994, Broda & Weinstein 2006, Ossa 2015, Soderbery 2018), using the non-arbitrage condition and product-level price data (Simonovska & Waugh 2014a, Giri, Yi & Yilmazkuday 2021), considering imports as inputs into the GDP function (Kee, Nicita & Olarreaga 2008) or in a gravity framework (Caliendo & Parro 2015). The requirement in terms of observed trade costs therefore depends on the choice of identification strategy. Estimating a demand system implies volume and prices at the finest classification level of traded products (Feenstra 1994) with no *explicit* consideration of trade policies. Similarly, Simonovska & Waugh (2014a) and Giri et al. (2021) use disaggregated prices data in respectively 2004 and 1990. Trade unit values are used as a proxy for prices in Kee, Nicita & Olarreaga (2009), when estimating the import-demand elasticity as the percentage change in the imported quantity, holding the prices of other goods, productivity and the endowment of the importer constant. In contrast, Caliendo & Parro (2015) rely on the cross-sectional variations in trade shares and applied tariffs in 20 sectors and 30

[1] The trade (or Armington) elasticity can be interpreted differently according to the underlying theoretical framework (Armington 1969). Feenstra, Luck, Obstfeld & Russ (2018) underline the conceptual distinction between the "macro" elasticity between domestic and imported goods, and the "micro" elasticity of substitution between different import suppliers at the core of the current paper (i.e. how bilateral tariffs affect bilateral import flows). While there is no such distinction in the new generation of computable trade models *à la* Dekle, Eaton & Kortum (2008), the two elasticities are usually nested in Computable General Equilibrium models with a Constant Elasticity of Substitution (CES) demand system (see Costinot & Rodriguez-Clare (2014) for a detailed comparison of the two approaches). Using US data, Feenstra et al. (2018) show that the macro elasticity is significantly lower than the micro elasticity for one quarter of goods.

countries to estimate sectoral trade elasticities. Data availability on trade costs and prices has accordingly constrained previous estimates of trade elasticities at product level.

In their survey of open questions related to the analysis of commercial policies, Goldberg & Pavcnik (2016) stress that "*perhaps surprisingly, estimates of the trade elasticity based on* actual *trade policy changes are scarce [...] it is surprising that trade policy has not been exploited to a larger extent to identify this crucial parameter*".[2] This paper aims to at least partially fill this gap by constructing a new dataset on trade costs, and resorting to a simple and transparent estimation strategy to obtain product-level trade elasticities. By considering the universe of (preferential or MFN) applied tariffs and import flows at the bilateral and product level (using the 6-digit level of the Harmonized System – HS6 thereafter) for 152 importing countries and 189 exporting countries over the 2001-2016 period, we provide a set of estimations of theory-consistent trade elasticities at the product level and identify the determinants of heterogeneous product-level trade elasticity. In the process, we also recover the elasticity of shipping costs with respect to distance for each product. Our identification strategy does not rely on the prices of imports generally measured by disaggregate trade unit values and therefore subject to considerable measurement error and simultaneity bias.[3] One important contribution of this paper is therefore identifying the trade elasticities *entirely through variations in tariffs* and using a global coverage of importing and exporting countries.

While Caliendo & Parro (2015) rely on the multiplicative properties of the gravity equation in order to cancel out unobserved trade costs, in line with the "ratio approach" introduced by Head & Ries (2001) and systematized as "Tetrads" by Martin, Mayer & Thoenig (2008) and Head, Mayer & Ries (2010),[4] we here take a gravity approach using a strategy of fixed effects, as suggested by Head & Mayer (2014).[5] This approach has the merit of generality, tractability and transparency, while being theoretically consistent.

To proceed, we use the most-disaggregated level of information on trade policies and bilateral imports available for the universe of products and importing countries – the HS6 that covers over 5,000 different product categories – for a sample of 152 importing countries, including countries at lower levels of development with only partially-liberalized trade.[6] We

[2]See Goldberg & Pavcnik (2016), pp. 24-25. Recent exceptions are Amiti, Redding & Weinstein (2019), Boehm, Levchenko & Pandalai-Nayar (2020), De Bromhead, Fernihough, Lampe & O'Rourke (2019) and Fajgelbaum, Goldberg, Kennedy & Khandelwal (2020).

[3]At the product level, import *quantities* are very-imprecisely measured, with many missing values. Moreover, using unit values would imply the omission of new product varieties from the import-price index (Feenstra 1994).

[4]The triple-difference approach proposed by Caliendo & Parro (2015) differs, however, from the odds ratio and the "Tetrad" approach, as it does not require domestic-sales data or a reference country to identify the parameters. The triple-difference approach relies on the assumption that tariffs are the only non-symmetric trade cost (all others are assumed to be symmetric, and so cancel out in the triple difference).

[5]Under the usual CES demand system assumption, the trade elasticity ε is equal to one minus the elasticity of substitution σ; σ in turn is equal to the negative of the tariff elasticity when using Free On Board (FOB) trade flows (as in this paper). We discuss in Section 4.3 whether our estimated elasticities suggest a demand system other than the CES.

[6]Imports can be observed at the tariff line for single countries. This is why US imports have repeatedly

calculate the tariff elasticity of a given HS6 product (and so recover the trade elasticities and the elasticities of shipping costs with respect to distance) by comparing country's product-specific imports from different origins on which different tariffs are imposed.

For each HS6 product category we observe the universe of bilateral trade flows between countries, in value, in a given year, and the tariff (preferential or not) applied to each exporter by each importer on the specific product. This is done for 2001, 2004, 2007, 2010, 2013 and 2016. A great deal of the variation in tariffs is cross-sectional.[7] For this reason, we explain – for a given importer (and product) – the cross-country variation in imports *via* the cross-country variation in tariffs. We benefit from the fine grain of our data, and estimate not only product-level (HS6) trade elasticities but also sector-level trade elasticities by pooling the product-level observations within each sector.[8]

Our preferred set of trade elasticities, when we keep the 1% level statistically-significant tariff elasticities and statistically-insignificant estimates are replaced by zero,[9] is centered around -5, with an average figure of -5.3. Our results show considerable heterogeneity in trade elasticity across products. Beyond estimating these product-level trade elasticities, we show what lies behind their magnitude. Product differentiation plays a large role, as predicted by theory. Also, the estimated product-level elasticity is sensitive to distance, consistent with the selection of heterogenous exporters into distant markets. The observed heterogeneity of product-specific trade elasticity matters, not only because the average of inverse trade elasticities differs from the inverse of the average trade elasticity (Ossa 2015): it matters also for the comparison of the welfare gains from trade for countries at different level of development. Using a standard Arkolakis et al. (2012) - ACR - multi-sector framework featuring a two-tier utility function, with the upper tier Cobb-Douglas and the lower tier Dixit-Stiglitz, we show that gains are *lower* for developing countries.[10]

A second contribution of this paper is showing that using tariff data produces accurate estimates of trade elasticities. We subject the data to a very demanding test in order to assess the accuracy of the estimated elasticities. While computable models generally fail to correctly predict the changes in trade flows from Free Trade Agreements,[11] here we compare

been used to estimate trade elasticities. An influential set of elasticities at the tariff-line level for the US (13,972 product categories) and the 1990-2001 period is found in Broda & Weinstein (2006).

[7] In Section 1.2 we show that the cross-country variation (the *between* component) in import tariffs is larger than the over-time variation (the *within* component).

[8] The estimated trade elasticities at different level of aggregation, as well as related additional material, are available on a dedicated web page: `https://sites.google.com/view/product-level-trade-elasticity/home`

[9] Trade elasticities obtained by adopting other levels of statistical significance, as well as point estimates of tariff elasticity, are discussed in Section 3.1

[10] See Costinot & Rodriguez-Clare (2018) for a discussion on the functional forms needed to obtain the standard ACR formula for welfare gain from trade.

[11] Reproducing variations in bilateral trade shares with a standard computable general equilibrium model is difficult. In a calibration-as-estimation procedure applied to the GTAP model, Hillberry, Anderson, Balistreri & Fox (2005) show that the trade elasticity had to be set at a value above 15 in 21 out of 41 sectors in order to reproduce the actual variation in trade shares. No solution was found in five sectors. Kehoe (2005), summarizing the ex post assessment of the calibrated models used to simulate the impact of NAFTA, concluded "*The models drastically underestimated the impact of NAFTA (...) (and) failed to*

the *ex post* realized change in imports after a bilateral systematic tariff shock with the *predicted* changes based on the retrieved product-level trade elasticities. Considering the period covered by our data, the ideal candidate for such ex-post test is the 2004 US-Chile agreement. The *ex post* and *predicted* changes in product-level share of Chile's imports from the US line up fairly well, and importantly, much better than the predicted changes based on homogenous elasticity artificially created by averaging over the products. This test confirms the accuracy of our tariff-based product-level trade elasticities.

This paper speaks to the literature estimating trade elasticities with different methods. De Bromhead et al. (2019) take advantage of the swing in British protection during the 1930s and estimate trade elasticities for 9 categories of goods ranging from 1.47 to 23.47. Romalis (2007) obtains mean elasticities of substitution of between 6.3 and 10.9, based on US and EU imports from Canada (or Mexico) and control countries from 1989 to 1999. Using import data at the HS6 level, and trade unit values for 117 importers over the 1988-2001 period, Kee et al. (2009) obtain a simple average across product-specific import-demand elasticities of 3.12. Broda & Weinstein (2006) find an average value of 6.6 for US imports with 2,715 SITC 5-digit categories, and 12.6 at the tariff-line (13,972 categories) level over the 1990-2001 period.[12] Soderbery (2018) obtains a mean elasticity of 3.4 for 1,243 HS4 product categories over the 1991-2007 period. Simonovska & Waugh (2014a) use disaggregated prices from the International Comparison Programme for 62 product categories in 2004, matched to trade data in a cross-section of 123 countries. Their benchmark trade elasticity is 4.12. Giri et al. (2021) adopt the same strategy for 12 EU countries and 1,410 goods (in 19 traded sectors) in 1990. They find a median trade elasticity of 4.38. At the industry level, Ossa (2014) estimates CES elasticities of substitution by pooling the main world importers in cross-section, which produces a mean value of 3.42 (ranging from 1.91 for Other Animal Products to 10.07 for Wheat). By combining GTAP 7 and NBER-UN data for 251 SITC-Rev3 3-digit industries, Ossa (2015) obtains an average elasticity of 3.63 (ranging from 1.54 to 25.05). Amiti et al. (2019) and Fajgelbaum et al. (2020) take advantage of the large swings in US tariffs and rely on US imports from January 2017 to December 2018 at the origin-month-HS10 level. Amiti et al. (2019) estimate an elasticity of substitution between varieties of 6,[13] while the preferred value for US import-demand elasticity in Fajgelbaum et al. (2020) is 2.47. After controlling for exporter and importer fixed effects in their triple-difference approach, the trade elasticities in Caliendo & Parro (2015) range from 0.49 in the Auto sector to 69 in the Petroleum sector.[14] Finally, in order to identify short- and long-run trade elasticities, Boehm et al. (2020) use the differential effects of variations in MFN *ad valorem* tariffs on imports from countries subject to MFN, relative to the control group of countries not subject to the MFN, and obtain product level long-run elasticities at the lower end of

capture most of the relative impact on the different sectors" (p.343).

[12] Note that the corresponding median figures are much lower, at respectively 2.7 and 3.1.

[13] See column 3 of Table 1 in Amiti et al. (2019).

[14] See Table A2 in Caliendo & Parro (2015).

the range of existing estimates ranging from 1.75 to 2.25.

The remainder of the paper is structured as follows. The construction of the dataset is detailed in Section 1. We present our theoretical framework and identification strategy in Section 2. Our trade elasticities estimated at the product level appear in Section 3, which also compares the change in welfare of a move to autarky for countries at different level of development, and tests the accuracy of our product level trade elasticities with an *ex post* validation exercise. Section 4 contains a series of robustness checks. Section 5 concludes.

1 Data

1.1 Trade and tariff data

We employ two main data sources in our analysis, bilateral trade flows in Free On Board (FOB) terms and bilateral applied (MFN or preferential) tariffs, ultimately combined with common gravity variables such as bilateral distance, common language, border and colony dummies.[15]

For a full matrix of importer and exporter countries, we use the *BACI* (CEPII) database that provides information on bilateral trade flows, in current US Dollars, over the 1996-2016 period at the HS6 level. Three important features make *BACI* data particularly suitable for our exercise. First, *BACI* fills empty cells in the World trade matrix using mirror trade flows. Second, *BACI* reconciles reported values between exporter i and importer j in a given product category k and year t pair: we can use either exports $X_{i,j,k,t}$ or imports $M_{j,i,k,t}$ as the figures are identical.[16] Third, and most importantly, *BACI* provides import values net of transport costs (hence FOB).[17]

Concerning tariffs, we start from the three releases (2001, 2004, 2007) of $MAcMap{-}HS6$ made available by CEPII. Each release is the aggregation (at the HS 6-digit level) of the tariff-line level trade policy instruments at the importing country level provided by the International Trade Center (ITC, UNCTAD-WTO). Raw data collected by the ITC from each importer at the tariff line level, *vis-à-vis* each exporter, is the minimum between the Most Favoured Nation (MFN) custom duty and the preferential duty when it exists (bilateral agreement, unilateral preference, customs union). The resulting raw database accounts for an exhaustive coverage of regional agreements and trade preferences. A drawback of such a detailed classification is that the national product codes (tariff-line) that refer to imported goods are not consistent across countries. Our data address this issue by aggregating the information at the HS6 level, using the same revision of the HS6 classification for each country.

[15]Gravity variables are taken from the *Gravity* database available at `http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=8` and documented in Head et al. (2010).

[16]The reliability of reporting countries is used as a weight to reconcile bilateral trade flows.

[17]The data is documented in Gaulier & Zignago (2010) and can be accessed at `http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=37`.

Our data take into account also the *ad valorem* equivalents of specific tariffs. Specific duties are converted into *ad valorem* tariffs using unit values taken from CEPII Trade Unit Values (TUV) dataset.[18] As prices charged by the exporter country may be affected by the presence of specific tariffs imposed by the importer country, unit values used to convert the specific tariff are likely to be exogenous. To address this issue, we rely on the Exporter Reference Group Unit Value approach (Bouet, Decreux, Fontagné, Jean & Laborde 2008). This approach delivers plausibly exogenous TUV by averaging country-specific TUV within a reference group of countries. The first step consists in defining the reference group of the exporter country using a hierarchical clustering based on GDP per capita and trade openness, and delivers five groups of exporters with similar income level and degree of openness. The second step consists in computing the weighted median of the trade unit values for each reference group and HS6 product. As a final step, extreme TUV values exceeding one-third (below) and three times (above) the world median unit value are capped. The reference group specific TUVs are then used to convert *specific* duties to *ad valorem* equivalent tariff rates.[19]

We extend the aforementioned database up to 2016 by keeping the same time intervals (three-year windows) and methods (i.e. specific tariffs converted into *ad valorem* equivalents and same source of unit values for conversion). Finally, all the different releases of the $MAcMap - HS6$ database are converted into the 2007 revision of the HS classification comprising 5,052 products categories. The 2007 revision of the HS classification is adopted because it is the most frequent revision used by reporting countries in our raw data. We end up with a database on applied bilateral tariffs for years 2001, 2004, 2007, 2010, 2013 and 2016, built using a unified and consistent methodology across years.

Then we merge $BACI$ trade data with $MAcMap - HS6$ tariffs data. Our different vintages of tariff data have 154 importers in common. Two of those jurisdictions (Mayotte and Taiwan) are absent from the gravity database and we retain therefore a sample of the 152 importers (the list of importing countries appears in Table 1). On the exporters side the constraint is less binding, and we keep exporters that have been present in $BACI$ since 2001. Ultimately, our dataset includes 189 exporters to 152 destinations in years 2001, 2004, 2007, 2010, 2013 and 2016.[20]

[18]This is the only occurrence where unit values are used in this paper (i.e. to convert tariff-line *specific* into *ad valorem* tariffs before aggregation at the HS6 level). The CEPII Trade Unit Values database provides unit values data based on the Tariff Lines database of the United Nations Statistical Division, containing the values and quantities of trade declared by individual countries to the UN. $MAcMap - HS6$ 2001 and 2004 used $BACI$ unit values in the absence of the TUV dataset.

[19]In the original 2001 and 2004 releases of $MAcMap - HS6$, administration methods and filling rates of Tariff Rate Quota (TRQ) were used to choose between the inside and outside tariff rate. From 2007 on, this solution has been replaced by the outside tariff rate that is actually applied in most of the cases by importer countries. As a consequence, when a TRQ is present for a given importer, we use by default the outside tariff rate. For instance, in 2007, out of 2563 TRQ-importer pairs, only 8 pairs corresponded to the inside quota tariff. The associated measurement error is therefore low, and attenuated by the instrumental variable strategy in Section 4.1.

[20]Datasets with non-consecutive years have been used in similar empirical setting in Baier & Bergstrand

At the HS6 level, the worldwide matrix of bilateral trade includes many zeros. However, not all of these zeros convey useful information for our exercise. If country j does not import product k from exporter i, this might just reflect that i never exports k. In this case, including all of the zeros originating from country i in product k across all destinations j would inflate the dataset with useless information.[21] So, we drop exporters i that never export a given k over the entire period to any of the destinations j.

1.2 The sources of variation in trade costs in our sample

Table 2 shows the share of non-missing importer-exporter-HS6 combinations with zero applied *versus* non-zero tariffs.[22] A first observation is that there has been a steady phasing-out of tariffs in the 2000s: the share of HS6 products with zero tariffs almost doubled between 2001 and 2007, and further rose to reach 40% in 2016. This "zeroing" goes beyond the commitments of the Uruguay Round, and mirrors either the phasing-out of nuisance tariffs[23] or the phasing-in of Preferential Trade Agreements (PTAs). The descriptive evidence in Table 2 calls for a deeper analysis of the respective contributions of the within and between changes in product bilateral tariffs. The characterization of the sources of tariff variation in our data is key in guiding our empirical exercise.

Product-level tariffs can vary both within each country pair over time (*within* variation) and/or across trade partners within a given year (*between* variation). Table 3 lists for each HS section the between and within country-pair variances of applied tariffs. Most of the variance for each product occurs between country pairs; we will therefore exploit the *between* pairs variation in bilateral tariffs to estimate tariff elasticities in the next section. The contribution of the within variance is non-negligible in Section XI (corresponding to the phasing out of protection for Textiles and Textile articles). The largest between variation is in Section IV (Prepared Foodstuffs, Beverages and Tobacco); this sector is also that with the highest average protection among all country pairs (16.9 percent in 2016) as well as the largest variance (38.6).[24]

The last interesting source of variation in the average applied tariffs is between countries at different levels of income per capita. Table 4 adopts the classification (high, upper-middle, lower-middle and low) provided by the World Bank in 2010 and shows that low- and middle-income countries impose higher average import tariffs than developed countries.

(2007) and Anderson & Yotov (2016).

[21]More specifically, our baseline PPML estimator would disregard this information, as the dependent variable would be perfectly predicted by exporter-year fixed effects.

[22]It should be noted that the vast majority of non-zero tariffs are *ad valorem*. Specific tariffs or compound tariffs (combining *ad valorem* and specific elements on the same tariff line) sum up to around one percent of all non-missing importer-exporter-HS6 observations. However, given the potentially high protection they provide, specific or compound tariffs should not be disregarded. As discussed in Section 1.1 we include the *ad valorem* equivalent of these specific or compound tariffs in our estimations.

[23]Nuisance tariffs are duties close to zero percent that are not worth collecting at the border.

[24]Average tariff by HS section and year, and standard deviation, are shown in Tables B1 and B2 in the Online Appendix.

2 The Identification Strategy

2.1 Set-up

We start from the prior that the coefficient associated with tariffs – a variable trade cost – corresponds to the import-demand elasticity in a structural gravity equation for bilateral trade.[25] Consider a World economy in which every country i exports goods $k \in K$ (with traded goods k corresponding to the 6-digit products in the HS classification). The production of k is differentiated by country of origin i according to the Armington hypothesis. Hence, the set of origins $i \in I$ (for a given product k) defines the set of varieties available for consumption in country j. Let us assume a one-tier CES demand system. This implies the separability of the k specific consumption demand functions, which is at the core of our empirical approach since we estimate a structural gravity model for each product k.[26] Each country j is populated by a representative agent whose consumption of product k maximizes the following CES utility function:

$$U_{jk,t} = \left(\sum_i \alpha_{ik,t}^{(1-\sigma_k)/\sigma_k} c_{ijk,t}^{(\sigma_k-1)/\sigma_k} \right)^{\sigma_k/(\sigma_k-1)} \quad s.t. = \sum_i p_{ijk,t} c_{ijk,t} = E_{jk,t} \tag{1}$$

where $c_{ijk,t}$ is the demand for good k originating from i at time t, σ_k (with $\sigma_k > 1$) the product-specific elasticity of substitution across varieties originating from different origins i, $E_{jk,t}$ the expenditure in country j on good k at time t, $p_{ijk,t}$ is the price of product k originating in i and $\alpha_{ik,t}$ a positive distribution parameter. The set of origins i also includes the domestic country j.

The Cost, Insurance and Freight (CIF) price is inclusive of the transport cost ψ_{ijk}, whose functional form is $(1+\psi_{ijk}) = (d_{ij})^{\rho_k}$, where d_{ij} is the bilateral distance between i and j and ρ_k the elasticity of the shipping cost of good k with respect to distance (Hummels 2007). If the importer country j imposes an (applied)*ad valorem* tariff τ_{ijkt} on the CIF price of good k,[27] and under the assumption of the full pass-through of this tariff to the consumer price

[25]With such disaggregated data discussed in Section 1.1, one may also be tempted to estimate product-specific export-supply elasticities by applying the method proposed in Romalis (2007) and Fajgelbaum et al. (2020). However, a lack of complete information on import *quantities* at the HS 6-digit product level (a large number of missings) would imply very imprecise proxies for before-duty export prices (i.e. import trade unit values), and considerable measurement-error bias when applying the method in Romalis (2007) and Fajgelbaum et al. (2020). We therefore refrain from the analysis of product-level export-supply elasticities in this paper.

[26]We choose a one-tier CES demand system for the sake of tractability. This implies considering the domestically-produced variety as a consumption option among other foreign-produced varieties at the same level of the consumer's utility function. While this approach has been used repeatedly in the literature (Romalis 2007, Arkolakis et al. 2012), an alternative is to adopt a two- or three-tier CES demand system where the upper nest differentiates between foreign and domestic products, and the lower nest(s) among foreign-produced varieties (Fajgelbaum et al. 2020, Feenstra et al. 2018).

[27]The tariff is charged on CIF values in most countries (the United States is an exception). In what follows we also assume the full use of the preferential tariff rate. Any exporter-specific deviation from this practice is absorbed by exporter-year fixed effects in the empirical specification. In the presence of exporter-importer specific deviations from the full use of the preferential rate, our estimations produce lower-bound elasticities

p_{ijkt}, the price paid by the consumer at destination is:[28]

$$p_{ijk,t} = p_{ik,t}(1 + \tau_{ijk,t})(1 + \psi_{ijk}) \tag{2}$$

where $p_{ik,t}$ is the before-duty and transport-cost price at country i's border. Import demand (in nominal terms) can be therefore written as:

$$p_{ijk,t}c_{ijk,t} = \alpha_{ik,t}^{(1-\sigma_k)} p_{ik,t}^{(1-\sigma_k)} (1 + \tau_{ijk,t})^{(1-\sigma_k)} (1 + \psi_{ijk})^{(1-\sigma_k)} P_{jk,t}^{(\sigma_k-1)} E_{jk,t} \tag{3}$$

where $P_{jk,t} = \left(\sum_i (\alpha_{ik,t}p_{ijk,t})^{(1-\sigma_k)}\right)^{1/(1-\sigma_k)}$ is the price index in j of the varieties of product k at time t. Our empirical strategy disregards unit values, subject to measurement errors and aggregation issues,[29] which prevents us from estimating Equation (3) in quantities $c_{ijk,t}$. We instead use imports Free On Board (FOB), valued at the before-duty and transport-cost export price p_{ikt}. Rewriting Equation (3) in FOB terms, and observing that $(1 + \psi_{ijk}) = (d_{ij})^{\rho_k}$, we obtain:

$$p_{ik,t}c_{ijk,t} = (\alpha_{ik,t}p_{ik,t})^{(1-\sigma_k)} (1 + \tau_{ijk,t})^{-\sigma_k} (d_{ij})^{-\sigma_k\rho_k} P_{jk,t}^{(\sigma_k-1)} E_{jk,t} \tag{4}$$

We note immediately that the tariff elasticity can be recovered from the coefficient $-\sigma_k$. We can also incidentally recover the elasticity of shipping costs with respect to distance ρ_k by dividing the exponent of distance by the estimated σ_k. This last structural interpretation of estimated parameters warns against the use of the elasticity of exports to distance as a trade elasticity.[30] The tariff elasticity is (minus) the elasticity of substitution σ_k across products coming from different origins i. This is at the core of our empirical approach to estimate product-specific elasticities of demand, $\varepsilon_k = 1 - \sigma_k$. This is the average demand elasticity for product k, common across importers, over the time period considered. The empirical counterpart of Equation (4), with exporter-time and importer-time fixed effects, is discussed below.[31]

(i.e. an *actual* tariff cut that is smaller than that observed in the tariff data, and the same observed change in bilateral imports). By the same token we also assume the full use of the preferential-tariff rate notwithstanding the Rules of Origin. Applied tariffs at the date of the trade flow may differ from future tariffs to the extent that tariffs are bound above the MFN, or even not bound at all. Tariffs in advanced countries are fully bound, however.

[28]Recent empirical evidence suggests the full pass-through of US tariffs into the export prices of Chinese goods (Amiti et al. 2019, Fajgelbaum et al. 2020, Cavallo, Gopinath, Neiman & Tang 2021). Any exporter-specific deviation from full-pass through is absorbed by the exporter-year fixed effects in our estimations.

[29]The variety effect spotted by Feenstra (1994) acts in our specification as a demand shifter that is captured by $\alpha_{ik,t}$ in Equation (3) and by the exporter-time fixed effect in our empirical specification at the product level.

[30]More specifically, we identify the elasticity of exports to all frictions related to distance.

[31]We also estimate in Section 4.3 import-demand elasticities that are consistent with non-CES demand systems, and in particular with an additively-separable demand system.

2.2 Estimating import-demand elasticities

As discussed in Section 1.1, the final dataset includes bilateral FOB trade flows and applied bilateral tariffs at the HS6 level and gravity control variables for 189 exporters to 152 destinations over the 2001-2016 period. To estimate the tariff elasticity *for each* of these 5,050 HS6 product categories,[32] we rely on the standard structural-gravity framework with country-time fixed effects. Using the notation $X_{ijk,t}$ for the FOB value $p_{ik,t}c_{ijk,t}$ of the imports in destination j of product k originating in country i in year t, the following empirical model is estimated to recover the tariff elasticity at the product level (and is hence estimated 5,050 times, once for each product $k = 1, ...K$):

$$X_{ijk,t} = \exp\left[\theta_{ik,t} + \theta_{jk,t} + \beta_k ln\left(1 + \tau_{ijk,t}\right) + \gamma_k ln\left(d_{ij}\right) + \zeta_k \mathbf{Z}_{ij}\right] \times \epsilon_{ijk,t} \quad \forall k \in K. \qquad (5)$$

Here the tariff elasticity is $\beta_k = -\sigma_k$ in the usual CES framework discussed above, with σ_k being the elasticity of substitution between varieties of a given HS6 product exported by different countries.[33] The elasticity of the shipping cost with respect to distance for good k is simply $\rho_k = \gamma_k/\beta_k$. With the product-specific tariff elasticity at hand we can recover the trade elasticity accordingly, i.e. $\varepsilon_k = 1 + \beta_k$.[34]

Equation (5) always includes importer-time ($\theta_{jk,t}$) and exporter-time ($\theta_{ik,t}$) fixed effects which fully capture respectively the terms $(\alpha_{ik,t}p_{ik,t})^{(1-\sigma_k)}$ and $P_{jk,t}^{(\sigma_k-1)}E_{jk,t}$ in Equation (4).[35] Beyond the specific structure of the import demand in Equation (4), and notwithstanding the fact that we already control for distance, we also want to control for bilateral-specific geographic-related trade costs: we therefore introduce the set of control variables $\mathbf{Z}_{ij}$, which always includes dummies for (i) a common colony, (ii) a common border, and (iii) a common language. We pool cross-sectional data across years, and therefore exploit both the cross-section and the within country-pair-product variation of data. Given the structure of fixed effects in Equation (5), we identify the tariff coefficient β_k by exploiting the cross importer-

[32] The 2007 revision of the HS classification consists of 5052 HS 6-digit products. We disregard positions 710820 (Monetary gold) and 711890 (Coins of legal tender) due to missing information on trade.

[33] It should be noted that the interpretation of the tariff elasticity as an elasticity of substitution applies only in models with a CES demand system and homogeneous firms. In other models of trade, in particular those with heterogeneous industries (Eaton & Kortum 2002) or heterogeneous firms (Chaney 2008), the trade elasticity (i.e the elasticity of trade to changes in variable trade costs) represents the shape parameter of the productivity distribution. See Head & Mayer (2014) Section 2.3 for a detailed discussion of the economic meaning of trade elasticities across different classes of trade models. Importantly, in the presence of sub-convexity of demand (Mrázová & Neary 2017), our measured elasticity is the average of the elasticities at different levels of demand (levels of trade volume) across country-pairs for a given HS6 product category. Mrázová, Neary & Carrere (2020) show that the elasticity of trade to distance (for overall trade between country-pairs) falls with the volume of bilateral trade, which is suggestive of sub-convexity of demand. We will examine below whether import demand is sub-convex in our sample.

[34] The final database, available at `https://sites.google.com/view/product-level-trade-elasticity/home`, contains a variable indicating the trade elasticity for each HS6 position.

[35] In practice, each k-specific regression includes importer-year and exporter-year fixed effects. When applied to product-specific regressions, the country-year terms subsume the country-sector-year fixed effects.

product variation in tariff imposition for each exporter-product combination ik. Importantly, since we estimate Equation (5) by product category k, the MFN tariff imposed by j is captured by the importer-time fixed effect ($\theta_{jk,t}$). To address heteroscedasticity in the error term (and the zero trade-flows problem - missing information), we follow Santos-Silva & Tenreyro (2006) and adopt (non-linear) Poisson Pseudo Maximum Likelihood - PPML - as the baseline (and preferred) estimator of Equation (5).[36]

As the source of variation used to identify β_k is mostly *cross* country pairs, an alternative approach would be running the regressions separately year by year, and including importer and exporter fixed effects only (i.e. cross-section approach). However, the cross-section approach would not capture any exporter (or importer) specific time-varying shock affecting the tariff elasticity (i.e. demand or supply shock). For this reason, we prefer the panel approach outlined in Equation (5) and consider the cross-section estimations a simple robustness check whose results are discussed in Section 3.2.

The error term $\epsilon_{ijk,t}$ accounts for the combined effect of the omitted explanatory variables in Equation (5) and the measurement error that may concern the dependent variable (such as reporting errors by the customs in j or misclassification of products by the exporter i), and the tariffs variable. While the measurement error is a remote concern here considered the high quality of both tariff and bilateral trade data used in estimations, the structure of the error terms due to omitted explanatory variables deserves a detailed discussion.[37] The main threat to identification is the potential correlation between $\tau_{ijk,t}$ and the error term (containing the omitted country-pair product specific demand shocks). This issue arises if the importer country grants tariff preferences to an exporter benefiting from a positive demand shock.[38] We discuss this in Section 4.1. In contrast, any technological and/or productivity shock affecting the competitiveness of producers of k in the exporting country i (in all their markets) is captured by $\theta_{ik,t}$ fixed effects. Finally, considered the increasing importance of preferential bilateral tariffs through PTAs, a robustness check in Section 4.2 augments Equation (5) with a dummy for the presence of an active PTA between the importing and exporting countries.

In our baseline set of estimations, showed in Figure 1, Equation (5) is estimated for each HS6 category of product k. It can alternatively be estimated by pooling the products k in sector $\kappa \in \mathcal{P}$ (with $\mathcal{P}$ being a partition of K), thus recovering average parameter for $ln(1 + \tau_{ijk,t})$ (average tariff elasticity across products k of a same sector κ). We adopt this approach, which constrains the elasticity of the other covariates to be constant across

[36]Note that relying on a strategy of country (or country-time) fixed effects estimated with a PPML is consistent as the sum of fitted export values for each exporter (importer) is equal to its actual output (expenditure): see Fally (2015).

[37]The issue of omitted variable possibly correlated with the error term is discussed below in the section dedicated to address the endogeneity concern.

[38]Conversely an idiosyncratic regulation (other than tariffs) of the importer country, targeting specifically an exporter, will affect imports without being correlated with our variable of interest. An example is the ban imposed by the European Union on Chinese honey in 2002, motivated by sanitary considerations. The ban was lifted in July 2004.

a sector's products, to obtain trade elasticities at the HS4, TiVA and GTAP levels: see Section 3.3. Figure 2 shows that the distribution of trade elasticities, when estimated at the HS 4-digit, is in line with the baseline results in Figure 1.

2.3 Identification Issues

There are four identification issues that need to be discussed before estimating trade elasticities using tariffs in a gravity framework.

First, the omission of unobserved confounding factors correlated with both tariffs and import demand may introduce bias into our baseline estimation (an *omitted-variable* bias). The inclusion of country-year fixed effects (controlling for any unobserved country-product-year specific variables in product-specific regressions), along with the geographic controls that capture the bilateral transport cost, sharply reduce omitted-variable concerns in Equation (5). As discussed in the previous section, only unobserved country-pair $\times$ product-specific shocks may continue to pose problems in this respect. To reduce concerns about omitted variable, in Section 4.1 we also follow Fajgelbaum et al. (2020) and provide a pre-trend test. The aim is to exclude the presence of a pre-existing (unobserved) trend in bilateral import demand that subsequently affects changes in tariffs. Yet the main threat to identification of Equation (5) stands from unobserved country-pair shocks. The Instrumental Variable (IV) strategy proposed in Section 4.1 further reduces the residual concerns regarding omitted variables.

Second, were tariffs at the product and exporter level to be set in response to a positive import-demand shock, the coefficient on tariffs in Equation (5) would be affected by *reverse causality*. In the vein of Shapiro (2016), we first rely on the lagged tariff variable to reduce reverse-causality concerns in Equation (5). This strategy is more reliable here considered the non-consecutive years nature of our data (three-year windows panel). The use of lagged tariff variable and the absence of a pre-existing trend in import demand reduce the reverse causality worry. The use of an IV approach in Section 4.1 further reduces the residual concerns regarding reverse causality.

Third, the identification of the import-demand elasticity through the estimation of a tariff coefficient requires that consumers in the importing country base their consumption decisions on the duty-inclusive price $p_{ijk,t} = p_{ik,t}(1 + \tau_{ijk,t})(1 + \psi_{ijk})$. We already noted the assumption of the full pass-through of the tariff in prices at destination. If pass-through is incomplete but common across destinations for a given exporter in a given year, this will be captured by the exporter-time fixed effect. Another potential issue is that in some particular developing countries with pervasive corruption, where small bribes can significantly alleviate tariffs, import demand may be insensitive to tariffs (Sequeira 2016). If the use of bribes in the importing country is exporter-invariant, it is captured by the importer-time fixed effect. However, it remains a threat to identification if the intensity of corruption in the importing country is correlated with the *bilateral* applied tariff. In this case, the estimated elasticity would be affected by the indirect effect of corruption on bilateral imports.

Last, another possible omitted variable is the distribution of firms' productivity of each exporter i for the considered product k. Trade elasticities can be estimated at different levels of disaggregation, ranging from the sector to the product or even the variety. In the latter case, it has to be estimated at the level of individual exporters using transaction-level customs data, with the challenge that export prices and export quantities are endogenous at the firm level.[39] To overcome this difficulty, and as firm-level export information over multiple countries is rare,[40] we here rely on the finest grain: the HS 6-digit product level. By doing so, we implicitly aggregate firms (with different levels of productivity) within a given exporting country-product cell. In this case the shape of the distribution of productivity within the cell will affect the observed elasticity (Chaney 2008).[41] This unobserved variable is not affecting our estimation, as exporter-product-year fixed effects $\theta_{ik,t}$ in Equation (5) control for the distribution of firms' productivity in each product-exporter cell and its evolution over time.

3 Disaggregated Trade Elasticities

This section presents the estimated trade elasticity parameters ε_k for the 5,050 product categories of the HS6 classification. Section 3.1 presents our baseline results. Section 3.2 shows a robustness check using cross-section estimations. Section 3.3 proposes an evaluation of the welfare gain from trade when using heterogenous (sector-specific) elasticities for countries at different level of development. Lastly, Section 3.4 provides evidence of the accuracy of our ε_k estimates by carrying out an ex-post evaluation of the USA-Chile trade agreement entered into force on January 1, 2004.

3.1 Baseline results

Despite the intrinsic obstacles in obtaining point estimates for k-specific tariff elasticities (i.e. limited variation in tariffs and/or trade flows for some products k), our estimations are successful. In most of the sectors, our method successfully recovers trade elasticities for most of the products within an HS section. For some HS-6 digit positions, however, the bilateral variability in tariffs is insufficient to estimate the parameter β_k in Equation (5)

[39]Fontagné, Martin & Orefice (2018) use a firm-level time-varying instrumental variable for export prices, and estimate the firm-level elasticity to tariffs controlling for how exporters absorb tariff shocks in their export prices.

[40]Bas, Mayer & Thoenig (2017) is an exception, as they are able to combine French and Chinese firm-level exports to estimate trade elasticities.

[41]Using firm-level export data for the universe of French manufacturing firms, Fontagné & Orefice (2018) estimate trade elasticities at the sector level and - in line with the theory in Chaney (2008) - show that the effect of stringent Non-Tariff Measures in reducing export flows is magnified in sectors with a more-homogeneous distribution of firm productivity (i.e. where a non-negligible share of exports is concentrated among less-productive firms).

as this variation is absorbed by our set of fixed effects. Table 5 reports such occurrences for each HS section. For Pulp of wood or other cellulosic materials, only two product-level elasticities are missing out of 144 product categories; the same observation can be made for Articles of stone, plaster, ceramic and glass (1 out of 143). Section VI (Products of chemical industries) is a little more problematic, with 743 β_k coefficients estimated out of 789 product categories. The average trade elasticities within the different HS sections in Table 5 take on reasonable values: for fairly-standardized products like Mineral products the average trade elasticity is close to -19, while this is -3.6 in highly-differentiated products like Footwear. The largest elasticity in each HS section is also indicated in Table 5, and high average figures can be driven by very large elasticities for some homogeneous products at the HS6 level (such as those for Mineral products sector).[42]

As for the statistical significance, our estimations perform fairly well: the median t-statistic is 3.1, and 72%, 67% and 57% of the estimated β_k's are significant at the 10-, 5- and 1-percent significance levels respectively.[43] The empirical distribution of negative and statistically-significant at the 1% level trade elasticities ε_k appears in Figure 1. The left tail of the empirical distribution depicted in Figure 1 has been cut at -25 to make the figure more readable, but we only obtain larger (in absolute value) trade elasticities for a very-few HS6 products (3% of the total product lines).[44] The *average* trade elasticity after excluding products with a positive tariff elasticity,[45] and setting insignificant β_k's to zero, is -5.3.[46] If we consider trade elasticities that are significant at the 5% level, the average figure is -6.0.[47] Finally, abstracting from the statistical significance of the underlying tariff elasticity (i.e. without replacing insignificant β_k values by zero), the average trade elasticity is -7.6 and

[42]This section contains our largest estimated elasticity, 123 for product code "270210" (Lignite; whether or not pulverised, but not agglomerated, excluding jet). Very large elasticities have been also obtained in previous papers. See for example the average elasticities in Broda, Greenfield & Weinstein (2006) for the HS 3-digit product headings "860" and "021".

[43]We can benchmark these figures with Kee et al. (2009), who also use HS6 data, although their estimation method and the period differ (1998-2001 instead of 2001-2016). The corresponding figures are 71%, 66% and 57%. Their median t-statistic is identical. Probit model estimation reveals that the probability of obtaining non significant tariff elasticity depends positively and significantly on whether the product is differentiated, on the average GDP of the exporting country, on the average distance covered by the traded product, and on the average tariff protection of the HS4 chapter to which the product belongs to. This probability depends negatively and significantly on the number of countries exporting the product. This probit model results are available upon request.

[44]We examine the determinants of the occurrence of very-large trade elasticities later in this section.

[45]For a small set of 97 products (1.9% of products) we obtain positive and significant tariff elasticities. These rare occurrences are more likely to be observed for product whose trade matrix is dominated by few high-income exporting countries. Organic chemicals, Inorganic chemicals, and Nuclear reactors represent almost half of the total number of occurrences.

[46]This average value may be recovered from the online dataset by (1) dropping products with positive tariff elasticities (the "positive" dummy in the online dataset), (2) replacing trade elasticities as missing if the "missing" dummy is one in the online dataset (these are products for which the tariff variable has been dropped by STATA due to collinearity with the fixed effects), and (3) replacing the trade elasticity figure by one if the underlying tariff elasticity is zero (i.e. the "zero" dummy is one in the online dataset).

[47]The median trade elasticity is 3.5 and 4.4 respectively at 1% and 5% significance level. If we set the elasticities that are statistically insignificant to the minimum statistically-significant elasticity, the average trade elasticity becomes -5.8.

the median elasticity −5.6.[48] In the remainder of the paper, to be on the conservative side, we will adopt the strictest statistical criterion and only comment on trade elasticity values that are significant at the 1% level.[49]

Our identification strategy also recovers the shipping cost elasticity to distance ρ_k. Figure 3 shows the distribution of this elasticity obtained as a ratio between the distance and tariff coefficients in Equation (5). This can be compared to the shipping-cost elasticity estimated by Hummels (2007) on US imports at the SITC 5-digit level. The average ρ in our data is 0.155 (median 0.128), to be compared to the figures of 0.151 for the 1974-2004 period for maritime transportation, and 0.160 in 2004 for air transportation in Hummels (2007).[50]

Regarding the heterogeneity in trade elasticities by product type, an interesting characterization emerges from the Rauch classification of differentiated *vs.* homogeneous products. As expected, Figure 4 shows larger and more dispersed ε_k coefficients for homogeneous than for differentiated products.[51] This pattern is more formally tested in Table 6, where we explore some empirical regularities in the size of the absolute value of the estimated trade elasticity $|\varepsilon_k|$.[52] We firstly show in columns 1 and 2 the results of an OLS regression of the absolute value of the trade elasticity on the average distance across country-pairs trading a given product k, controlling for the type of product (differentiated *vs.* homogeneous) and for time-invariant sectoral unobserved characteristics. We then show in columns 3-5 the results of probit regressions where the dependent variable is a dummy equal to one when the trade elasticity is respectively in the top first, fifth or tenth percentile of the distribution, using the same regressors.[53] There are two clear results. First, as expected, the trade elasticity is

[48] While the distribution of the product-level elasticities obtained here is centered around values that are in line with those in the literature, the comparison with trade elasticities obtained in other studies shows more differences. By aggregating our trade elasticities (simple average) at the 3-digit level of the HS classification, we obtain a correlation 0.20 with Kee et al. (2009) and 0.11 with Broda et al. (2006). The correlation is stronger with the ISIC 2-digit aggregated elasticities produced in Caliendo & Parro (2015): correlation 0.75.

[49] The statistical threshold used to define significant trade elasticities does not affect the overall shape of the elasticity distribution. In the Online Appendix Figure B1 we compare the distribution of elasticities obtained by keeping coefficients that are significant at the 1% and 5% levels and the two distributions are almost identical. Online Appendix Figures B2 and B3 plot the empirical distribution of trade elasticities based on 5% and 10% statistically-significant tariff elasticities, while Online Appendix Figure B4 shows the empirical distribution of trade elasticities independent of their underlying statistical significance. Finally, in the database available at `https://sites.google.com/view/product-level-trade-elasticity/home` we include a variable with trade elasticities values based on non-positive tariff coefficient point estimates, abstracting from their statistical significance.

[50] Note also that our estimates of distance elasticities γ_k are distributed around -1, in line with Head & Mayer (2014).

[51] Another interesting characterization of trade elasticity emerges from macro-sector comparison. Trade elasticities ε_k are more dispersed in Manufacturing than in Agriculture, although centered around the same value, see Online Appendix Figure B5. The distribution of trade elasticities estimated by dropping the country pairs with a specific tariff for product k remains qualitatively unchanged. See Online Appendix Figure B6.

[52] In table 6 we use 1% significant trade elasticities. However, the same regularities emerge from using trade elasticities based on tariff coefficient point estimates abstracting from statistical significance. See table B3 of the Online Appendix.

[53] We use the absolute value of trade elasticity to render the interpretation of the results easier, and only consider negative and statistically-significant tariff elasticities. The results in Table 6 are correlations and cannot be interpreted as causal.

smaller for differentiated products. In line with columns 1-2, we confirm in columns 3-5 that the probability of obtaining very high trade elasticities (respectively above the 1^{st}, 5^{th} and 10^{th} percentile) is smaller for differentiated products. Second, within HS 2-digit chapters, products covering (on average) a larger distance in the bilateral-trade matrix have smaller trade elasticities. This may reflect that products that are traded in spite of sizeable trade frictions (as reflected by distance) are less elastic to tariffs, or that only the most-productive firms manage to export to remote markets thanks to the inelastic demand for their products. This is in line with Spearot (2013), suggesting that high-revenue varieties (those exported to distant markets), are less affected by trade liberalization as they have lower demand elasticities. It also echoes the interpretation of the impact of composition effects on the aggregate trade elasticity to distance by Redding & Weinstein (2019), along the lines of the "shipping the good apples out" statistical regularity (Hummels & Skiba 2004).

3.2 Cross-section estimates

We adopt here a cross-section approach and estimate trade elasticities for each (product and) year separately. We adapt and replicate Equation (5) for each product and year (for years 2001, 2004, 2007, 2010, 2013 and 2017). Considered the cross-section nature of this estimations, we always include exporter and imported fixed effects only.

The first question we aim to address is whether elasticities estimated in cross-section line-up with those estimated in panel (our baseline). In Figure 5 we correlate the baseline elasticities obtained by estimating Equation (5) on our panel dataset with the average elasticity (across years) obtained using the cross-sectional approach. Although (as expected) the correlation is strongly positive, with the vast majority of product elasticities lying around the 45 degree line, for certain product categories (in particular in the stone and metals sectors HS chapters 71 and 72) the trade elasticities obtained with the two approaches differ. Notice the absence of any systematic bias of under- or over-estimation using panel approach (outliers on both sides of the 45 degree line). An alternative way of showing the similarity in panel *vs* cross-section based trade elasticity is computing the difference (in absolute value) between the values obtained with the two approaches. For the majority of products the difference is comprised between zero and two, which illustrates the similarity in the results using the two approaches.

The previous results refer to a comparison between panel and average cross-section estimates. Another question is whether the estimated cross-sectional elasticities vary significantly over time. To proceed, we report in Figure 6 the time variation in product-specific trade elasticities. This is measured by the coefficient of variation of the estimated trade elasticity across different years, for each HS 6-digit product. For most of the products, the time variation in trade elasticity is limited (i.e. coefficient of variation below 0.5), though not negligible. This is likely due to the impossibility of controlling for country-specific shocks in pure cross-section estimations, and supports the use of panel-based estimations as baseline elasticities (where country-specific shocks are captured by fixed effects).

3.3 Gains from trade

The considerable trade-elasticity heterogeneity that we have uncovered raises the question of calculating the welfare gains from trade for countries at different level of development, different sectoral domestic shares and expenditure shares.

We revisit this question using our estimated elasticities and the welfare gain from trade formula in Arkolakis et al. (2012) - ACR. Here we simply aim at computing welfare gains from trade by using sector specific trade elasticities and see how gains differ across countries of different income level. Indeed, as the level of applied tariffs is inversely correlated with the country's level of development (Table 4), the introduction of heterogenous trade elasticities in calibrated models becomes particularly relevant in evaluating the welfare impacts of trade policies in countries with different income levels.[54]

To proceed, we closely follow Arkolakis et al. (2012) and calculate the gains from trade as the negative of moving to autarky, with heterogeneous trade elasticities across sectors. The change in real income is related to the total expenditure devoted to domestic production (the domestic market share) and the trade elasticity. We use TiVA (OECD) data to compute both the share of country j's total expenditure devoted to domestic production (i.e. λ_{jj} in ACR) and country j's consumption share in sector s (i.e. η_{js}, the upper-tier in consumer utility in ACR). These shares are calculated using trade in value-added.[55] We then compare the ex-ante evaluation of the welfare change for countries with different income level.

The first step is to estimate tariff (and therefore trade) elasticities using the TiVA sector aggregation. To this end, we pool HS6 products within each TiVA sector and estimate the average tariff elasticity by TiVA sector. The empirical model used to obtain TiVA sector-specific trade elasticities is:

$$X_{ij,HS6,t}^{TiVA} = \exp\left[\theta_{i,HS6,t} + \theta_{j,HS6,t} + \beta_k^{TiVA} \ln\left(1 + \tau_{ij,HS6,t}\right) + \gamma_k^{TiVA} \ln\left(d_{ij}\right) + \zeta_k^{TiVA} \mathbf{Z}_{ij}\right] \times \epsilon_{ij,HS6,t} \tag{6}$$

[54]This question is distinct from the one raised by Ossa (2015) who compares the welfare change from the simple ACR formula to that in a multi-sector economy with heterogenous sector-level elasticities. Since the average of the inverse trade-weighted elasticities differs from the inverse of trade-weighted average elasticities, accounting for sectoral heterogeneity mechanically produces larger welfare changes. On the top of the sectoral variation in the elasticity of trade to trade costs, Giri et al. (2021) introduce sectoral heterogeneity along four additional dimensions and compare the gains from trade to their benchmark model by removing one or two sources of heterogeneity at a time.

[55]Costinot & Rodriguez-Clare (2018) stress the importance of using value-added trade flows in calculating the welfare gains from trade, as gross trade flows systematically underestimate countries' import penetration. While the share of intermediate goods in production costs amplifies the gains from trade, the share of non-traded services reduces them. Ossa (2015) shows that these two additional determinants are roughly offsetting when introduced in the calculation of the gains from trade. Here we follow Costinot & Rodriguez-Clare (2018), and consider the input-output structure of countries' production by using trade in value-added data. We consider the Manufacturing sector only, as we do not estimate trade elasticities for Services.

We run Equation (6) for each TiVA sector to produce a sectoral tariff elasticity (β_k^{TiVA}): this is the average tariff elasticity across HS6 products within the same TiVA sector.[56] The advantage of this approach is that it constrains the other parameters (e.g. distance) to be equal for all products in a given TiVA sector, and avoids the composition effect that arises in aggregate data by summing (averaging) imports (tariffs) across products within a TiVA sector (Redding & Weinstein 2019).[57] The results appear in Table 8. We exclude the pure Service-oriented sectors (such as Construction, Wholesale, Hotel and Restaurants) in the TiVA classification.[58]

Then, we compute λ_{jj}^s (the country-sector share of domestic expenditure, i.e. the inverse of the sectoral import-penetration ratio) for each country and sector, and η_{js} the country's consumption shares for the different sectors. The welfare change $\widehat{W_j}$ then becomes:

$$\widehat{W_j} = 1 - \prod_{s}^{S} \left(\lambda_{jj}^s\right)^{-\eta_{js}/\varepsilon_s} \tag{7}$$

Equation (7) applies under the important restrictions of CES preferences and Cobb-Douglas aggregation across sectors.[59] In Figure 7 we show the correlation between the welfare change of countries ($\widehat{W_j}$) and their income level in 2010. The welfare-gain estimation is larger for richer countries because developed countries have higher import penetration in low trade elasticity sectors as shown in Figure 8.[60]

3.4 The accuracy of the estimated elasticities

We have calculated trade elasticities for thousands of HS6 product categories. Although the distribution of these elasticities is centered around values that are in line with those in the literature, how can we ascertain that these elasticities are correctly distributed? This section aims to answer this question by comparing the variations in bilateral imports (and import share) at the product level predicted by our product-specific elasticities β^k to the actual variation in imports in response to a change in bilateral tariffs (an ex-post evaluation test).

Our estimated elasticities can be used to calculate the *predicted* import growth following a reduction in preferential applied tariffs due to the signature of a Preferential Trade

[56] With the exception of two service oriented sectors (i.e. Electricity, gas and water supply; R&D and other business activities), all TiVA elasticities are negative and statistically significant, making possible the calculation of the ACR formula for all sectors (i.e. there is no indefinite exponential in the ACR formula).

[57] As the specification is country pair-HS6-year specific, we include both exporter-HS6-year and importer-HS6-year fixed effects to fully capture the multilateral resistance term.

[58] We use a similar empirical strategy to estimate trade elasticities at the level of the GTAP sector (revision 10). We consider GTAP sectors that include at least one HS6 product with non-missing tariffs. The results appear in Online Appendix Table B4.

[59] In monopolistic competition with free entry one more variable enters in the calculation of welfare change, namely the industry shares in employment. As this information is missing for a number of countries in TiVA, we did not use this approach.

[60] The alternative explanation based on consumption shares of countries with different income levels in low trade elastic sectors is not supported by the data.

Agreement (PTA). This exercise mirrors exactly the spirit of our estimation strategy: the trade elasticities estimated here correspond to the substitution of imports from different origins, and this is what is captured by our strategy implemented at the bilateral level. The comparison between *predicted* and *effectively-observed* post-PTA import growth will help establish the reliability of our product-level elasticities. As a benchmark, we also compare the predicted import growth obtained using product-specific heterogeneous elasticities to that from a homogeneous (average) trade elasticity $\bar{\beta}$.[61]

The US-Chile Agreement is well suited to test the accuracy of our trade elasticity estimates. This agreement, entered into force in January 2004, allows us having sufficient pre- and post-implementation period to calculate both the variation in tariffs implied by the policy, and the observed variation in imports after its implementation. Also, the pure bilateral nature of the US-Chile agreement reflects the notion of trade elasticity (based on the elasticity of substitution between varieties).[62] Moreover, in both the pre- and post- PTA period, the US represented on average almost one-fifth of total Chilean imports. Compared to 2001, Chile reduced in 2004 its (average) preferential import tariff towards US products by 93% (from an average applied tariff of 6.9% to 0.5%), with a peak of a 100% tariff cut (i.e. the complete removal of import tariffs) for many organic and inorganic chemical products (HS chapters 28 and 29) as well as for many plastic and rubber products (HS chapter 40). We run this ex-post evaluation focusing on products with (i) non-zero *ad valorem* tariffs in the pre-PTA period (year 2001), (ii) the same HS 6-digit classification over time (i.e. no contrasting revisions codes), (iii) an actual tariff cut in the 2001-2004 period and (iv) imports that rose over the post-PTA period. Sampling rules (i)-(iv) allow us to focus on products for which the ex-post PTA evaluation is economically relevant, and for which heterogeneous *vs.* homogeneous tariff elasticities matter for predicting import growth.[63]

Based on the observed tariff cut in percentage points, we calculate the *predicted* percentage change in Chilean imports from the US using heterogeneous *vs.* homogeneous tariff elasticities and correlate them with the post-PTA *observed* bilateral import growth (over the 2004-2007 period).[64] The results appear in Table 7 columns (1)-(3). The top part of the

[61] To aggregate from HS6 specific to a product-invariant (homogeneous) elasticity we rely on a weighted average (with the product export share over total 2001 exports as the weight). This is required when aggregating (by averaging) very different products. The results remain qualitatively unchanged if we use a simple average to approximate the homogeneous trade elasticity.

[62] More details on the US-Chile agreement can be found on the dedicated page `https://ustr.gov/trade-agreements/free-trade-agreements/chile-fta`.

[63] For products with no tariff cut (i.e. those violating sampling rules i and iii), the predicted import growth with the heterogeneous *vs.* homogeneous tariff elasticity would be the same (zero). Products violating condition (iv) likely experienced an unobserved shock (import demand) that reduced imports at the same time as tariffs fell.

[64] Tariff cut is from the tariff data discussed in Section 1.1. The predicted import growth is simply the product of the tariff elasticity β_k in Equation (5) and the percentage tariff reduction implied by the PTA, here approximated by the change in tariffs between 2001 (pre-PTA) and 2004 (the year of entry into force of the PTA). As this exercise aims to evaluate the accuracy of the elasticities proposed here for model calibration, the ex-post evaluation exercise uses the values of the elasticities made available online: these come from the estimation of Equation (5) with positive and insignificant estimates replaced by the average

table shows the correlation between the *observed* post-liberalization Chilean import growth from the US (2004-2007) and *predicted* import growth using *heterogeneous* elasticities; the bottom part of the table carries out the same exercise using a *homogeneous* elasticity. We condition these correlations respectively on HS 1-digit section fixed effects (column 1), HS 2-digit chapter fixed effects (column 2) and HS 4-digit heading fixed effects to absorb any sector-specific factor that may have affected Chilean import growth independently of tariff cuts (i.e. some import-demand shock that is uncorrelated with tariff cuts). An alternative way of purging correlations from product-specific demand shock is comparing predicted and observed change in product-level *share* of Chile's imports that come from the US.[65] This robustness check is reported in column (4) of Table 7.[66]

The results show clear evidence of the accuracy of the product-specific tariff elasticities over the average (homogeneous) tariff elasticity in predicting import growth. Independently of the type of fixed effects, the predicted import growth with heterogeneous tariff elasticities is positively and significantly correlated with the observed import growth, as opposed to the import growth that is predicted with a homogeneous elasticity. Despite a slightly lower precision in estimates when using growth in import shares (i.e. reduced sample) in column (4) of Table 7,[67] the accuracy of the estimated elasticities holds even after controlling for product-specific import demand shocks. Figure 9 provides a graphical representation of the results, where we correlate post-PTA *observed* import growth (horizontal axis) to *predicted* import growth using heterogeneous (panel a) and homogeneous (panel b) tariff elasticities (vertical axis). Both observed and predicted import growth are conditioned on HS 1-digit section fixed effects. There is a strong positive correlation with heterogeneous elasticities (panel a), but no correlation with the homogeneous elasticity (panel b). Products with predicted large import growth but stable observed imports may reflect some HS 6-digit specific factors acting as a brake on imports despite the lower tariffs. This is, for example, the case of product HS "290516" (alcohols; saturated monohydric, octanol and isomers thereof), on which Chile applies a non-tariff measure restricting or preventing the use of certain substances contained in food and feed imports.

Overall, this exercise not only underlines the accuracy of our estimated tariff elasticities, it also highlights the potential bias in predicting import growth based on homogeneous (rather than heterogeneous) tariff elasticities.

HS-4 trade elasticities.

[65]To compute these shares we use the post-PTA value of Chilean imports from the Rest of the World.

[66]We are grateful to the editor for suggesting this alternative approach.

[67]We end up with less observations in column (4) because the fourth condition for selecting products has now to be expressed in shares and proves to be more restrictive: we run the ex-post evaluation in column (4) focusing on products with imports shares (instead of imports values as in columns 1 to 3) that rose over the post-PTA period.

4 Robustness checks

We now carry out a battery of robustness checks to (i) address the endogeneity of tariffs to import flows; (ii) establish whether/how the inclusion of a PTA dummy affects our results; (iii) include in turn country-pair fixed effects to control for unobservable time-invariant and trend-specific country-pair characteristics; and last (iv) estimate import-demand elasticities that are consistent with a non-CES demand system. All of these robustness checks suggest that our baseline estimates are valid.

4.1 Endogeneity

As liberalization episodes generally start by lowering tariffs for industries that are only slightly affected by foreign competition, or on a declining trend that induces rising import competition, tariff cuts may be only spuriously correlated with imports.

Table 9 correlates the dynamics of import demand *prior* to the change in the tariff set by country j on product k exported by i in year $\hat{t}$, with the subsequent change in $\tau_{ijk,t}$. In practice we simply calculate the correlation between $\left(\ln\left(Import_{ijk,t}\right) - \ln\left(Import_{ijk,t-1}\right) \mid t < \hat{t}\right)$ and $\left(\ln\left(1+\tau_{ijk,t}\right) - \ln\left(1+\tau_{ijk,t-1}\right) \mid t > \hat{t}\right)$. The figures in Table 9 suggest little correlation – no matter which fixed effects are included – so that (on average) the varieties ik targeted by a trade policy in country j did not exhibit a different trajectory before the actual tariff change. Trade liberalization episodes in our dataset did not follow specific trends in bilateral import demand. The lack of any pre-existing trend, and the inclusion of country-year fixed effects controlling for any unobserved country-product-year specific factors (along with gravity controls) reduce considerably the omitted-variable concerns, so that we consider our baseline PPML trade-elasticity estimated to be unbiased.

A second issue is that the imposition of high tariffs on certain exporting countries and products may aim to extract rents from an exporter with considerable market power. The political economy of protection provides a similar rationale for endogenous tariffs: domestic industries affected by increasing import competition will lobby for protection. Accordingly, tariffs should vary with the inverse penetration ratio and the price elasticity of imports (Gawande & Bandyopadhyay 2000). If an importing country sets tariff protection based on the level of imports from a specific exporter, imports and tariffs may appear to be *positively* correlated, so that the tariff coefficient β_k is positively biased (*via* reverse causality).

At the level of detail considered here (HS6 products), the penetration ratio is not observable as we have no expenditure information in the importing country. This precludes any instrumentation based on this common theoretical argument, and we resort to lagged variables as in Shapiro (2016), who estimates trade elasticities for 13 sectors using shipping costs (and not trade policy). Given the non-consecutive year nature of our dataset, and considering the results of the pre-existing trend test discussed above, the use of lagged tariffs alleviates the concern that the contemporaneous level of imports from a specific exporter correlates with the tariffs imposed three years beforehand. Figure 10 compares our baseline PPML trade-elasticity estimates to those using three-year lagged tariff information. The trade-elasticity distributions with contemporaneous and lagged tariffs are not notably different, reinforcing our conclusion that endogeneity due to potential reverse causality does not invalidate our results.

As a further robustness check, we instrument the bilateral HS6 specific tariff with the average tariff imposed on other similar products (i.e. other HS 6-digit products within the same HS 4-digit heading). Our instrument for the bilateral product-specific tariff τ_{ijkt} is therefore the average tariff imposed by country j on i on other products $s \neq k$:

$$\tau_{ijkt}^{IV} = \frac{1}{S} \sum_{s \neq k} \tau_{ijst} \tag{8}$$

with s and k belonging to the same HS 4-digit heading and S being the total (minus 1) number of HS 6-digit items within a given 4-digit heading. This instrumental variable has the same variability as the bilateral tariff τ_{ijkt} and allows us to retain the specification in Equation (5). The IV is valid if (i) the level of imports of country j from i of product k is not correlated with the tariff imposed on a different products s, and (ii) the tariff imposed on product s has an impact on the imports of k only through its effect on the bilateral tariff τ_{ijkt}. The exclusion restriction (i) is supported by the political-economy argument suggesting that the importer country reacts to import shocks (if any reaction happens) by protecting the specific product k. The validity of the IV is, however, challenged if a ijk specific import shock contributes to define the ijk specific tariff, and this correlates with the tariffs imposed in products s. The exclusion restriction (ii) is plausibly satisfied as products belonging to a given 4-digit heading are only imperfectly-substitutable for each other, and any change in s-specific tariffs will likely re-direct the import demand of country j toward an alternative supplier i for the same s, rather than to another product k (note that any jkt-specific diversion effect from a change in the tariff on product k is captured by jkt fixed effects). So, any change in s specific tariffs (IV) is unlikely to have a direct impact on the import demand for product k.

The trade elasticities from 2SLS estimation appear in Figure 11 as the dashed line, and are qualitatively the same as those from OLS estimation (the dotted line).[68] Were reverse causality to play a role in our log-linear estimations, then controlling for this *via* 2SLS should have produced larger tariff elasticities (more negative) and therefore higher trade elasticities. As the trade elasticities obtained *via* OLS and 2SLS are qualitatively the same, we are reassured that bilateral tariffs are not endogenously set as a response to the competitive pressure of the exporter country (as also suggested by our pre-trend test in

[68] This is the correct comparison because the 2SLS estimator (as the OLS) is a log-linear model that does not consider zeros.

Table 9).[69]

4.2 The role of PTAs and time-varying trade costs

Our evidence so far is based on Equation (5), which does not control for the presence of PTAs between trade partners. Consequently, any preferential market access is then captured by the applied tariffs, and our tariff elasticity β_k could simply reflect the impact of PTAs that may go beyond a simple market-access effect. PTAs are signal of good political and business relationships between the PTA partners, who are possibly engaged in the mutual recognition of standards and certification procedures, for example. This may affect bilateral trade, and so introduce omitted-variable bias in Equation (5). To address these potential concerns, Figure 12 compares the baseline distribution of ε_k (the unbroken line) to the empirical distribution controlling for PTA presence (the dashed line) in Equation (5).[70] The two distributions are very similar, suggesting that there is no systematic bias from PTA omission.

As discussed in Section 2.2, a natural concern on the empirical specification in Equation (5) is why not adding country-pair fixed effects. The dotted line in Figure 13 shows the trade-elasticity distribution when we control for country-pair fixed effects. The previous conclusions continue to hold, but elasticities are now less precisely estimated because country-pair fixed effects absorb specific systematic patterns of tariff schedules, such as preferential tariffs applied to most of the goods in a given country-pair, and hence much of the variation in bilateral applied tariffs.[71] Consistent with Boehm et al. (2020) elasticities estimated with country-pair-product fixed effects also have a lower magnitude.[72]

Tariff-elasticity estimations may be also affected by the omission of *unobserved* time-varying trade costs (such as changes in the cost of shipping goods between countries over time). To partially control for this omission, we include country-pair specific time trends in the baseline estimation.[73] The results in Figure 13 show that controlling for these trends reduces the average trade elasticity.[74]

4.3 Trade Elasticity with non-CES preferences

We motivated our equation to be estimated using a CES demand system. However, CES-based preferences may lead to biased gravity estimations when conducted at a very disag-

[69] The relevance of our IV is supported by the statistical significance of the first-stage coefficient and their point estimates, which are on average around one in Figure B8 in the online Appendix.

[70] The list of PTAs is taken from the WTO (see `http://rtais.wto.org/UI/PublicAllRTAList.aspx`).

[71] The median t-statistic is now 1.5 instead of 3.1. The reduction in elasticity t-stat is common across sectors (see Online Appendix table B5).

[72] Estimations with country-pair fixed effects produce missing tariff elasticities for 19 HS 6-digit products.

[73] By simply interacting distance with year-dummies only partially control for (linearly) time-varying transportation costs, and produces an average trade elasticity of -8.0.

[74] Estimations with country-pair specific trend produce missing tariff elasticities for 113 HS 6-digit products.

gregated level (Mrázová et al. 2020). Beyond our baseline CES-based estimations, we would therefore want to relax the constant-elasticity assumption, and follow Mrázová et al. (2020) in estimating trade elasticities that are consistent with more-general (but still theoretically-tractable) additively-separable preferences.[75]

The elasticity to trade cost (tariffs and/or distance) should now depend on the volume of trade, and under the subconvexity assumption we should expect tariff elasticities to fall (in absolute value) with trade volume. Empirically, this translates into the quantile estimation of Equation (5). Note that we are particularly interested here in the variation of the *tariff* elasticity across quantiles, as variations in the *distance* between i and j affect the volume of trade through a combination of the trade elasticity (ε) and the elasticity of the shipping cost to distance (ρ).

Each quantile $q \in (0, 1)$ denotes the value[76] of the dependent variable that partitions the distribution of product-specific bilateral imports ($X_{jik,t}$) into a proportion q below and $1-q$ above. Our baseline equation can therefore be estimated for each quantile q of imports. In doing so, we follow Machado & Santos Silva (2019) and adopt the Method of Moments-Quantile Regression technique that allows the inclusion of the large sets of fixed effects in Equation (5).[77] Unfortunately, available econometric software routines do not allow the application of quantile approaches to non-linear models (such as the PPML used in our baseline), so we here use a log-linear quantile estimator.[78] As a compromise to minimize the bias from zero trade flows in the log-linear model, we limit the amount of zeros by (i) pooling all of the HS 6-digit products k within a given HS 4-digit heading to obtain quantile q different from zero[79] and (ii) running log-linear models only for higher quantiles ($q \geq 25$), where the problem of zeros is reduced. For each quantile $q \geq 25$ and HS 4-digit heading we then estimate the following regression (with distance d_{ij} included in the set of controls $\tilde{\mathbf{Z}}_{ij}$):

$$X_{ijk,t,q}^{HS4} = \theta_{it} + \theta_{jt} + \beta_q^{HS4} \ln(1 + \tau_{ijk,t}) + \zeta \tilde{\mathbf{Z}}_{ij} + \epsilon_{ijk,t,q} \tag{9}$$

Equation (9) produces for each quantile q a distribution of HS 4-digit specific trade elasticities. Figure 14 summarizes the moments of these quantile-specific trade-elasticity distributions, which we find to be not statistically different across quantiles.[80] This suggests that the baseline results based on the CES demand system can be considered valid and unbiased.

[75] Note that additively-separable preferences nest the CES case.

[76] As we have incomplete information on trade volumes (missing observations) we rely on trade values.

[77] In STATA this is implemented by the xtqreg routine.

[78] The Method of Moments-Quantile Regression can be theoretically applied to a non-linear PPML model. See Machado & Santos Silva (2019) Section 3.2 for a discussion of the quantile approach in non-linear models with large sets of fixed effects.

[79] By applying the quantile approach to each specific HS 6-digit product, we would face a huge amount of zeros, implying many quantiles (up to the 50^{th} or 75^{th} in some cases) being zero, rendering impossible any meaningful quantile estimation.

[80] Table B6 in the online Appendix shows the mean and standard deviation of the HS 4-digit specific trade elasticities for each quantile q.

5 Conclusion

In this paper we identify trade elasticities at the HS6 product level entirely through changes in tariffs, without resorting to the prices of imports generally measured by disaggregated unit values and therefore subject to measurement error and simultaneity bias. We exploit the variation over the 2001-2016 period in bilateral applied tariffs for each product category and the widest-possible set of importers, and obtain trade elasticities for 5,050 HS 6-digit products. In the process, we also obtain the elasticity of shipping costs with respect to distance for each product. We calculate the welfare gains from trade for countries at different levels of development using our sector-specific trade elasticities. This is carried out *via* a simple exercise in line with Arkolakis et al. (2012). We show that using heterogeneous trade elasticities produces larger estimations of welfare gains from trade for developed countries due to high import penetration in low-elastic sectors. Although we obtain an average trade elasticity in line with that in the literature, we shed light on the wide range around the value that is generally used to calibrate empirical exercises. Using our trade elasticity estimates, the *observed* (ex-post) and *predicted* product-level changes in import demand after trade liberalization episodes line up fairly well. This highlights the importance of using product-specific trade elasticities in calibrating models of trade.

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Tables and Figures

Table 1: The list of importing countries included in the estimation of Equation 5.

Albania	Dominica	Latvia	Saint Lucia
Algeria	Dominican Republic	Lebanon	Saint Vincent & Grenadines
Antigua and Barbuda	Ecuador	Libya	Saudi Arabia
Argentina	Egypt	Lithuania	Senegal
Armenia	El Salvador	Macedonia	Seychelles
Australia	Equatorial Guinea	Madagascar	Singapore
Austria	Eritrea	Malawi	Slovakia
Azerbaijan	Estonia	Malaysia	Slovenia
Bahamas	Ethiopia	Maldives	Solomon Islands
Bahrain	Finland	Mali	South Africa
Bangladesh	France	Malta	South Korea
Barbados	Gabon	Mauritania	Spain
Belarus	Georgia	Mauritius	Sri Lanka
Belize	Germany	Mexico	Sudan
Benin	Ghana	Moldova	Suriname
Bermuda	Greece	Morocco	Sweden
Bhutan	Grenada	Mozambique	Switzerland
Bolivia	Guatemala	Myanmar	Syria
Bosnia and Herzegovina	Guinea Bissau	Nepal	Tajikistan
Brazil	Guyana	Netherlands	Tanzania
Brunei Darussalam	Honduras	New Zealand	Thailand
Burkina Faso	Hong Kong	Nicaragua	Togo
Cambodia	Hungary	Niger	Trinidad and Tobago
Cameroon	Iceland	Nigeria	Tunisia
Canada	India	Norway	Turkey
Central African Rep.	Indonesia	Oman	Uganda
Chad	Iran	Pakistan	Ukraine
Chile	Ireland	Panama	United Arab Emirates
China	Israel	Papua New Guinea	United Kingdom
Colombia	Italy	Paraguay	United States of America
Congo	Jamaica	Peru	Uruguay
Costa Rica	Japan	Philippines	Uzbekistan
Côte d'Ivoire	Jordan	Poland	Vanuatu
Croatia	Kazakhstan	Portugal	Venezuela
Cuba	Kenya	Qatar	Vietnam
Cyprus	Kuwait	Russia	Yemen
Czech Republic	Kyrgyzstan	Rwanda	Zambia
Denmark	Laos	Saint Kitts and Nevis	Zimbabwe

Table 2: The share of non-missing importer-exporter-HS6 cells with zero *vs*. non-zero tariffs (divided into MFN, preferential and non-WTO).

	Share of importer-exporter-product cells with:			
	Zero Applied Tariffs	Non-zero Applied Tariffs		
		MFN	*Preferential*	*Non-WTO*
2001	18.7	67.4	13.0	1.0
2004	31.0	65.6	3.3	0.1
2007	35.7	60.8	3.2	0.4
2010	37.8	58.1	3.6	0.5
2013	39.5	55.9	4.1	0.5
2016	40.1	56.3	3.6	0.1

Notes: Columns 2 and 3-5 list the share of non-missing importer-exporter-HS6 combinations with respectively zero and non-zero tariffs in force. Columns 3-5 show the share of MFN, preferential and non-WTO non-zero tariffs. *Source*: MAcMap-HS6, authors' calculations.

Table 3: The within *vs.* between variation in product-level bilateral applied tariffs by HS section, 2001-2016.

		Variance	
		Within	*Between*
I	Live Animals and Animal Products	0.112	0.217
II	Vegetable Products	0.104	0.194
III	Animal or vegetable fats and oils	0.074	0.136
IV	Prepared foodstuffs, beverages and tobacco	0.159	0.259
V	Mineral products	0.033	0.060
VI	Products of chemical industries	0.038	0.061
VII	Plastic and articles thereof	0.043	0.079
VIII	Raw hides and skins, leather and article thereof	0.051	0.104
IX	Wood/Cork and articles of Wood/Cork;	0.063	0.101
X	Pulp of wood or other cellulosic materials	0.040	0.075
XI	Textile and textile articles	0.100	0.116
XII	Footwear, Headgear, Umbrellas and prepared feathers	0.070	0.126
XIII	Articles of stone, plaster, ceramic and glass	0.045	0.100
XIV	Natural cultured pearls and precious stones and metals	0.050	0.109
XV	Base metals and articles of base metals	0.038	0.075
XVI	Machinery and mechanical appliances and electrical machinery	0.037	0.067
XVII	Vehicles, Aircraft and transport equipment	0.050	0.092
XVIII	Optical, photographic, precision and medical instruments	0.042	0.079
XIX	Arms and ammunitions	0.104	0.209
XX	Miscellaneous	0.053	0.108
XXI	Works of art	0.047	0.106

Notes: To construct this table we calculated the *within* and *between* variance for each HS6 product. The HS6 variances are then aggregated to the HS-section level as simple averages. *Source*: MAcMap-HS6, authors' calculations.

Table 4: The average applied import tariff by income group: high, upper-middle, lower-middle and low.

	High income	Upper-middle income	Lower-middle income	Low income
2001	3.8	11.8	18.1	14.4
2004	3.0	11.7	13.4	14
2007	2.7	10.1	13.4	12.2
2010	2.5	9.6	11.9	12.1
2013	2.4	9.3	10.5	11.8
2016	2.5	7.9	10.1	11.2

Notes: This table lists the mean import tariff for countries in different income groups. The mean is calculated by averaging applied tariffs within a given importer-product combination (across exporters), averaging within importing country, and finally averaging by income-level group of the importer. The final averaging follows the World Bank classification of countries' income levels, and define poor and middle-income countries as "developing" while high-income countries are "developed".

Table 5: The descriptive statistics for trade elasticities by HS section.

Section	Description	Average	Std Dev	Min	No. of HS6	No. of HS6 non-missing ε_k
I	Live Animals and Animal Products	-7.54	9.08	-70.55	228	222
II	Vegetable Products	-6.06	4.55	-37.51	256	251
III	Animal or vegetable fats and oils	-8.53	8.69	-46.70	45	43
IV	Prepared foodstuffs, beverages and tobacco	-6.17	4.50	-29.19	193	193
V	Mineral products	-18.50	17.68	-122.97	148	141
VI	Products of chemical industries	-10.33	10.67	-117.08	789	743
VII	Plastic and articles thereof	-8.39	7.20	-63.41	211	211
VIII	Raw hides and skins, leather and article thereof	-5.59	4.67	-20.20	69	67
IX	Wood/Cork and articles of Wood/Cork;	-8.47	8.12	-61.96	93	93
X	Pulp of wood or other cellulosic materials	-9.93	7.42	-62.82	144	142
XI	Textile and textile articles	-7.15	6.86	-51.42	801	792
XII	Footwear, Headgear, Umbrellas and prepared feathers	-3.61	2.77	-10.67	49	46
XIII	Articles of stone, plaster, ceramic and glass	-6.62	4.19	-21.26	143	142
XIV	Natural cultured pearls and precious stones and metals	-13.59	13.52	-68.81	51	50
XV	Base metals and articles of base metals	-9.59	9.76	-67.13	568	557
XVI	Machinery and mechanical appliances and electrical machinery	-6.08	5.55	-38.17	769	752
XVII	Vehicles, Aircraft and transport equipment	-10.46	8.53	-40.58	131	129
XVIII	Optical, photographic, precision and medical instruments	-5.61	5.53	-45.94	217	208
XIX	Arms and ammunitions	-6.52	5.14	-13.65	20	20
XX	Miscellaneous	-4.85	3.42	-14.39	118	117
XXI	Works of art	-5.96	4.37	-12.18	7	7

Notes: This table lists the descriptive statistics (mean, standard deviation, minimum and non-missing values) for the ε_k parameter estimated as in Equation (5), for each HS section. The numbers in columns 3-5 are calculated using non positive trade elasticity abstracting for their significance level. *Source*: Authors' calculations.

Table 6: OLS regression of the *absolute* value of the trade elasticity and probit regressions for the probability of very-high trade elasticity.

Dep var:	$\lvert\varepsilon_k\rvert$		Top-Elasticity dummy		
	(1)	(2)	(3)	(4)	(5)
Av. dist. across pairs ij (ln)	-0.609	-1.470**	0.175	0.088	-0.129
	(0.581)	(0.621)	(0.366)	(0.219)	(0.150)
Differentiated	-6.552***	-4.923***	-0.941*	-0.892***	-0.691***
	(0.461)	(0.626)	(0.506)	(0.234)	(0.149)
Estimator	OLS	OLS	Probit	Probit	Probit
Definition Top-Elast.			$\lvert\varepsilon_k\rvert > 1pct$	$\lvert\varepsilon_k\rvert > 5pct$	$\lvert\varepsilon_k\rvert > 10pct$
HS1 fixed effects	yes	no	no	no	no
HS2 fixed effects	no	yes	yes	yes	yes
Observations	2,378	2,378	478	1,214	1,642

Notes: The dependent variable in columns 1-2 is the absolute value of the trade elasticity when negative ($\varepsilon_k < 0$). The dependent variable in columns 3-5 is a dummy for the trade elasticity (when $\varepsilon_k < 0$) being above the 1^{st}, 5^{th} and 10^{th} percentile of the distribution. The number of observations in columns (3)-(5) reduces because non-linear (Probit) estimator drops observations perfectly predicted by fixed effects (i.e. HS6 products in HS2 chapters containing always non-top elasticities). Robust standard errors appear in parentheses.

Table 7: The correlation (OLS estimates) between observed and predicted Chilean growth in imports (and import share) from the US in the post-PTA period (2004-2007).

Dep var:	*Observed* 2004-2007 change in Chilean			
	imports			import share
	(1)	(2)	(3)	(4)
Predicted imports using β^k	1.948***	2.130***	1.946**	1.710*
	(0.338)	(0.390)	(0.776)	(1.010)
Predicted imports using $\bar{\beta}$	0.523	0.032	0.240	0.367
	(1.149)	(1.393)	(1.819)	(0.226)
HS1 fixed effects	Yes	No	No	No
HS2 fixed effects	No	Yes	No	No
HS4 fixed effects	No	No	Yes	No
Observations	199	199	199	141

Notes: Columns (1)-(3) show conditional correlation between predicted and observed growth in Chilean imports from US. There are 199 HS6 product categories that satisfy the sampling rules (i)-(iv) discussed in Section 3.4. Column (4) shows the conditional correlation between predicted and observed growth in the product-level *share* of Chile's imports originating from US. Robust standard errors appear in parentheses.

Table 8: Trade elasticity ε_k by TiVA 2016 sectors used to calculate the gains from trade in Section 3.

TiVA Industry code	Heading	Elasticity ε_k
C01T05	Agriculture, hunting, forestry and fishing	-2.91
C10T14	Mining and quarrying	-3.41
C15T16	Food products, beverages and tobacco	-4.17
C17T19	Textiles, textile products, leather and footwear	-4.71
C20	Wood and products of wood and cork	-8.80
C21T22	Pulp, paper, paper products, printing and publishing	-8.21
C23	Coke, refined petroleum products and nuclear fuel	-3.67
C24	Chemicals and chemical products	-10.56
C25	Rubber and plastics products	-6.75
C26	Other non-metallic mineral products	-4.79
C27	Basic metals	-7.39
C28	Fabricated metal products	-4.22
C29	Machinery and equipment, nec	-5.01
C30T33X	Computer, electronic and optical equipment	-5.14
C31	Electrical machinery and apparatus, nec	-4.11
C34	Motor vehicles, trailers and semi-trailers	-8.92
C35	Other transport equipment	-8.99
C36T37	Manufacturing nec; recycling	-4.06
C40T41	Electricity, gas and water supply	NS
C73T74	R&D and other business activities	NS
C90T93	Other community, social and personal services	-8.35

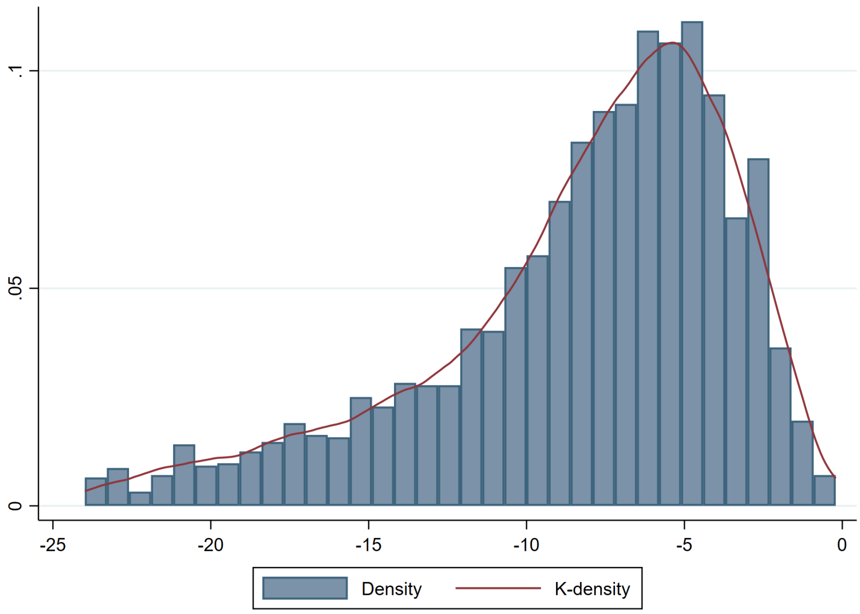
Note: We consider TiVA sectors that include at least one HS6 product with non-missing tariff information.

Table 9: Tests for pre-existing trends.

Dep Var:	Average import growth before the first change in tariff				
Avg tariff growth after the first change in tariff	0.134 (0.252)	-0.031 (0.265)	0.073 (0.134)	0.079 (0.137)	0.431 (0.384)
Exporter FE	No	No	Yes	No	No
Importer FE	No	No	Yes	No	No
Product FE	No	Yes	Yes	Yes	No
Exporter x Importer FE	No	No	No	Yes	No
Exporter x Product FE	No	No	No	No	Yes
Importer x Product FE	No	No	No	No	Yes
Observations	1,130,580	1,130,569	1,130,564	1,129,206	1,005,049
R-squared	0.000	0.013	0.043	0.067	0.338

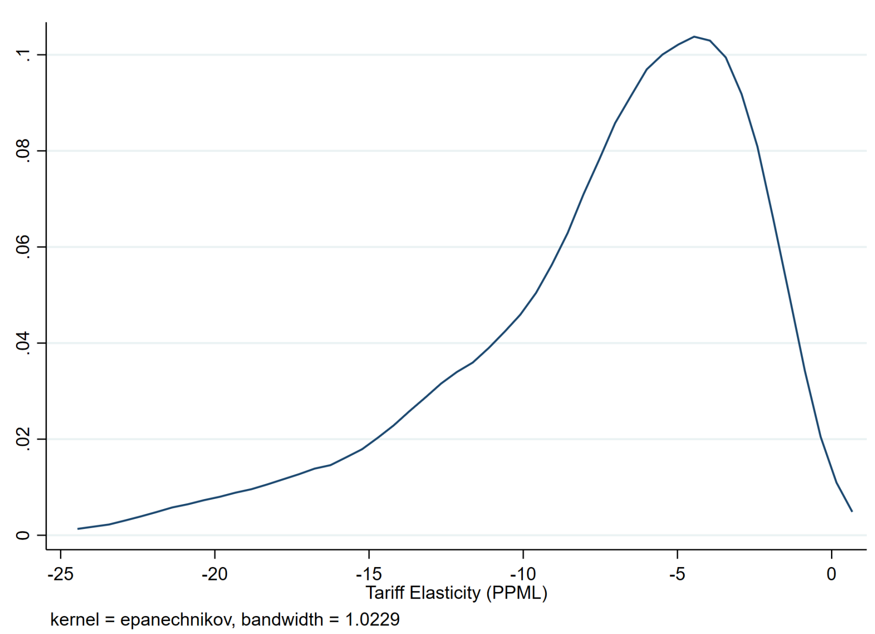
Notes: This table shows the pre-trend test for import demand. The dependent variable is the average growth rate of imports (i.e. $\ln(Import)_{ijk,t}$ - $\ln(Import)_{ijk,t-1}$) before the first change in the tariff imposed by importer i on variety jk. The explanatory variable is the average growth rate in tariffs after the first change in tariff ($ln(1+\tau_{ijk,t})$ - $ln(1+\tau_{ijk,t-1})$). *Source*: Authors' calculations.

Figure 1: The empirical distribution of trade elasticities ε_k across all products (PPML estimations).



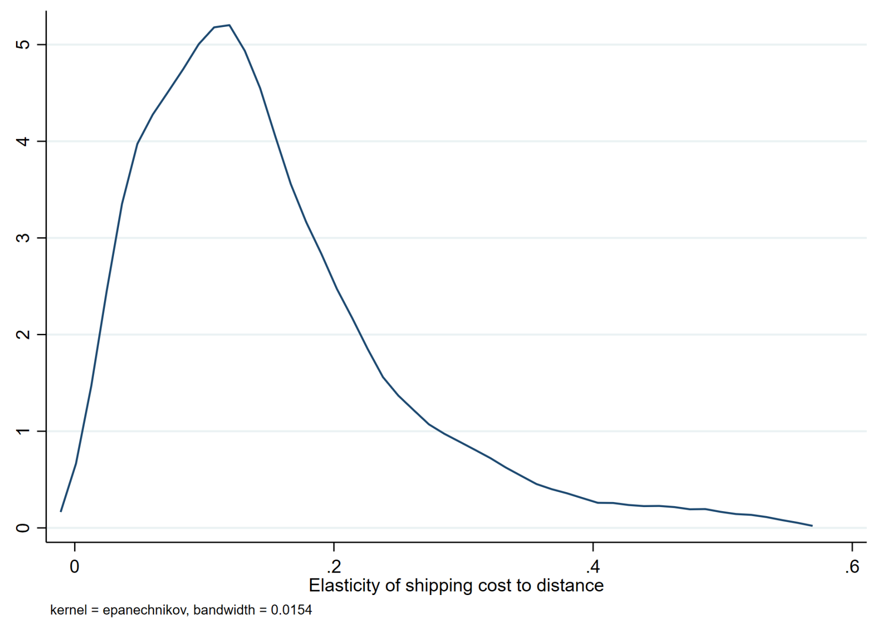
Note: This is the empirical distribution calculated for HS-6 products with $\varepsilon_k < 0$. *Source*: Authors' calculations.

Figure 2: The empirical distribution of trade elasticities across all HS 4-digit headings.



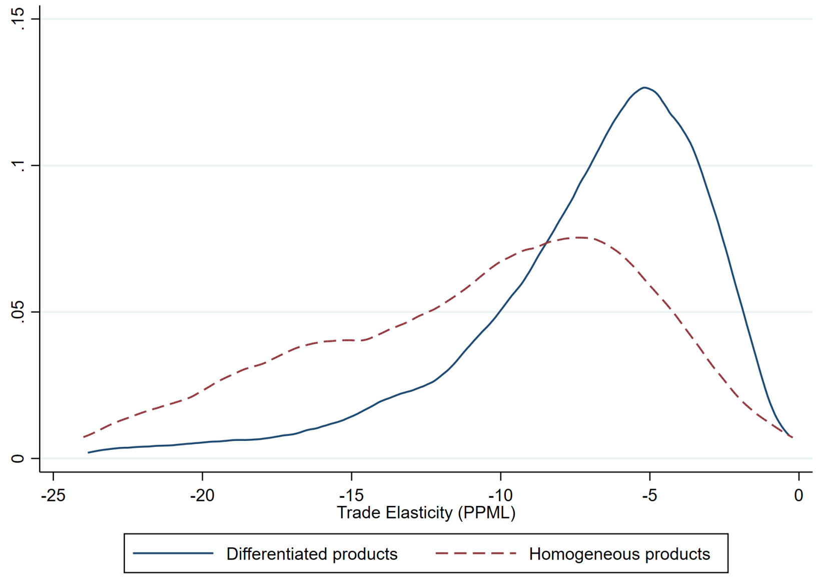
Note: The empirical distribution is calculated on HS-4 headings with $\varepsilon_k < 0$. *Source*: Authors' calculations.

Figure 3: The product-specific empirical distribution of the shipping-cost elasticity to distance (i.e. $\rho_k = \gamma_k/\beta_k$).



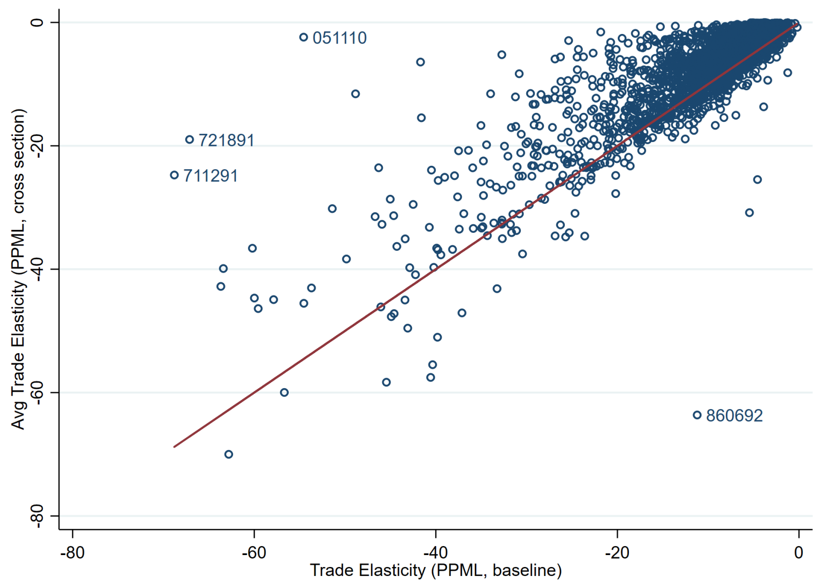
Notes: The empirical distribution is calculated on HS-6 products with negative distance to tariff elasticities. *Source*: Authors' calculations.

Figure 4: The empirical distribution of trade elasticities. Homogeneous *vs*. Differentiated products (based on the Rauch classification).



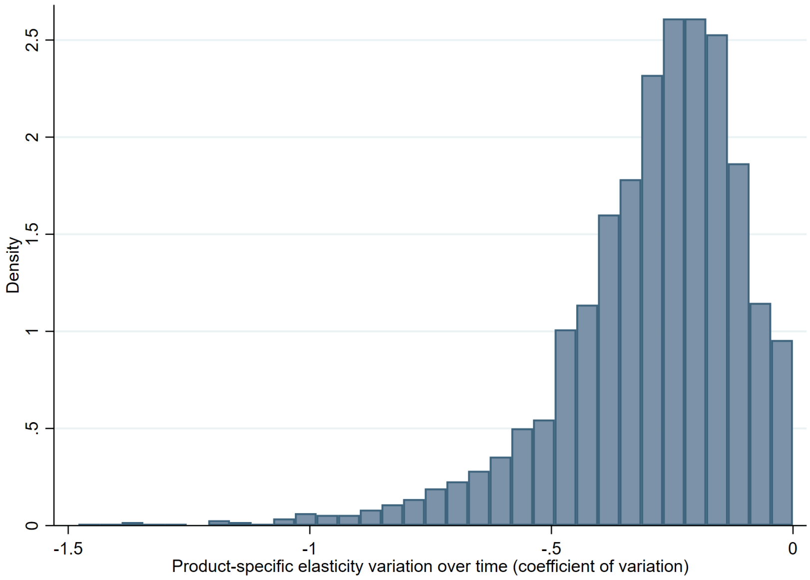
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$. *Source*: Authors' calculations.

Figure 5: Correlation between baseline trade elasticity estimations (PPML, panel) and the trade elasticity obtained by averaging HS6 elasticity across years (PPML, cross section)



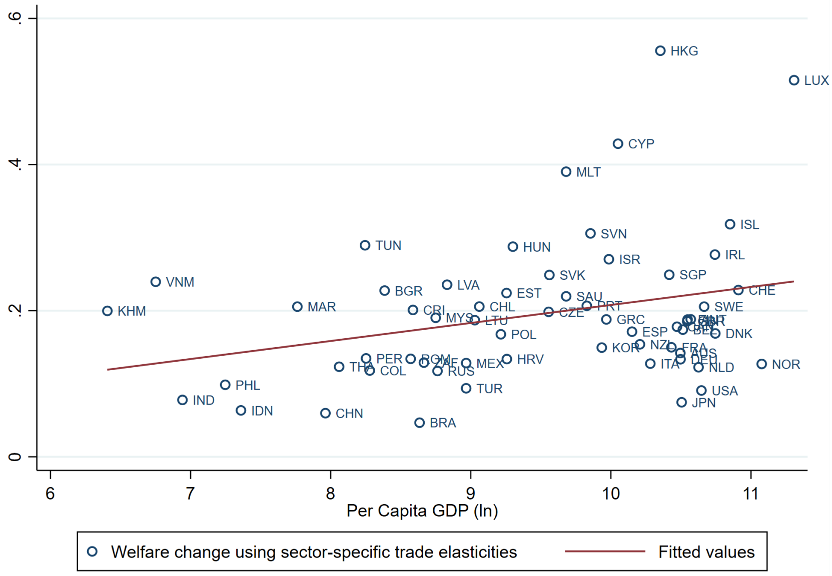
Source: Authors' calculations. Note: scatter plot based on HS-6 products with negative trade elasticity.

Figure 6: Time variation in product specific trade elasticity (coefficient of variation)



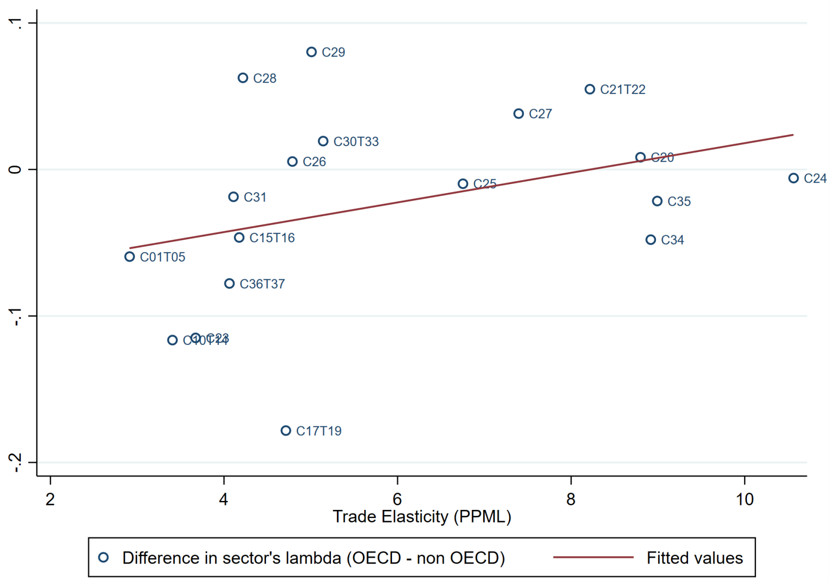
Source: Authors' calculations. Note: Coefficients of variation are calculated on HS-6 products with $\varepsilon < 0$.

Figure 7: The correlation between welfare-change evaluation (heteregeneous trade elasticities) and 2010 per capita GDP.



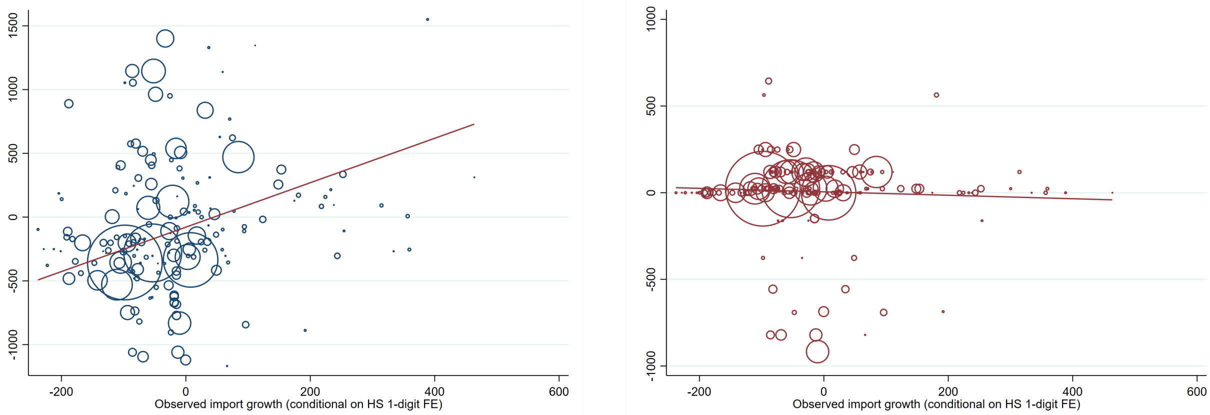
Notes: The vertical axis refers to the welfare change calculated using heterogeneous elasticities ($\widehat{W}_j$). Per capita GDP (ln) is on the horizontal axis. The unbroken line shows the fitted values. Brunei not reported for the sake of readability. *Source*: Authors' calculations.

Figure 8: Correlation between differences in domestic market shares (OECD vs non-OECD countries) and the trade elasticity of sectors.



Notes: The vertical axis refers to the difference in the domestic market share between OECD and non-OECD countries. TiVA sector trade elasticity is on the horizontal axis. The unbroken line shows the fitted values. *Source*: Authors' calculations.

Figure 9: Observed *vs.* predicted Chilean US import growth over the post-PTA period (2004-2007).

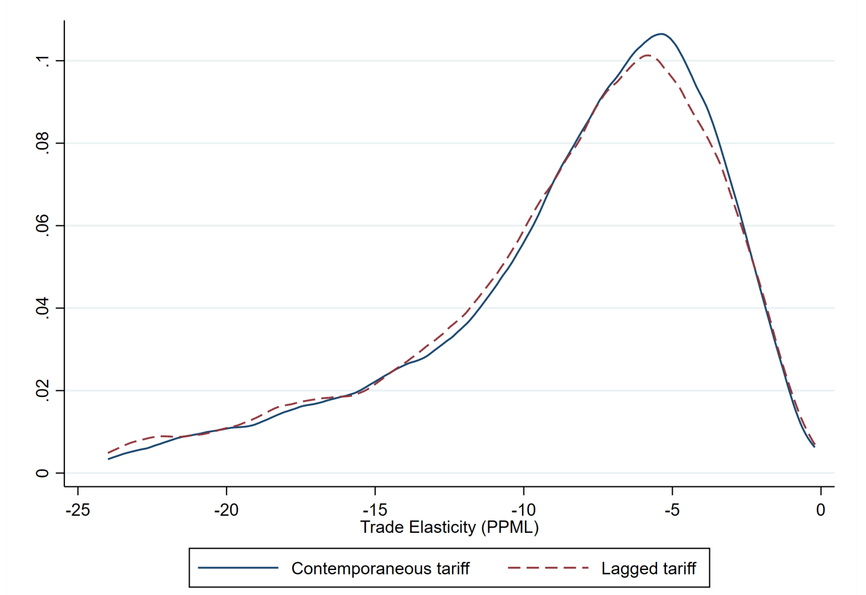


(a) Predicted import growth based on heterogeneous product-specific elasticities

(b) Predicted import growth based on a homogeneous elasticity

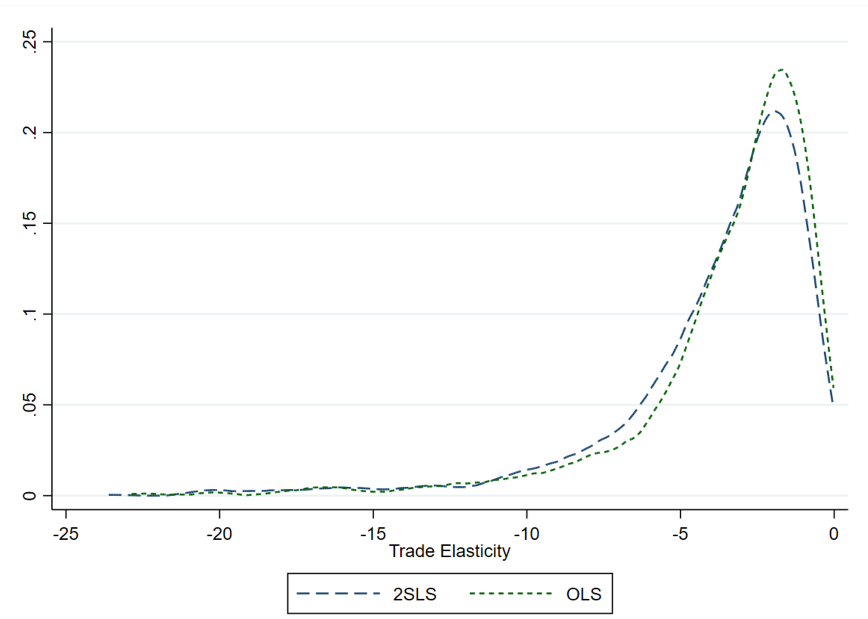
Notes: The figures show the predicted Chilean import growth from US in the post-PTA period based on heterogeneous (panel a) and homogeneous (panel b) trade elasticities on the vertical axis. Observed Chilean import growth from US in the post-PTA period is on the horizontal axis. Both predicted and observed import growth are conditional on HS 1-digit fixed effects. The unbroken lines in panels (a) and (b) shows the fitted values. The size of the circles reflects the level of Chilean imports from the US in 2004 (the starting year for the post-PTA period). *Source*: Authors' calculations on MAcMAP-HS6 and BACI (CEPII) data.

Figure 10: The empirical distribution of trade elasticities. Contemporaneous *vs*. lagged tariff estimations.



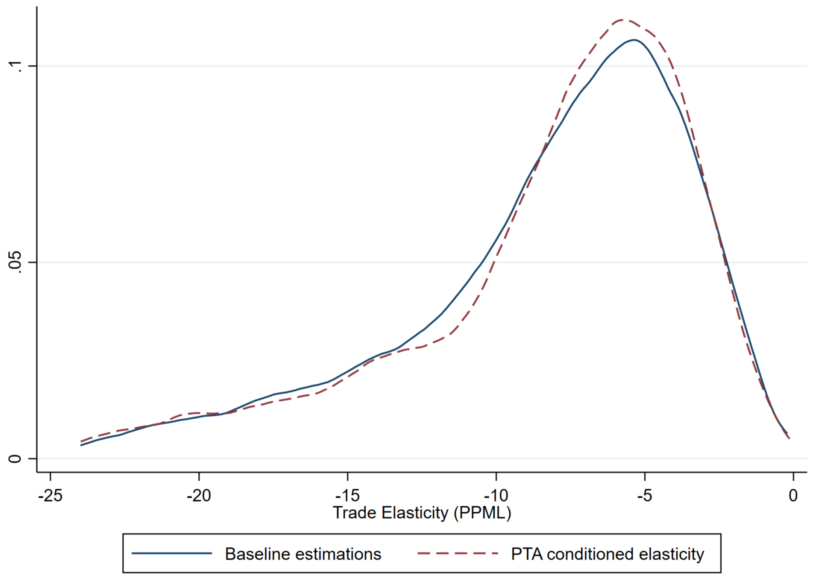
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure 11: The empirical distribution of trade elasticities. 2SLS and OLS estimations. IV based on the bilateral tariff imposed on similar products.



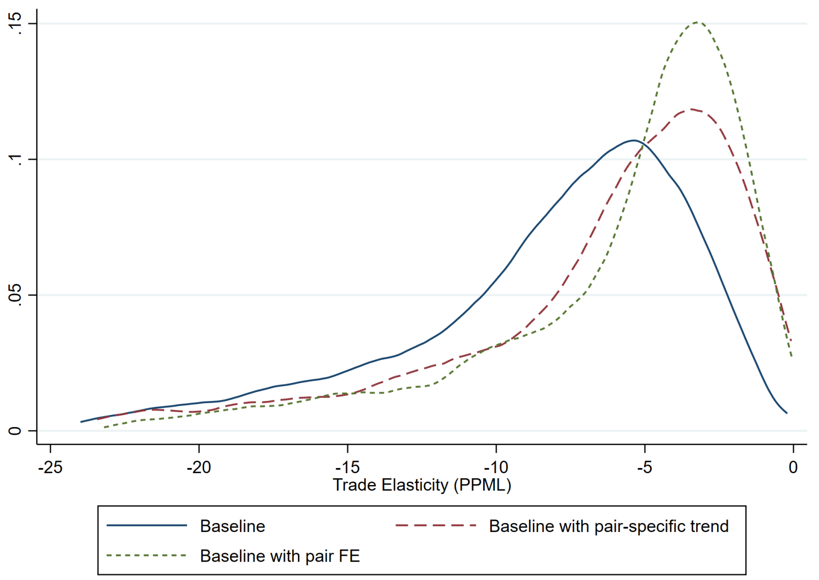
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure 12: The empirical distribution of trade elasticities: (i) baseline and (ii) conditional on a PTA dummy.



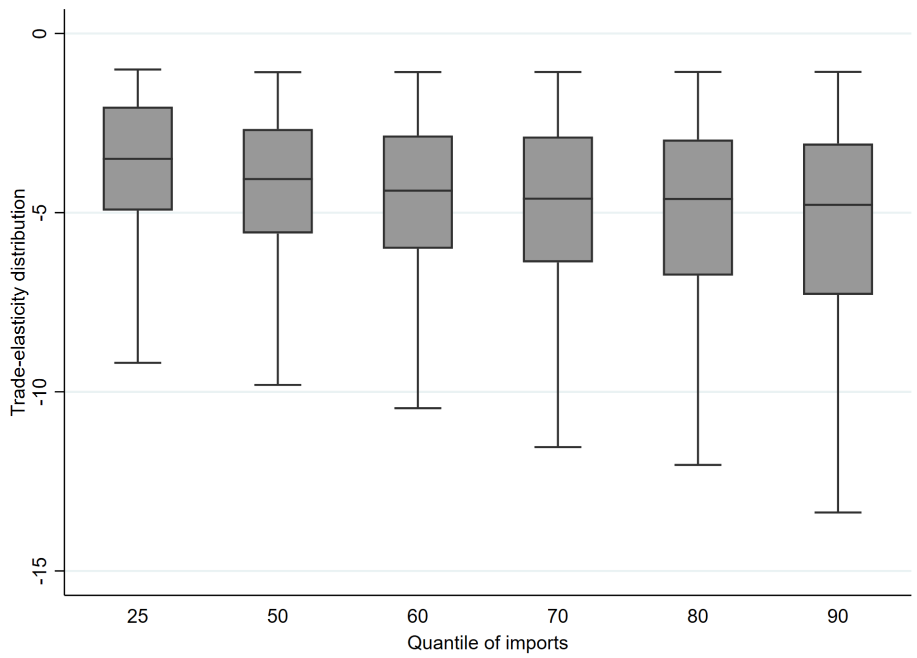
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure 13: The empirical distribution of trade elasticities: (i) baseline, (ii) conditional on country-pair fixed effects and (iii) conditional on country-pair specific trends.



Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure 14: Moments of the empirical distributions of trade elasticities across HS4 products, for different quantiles of import values.



Notes: These results come from the Method of Moments-Quantile regressions discussed in Machado & Santos Silva (2019). All regressions include exporter-year and importer-year fixed effects. Only HS 4-digit headings with tariff elasticities that are negative and significant at the 10% level across all quantiles are retained in this figure. The boxes are bordered at the 25th and 75th percentile of the quantile-specific trade-elasticity distribution (across HS 4-digit headings). The whiskers extend from the box to the upper and lower adjacent values. Outside values exceeding the adjacent are not shown.

“Tariff-Based Product-Level Trade Elasticities”

Online Appendix not for Publication

Table B1: Descriptive statistics. Average tariff by HS section and year.

Section	Description	2001	2004	2007	2010	2013	2016
I	Live Animals and Animal Products	17.4	17.6	16.4	15.5	14.8	14.2
II	Vegetable Products	15.3	15.2	13.5	13.0	12.5	11.7
III	Animal or vegetable fats and oils	13.6	13.6	12.0	11.0	10.6	10.4
IV	Prepared foodstuffs, beverages and tobacco	21.4	21.6	19.8	18.9	17.5	16.9
V	Mineral products	5.5	5.3	4.7	4.4	4.2	3.9
VI	Products of chemical industries	6.3	6.1	5.0	4.7	4.5	4.3
VII	Plastic and articles thereof	9.3	9.0	7.6	7.2	7.0	6.7
VIII	Raw hides and skins, leather and article thereof	11.2	11.0	9.7	9.5	9.1	8.6
IX	Wood/Cork and articles of Wood/Cork;	11.0	10.8	9.2	8.9	8.5	8.0
X	Pulp of wood or other cellulose materials	8.3	8.2	7.2	7.0	6.6	6.2
XI	Textile and textile articles	14.6	13.1	11.8	11.4	10.9	10.5
XII	Footwear, Headgear, Umbrellas, prep. feathers	16.6	16.2	14.4	14.0	13.3	12.6
XIII	Articles of stone, plaster, ceramic and glass	11.8	11.5	10.3	9.9	9.6	9.2
XIV	Natural cultured pearls, precious stones and metals	11.4	11.0	9.5	9.5	9.0	8.5
XV	Base metals and articles of base metals	8.3	8.1	7.1	6.8	6.5	6.2
XVI	Machinery and mechanical appl., electrical machin.	6.9	6.8	5.8	5.4	5.1	4.9
XVII	Vehicles, Aircraft and transport equipment	9.7	9.4	8.1	7.6	7.1	6.8
XVIII	Optical, photographic, precision, medical instr.	8.6	8.5	7.3	6.9	6.6	6.3
XIX	Arms and ammunitions	18.2	18.2	16.5	15.9	15.1	13.5
XX	Miscellaneous	14.2	13.9	12.3	12.1	11.6	11.3
XXI	Works of art	10.8	10.5	9.4	9.4	9.0	8.5

Note: This table shows the simple average tariffs by HS section and year. *Source*: MAcMap-HS6, authors' calculations.

Table B2: Descriptive statistics. The standard deviation of tariffs by HS section and year.

Section	Description	2001	2004	2007	2010	2013	2016
I	Live Animals and Animal Products	28.9	31.4	31.8	28.0	27.4	26.2
II	Vegetable Products	29.2	30.3	26.2	24.6	23.3	23.1
III	Animal or vegetable fats and oils	17.8	19.2	17.5	16.1	16.1	16.1
IV	Prepared foodstuffs, beverages and tobacco	41.4	46.9	47.8	45.6	39.9	38.6
V	Mineral products	7.4	7.5	6.7	6.7	11.3	6.4
VI	Products of chemical industries	9.2	10.0	8.6	8.5	8.2	7.4
VII	Plastic and articles thereof	10.5	11.1	9.6	9.5	9.6	8.9
VIII	Raw hides and skins, leather and article thereof	13.5	14.0	13.0	13.1	12.9	11.3
IX	Wood/Cork and articles of Wood/Cork;	16.4	16.7	10.8	10.7	10.4	9.8
X	Pulp of wood or other cellulose materials	9.6	10.7	9.3	9.3	8.8	8.5
XI	Textile and textile articles	34.6	14.3	13.9	13.3	13.3	13.1
XII	Footwear, Headgear, Umbrellas, prep. feathers	15.6	16.8	14.7	14.4	13.9	13.3
XIII	Articles of stone, plaster, ceramic and glass	11.9	12.9	11.3	11.2	11.0	10.7
XIV	Natural cultured pearls, precious stones and metals	13.8	13.7	12.2	12.4	12.0	11.6
XV	Base metals and articles of base metals	9.2	10.4	8.8	8.9	8.6	8.3
XVI	Machinery and mechanical appl., electrical machin.	8.5	10.2	8.1	8.1	7.8	7.6
XVII	Vehicles, Aircraft and transport equipment	14.6	15.1	12.5	11.9	11.5	10.5
XVIII	Optical, photographic, precision, medical instr.	10.2	11.7	9.5	9.5	9.2	9.0
XIX	Arms and ammunitions	26.1	27.0	25.4	24.9	21.2	15.1
XX	Miscellaneous	12.8	13.7	12.2	12.1	11.9	11.6
XXI	Works of art	12.6	12.5	11.3	11.4	11.2	11.0

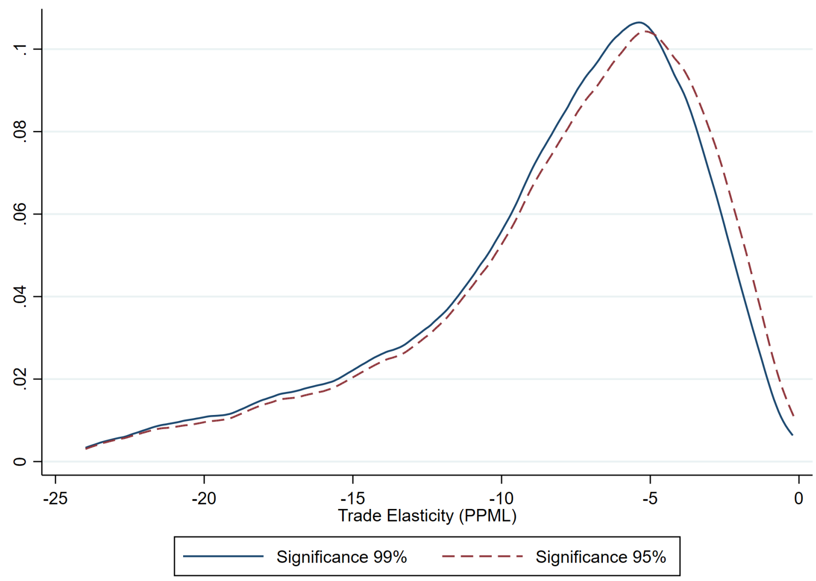
Note: This table shows the standard deviation of tariffs by HS section and year. *Source*: MAcMap-HS6, authors' calculations.

Table B3: OLS regression of the *absolute* value of the trade elasticity and probit regressions for the probability of very-high trade elasticity. Trade elasticity based on tariff point estimates.

Dep var:	$\lvert\varepsilon_k\rvert$		Top-Elasticity dummy		
	(1)	(2)	(3)	(4)	(5)
Av. distance across pairs ij (ln)	-1.837***	-2.073***	0.332	-0.123	-0.208*
	(0.476)	(0.523)	(0.274)	(0.144)	(0.114)
Differentiated	-5.278***	-4.294***	-0.509	-0.686***	-0.801***
	(0.365)	(0.495)	(0.327)	(0.154)	(0.118)
Estimator	OLS	OLS	Probit	Probit	Probit
Definition Top-Elast. dummy			$\lvert\varepsilon_k\rvert > 1pct$	$\lvert\varepsilon_k\rvert > 5pct$	$\lvert\varepsilon_k\rvert > 10pct$
HS1 fixed effects	yes	no	no	no	no
HS2 fixed effects	no	yes	yes	yes	yes
Observations	3,542	3,542	1,022	2,188	2,659

Notes: The dependent variable in columns 1-2 is the absolute value of the trade elasticity, abstracting for its statistical significance, when negative ($\varepsilon_k < 0$). The dependent variable in columns 3-5 is a dummy for the trade elasticity abstracting for its statistical significance (when $\varepsilon_k < 0$) being above the 1^{st}, 5^{th} and 10^{th} percentile of the distribution. The number of observations in columns (3)-(5) reduces because non-linear (Probit) estimator drops observations perfectly predicted by fixed effects (i.e. HS6 products in HS2 chapters containing always non-top elasticities). Robust standard errors appear in parentheses.

Figure B1: The empirical distribution of trade elasticities across all products. Comparison between the trade-elasticity distributions based on 1% and 5% statistical significance.



Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Table B4: The trade elasticity by GTAP revision 10 sectors.

GTAP code	Sector description	Trade elasticity ε
oap	Animal Products n.e.c.	-4.27
b_t	Beverages and Tobacco products	-2.73
c_b	Cane and Beet: sugar crops	-2.33
ctl	Cattle: bovine animals, live, other ruminants	-6.39
chm	Chemicals and chemical products	-7.83
coa	Coal: mining and agglomeration of hard coal	NS
ele	Computer, electronic and optical products	-5.26
ocr	Crops n.e.c.	-2.87
eeq	Electrical equipment	-4.62
ely	Electricity; steam and air conditioning supply	-9.48
pfb	Fibres crops	-12.04
fsh	Fishing and hunting (including related service activities)	-6.65
ofd	Food products n.e.c.	-4.70
frs	Forestry: forestry, logging and related service activities	-2.53
gdt	Gas manufacture, distribution	NS
gas	Gas: extraction of natural gas (including related activities)	NS
i_s	Iron and Steel: basic production and casting	-3.45
lea	Leather and related products	-5.99
ome	Machinery and equipment n.e.c.	-4.23
omt	Meat products n.e.c	-5.17
cmt	Meat: fresh or chilled	-4.04
fmp	Metal products, except machinery and equipment	-4.25
mil	Milk and dairy products	-4.77
mvh	Motor vehicles, trailers and semi-trailers	-8.98
nfm	Non-Ferrous Metals	-13.39
osd	Oil Seeds: oil seeds and oleaginous fruit	-2.05
oil	Oil: extraction of crude petroleum (including related activities)	-10.89
gro	Other Grains (maize, sorghum, barley, rye, oats, millets)	NS
omf	Other Manufacturing (includes furniture)	-4.91
oxt	Other Mining Extraction	-8.28
nmm	Other non-metallic mineral products	-4.83
otn	Other transport equipment	-7.98
ppp	Paper and Paper Products	-8.18
p_c	Petroleum and Coke	-3.64
bph	Pharmaceuticals, medicinal chemical and botanical products	-7.92
pcr	Processed Rice: semi- or wholly milled, or husked	-6.46
pdr	Rice: seed, paddy (not husked)	-7.63
rpp	Rubber and plastics products	-7.04
sgr	Sugar and molasses	-3.76
tex	Textiles	-6.04
vol	Vegetable Oils and fats	-2.75
v_f	Vegetables and Fruits (including nuts and edible roots)	-4.02
wap	Wearing apparel	-3.84
wht	Wheat: seed, other	-2.61
lum	Wood, products of wood, cork (except furniture) and straw	-8.69
wol	Wool, silk, and other raw animal materials used in textile	-7.28

Notes: Estimations based on the HS (rev 2007)-GTAP conversion table.

Table B5: Median t-stat for elasticities calculated with *vs* without country-pair fixed effects.

		Elasticity t-stat estimated	
		with pair FE	*without* pair FE
I	Live Animals and Animal Products	1.40	3.05
II	Vegetable Products	1.66	4.08
III	Animal or vegetable fats and oils	1.51	2.85
IV	Prepared foodstuffs, beverages and tobacco	1.98	6.16
V	Mineral products	1.43	2.70
VI	Products of chemical industries	1.45	2.72
VII	Plastic and articles thereof	2.10	4.79
VIII	Raw hides and skins, leather and article thereof	2.17	2.44
IX	Wood/Cork and articles of Wood/Cork;	1.80	4.03
X	Pulp of wood or other cellulose materials	1.63	5.27
XI	Textile and textile articles	1.44	3.83
XII	Footwear, Headgear, Umbrellas and prepared feathers	1.56	3.44
XIII	Articles of stone, plaster, ceramic and glass	1.61	3.80
XIV	Natural cultured pearls, precious stones and metals	1.40	2.10
XV	Base metals and articles of base metals	1.57	3.01
XVI	Machinery and mechanical appli. and elect. mach.	1.28	2.40
XVII	Vehicles, Aircraft and transport equipment	1.23	3.63
XVIII	Optical, photographic, prec. and med. instr.	1.50	1.82
XIX	Arms and ammunitions	0.66	1.70
XX	Miscellaneous	1.37	3.31
XXI	Works of art	1.89	2.32

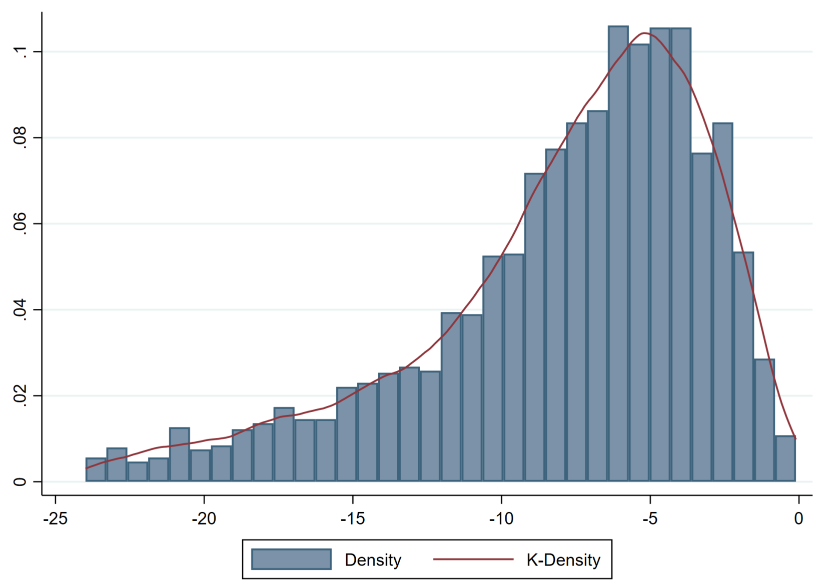
Note: This table shows the median t-stat (across products of a given HS 1-digit heading) of product-specific trade elasticities estimated with and without country-pair fixed effects.

Table B6: Quantile regressions. Log-linear model results by quantile q.

Quantile	Average elasticity ε_k	Std Dev	Min	Max	No. HS 4-digit headings
q=25	-4.10	2.97	-22.55	-1.00	269
q=50	-4.63	2.86	-18.28	-1.08	269
q=60	-4.96	3.05	-21.08	-1.08	269
q=70	-5.17	3.22	-23.47	-1.07	269
q=80	-5.36	3.40	-25.37	-1.07	269
q=90	-5.59	3.65	-27.85	-1.07	269

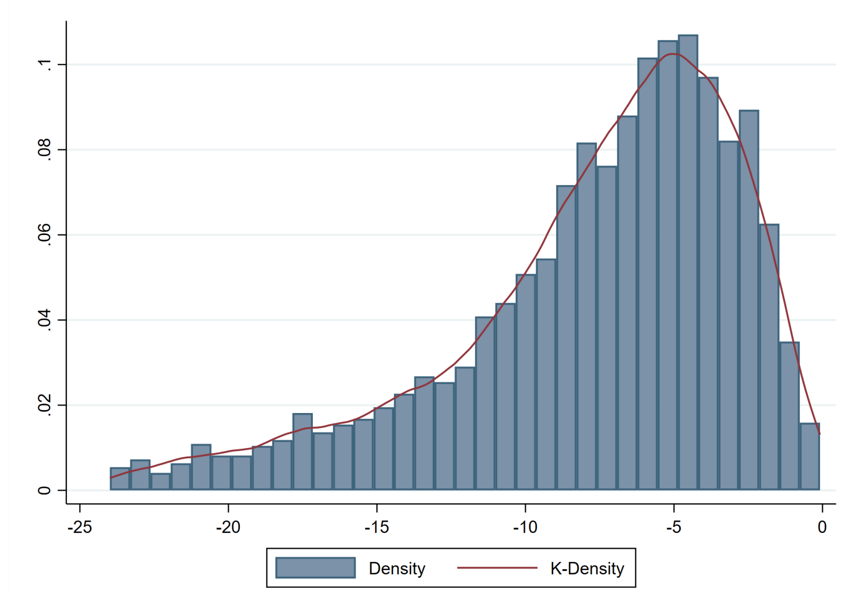
Notes: These results come from the Method of Moments-Quantile regression discussed in Machado & Santos Silva (2019). All regressions include exporter-year and importer-year fixed effects. Only HS 4-digit headings with negative and significant at 10% tariff elasticities across all quantiles appear in the statistics listed in this table.

Figure B2: The empirical distribution of trade elasticities ε_k (PPML estimations) based on 5% significant tariff elasticities.



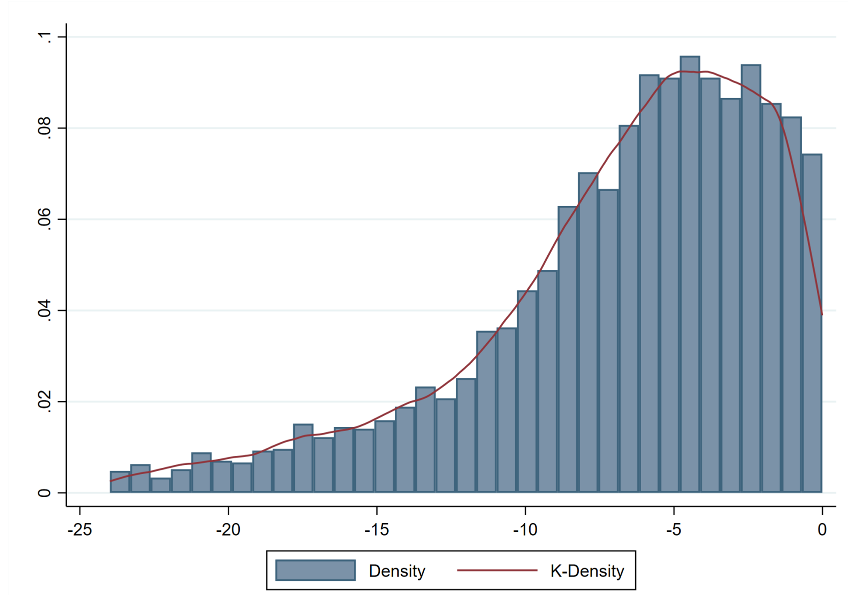
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure B3: The empirical distribution of trade elasticities ε_k (PPML estimations) based on 10% significant tariff elasticities.



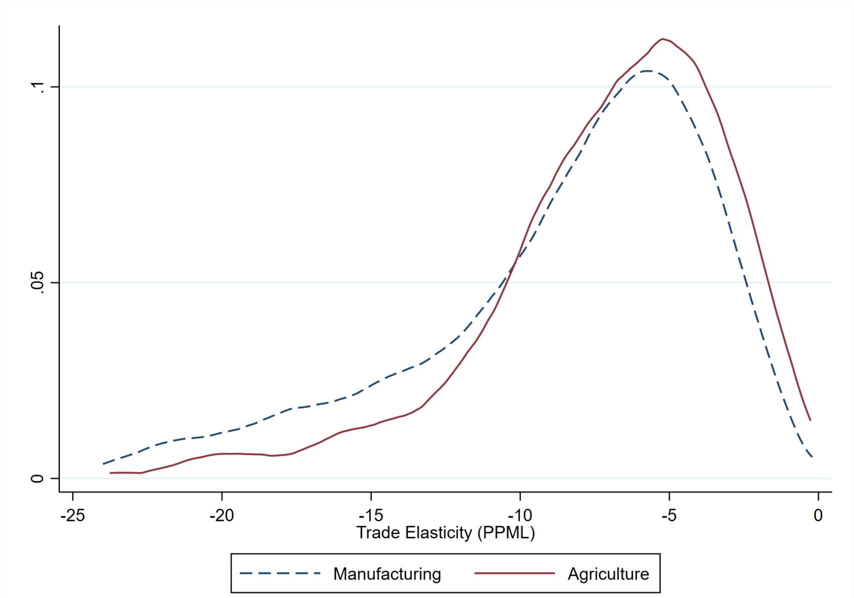
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure B4: The empirical distribution of trade elasticities ε_k (PPML estimations) abstracting from the statistical significance of tariff elasticities.



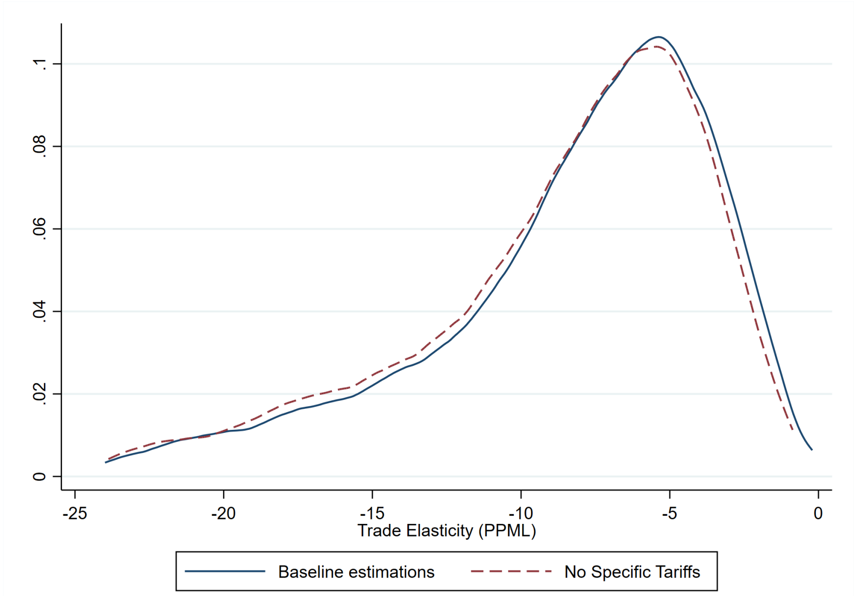
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure B5: The empirical distribution of trade elasticities. Manufacturing *vs*. Agriculture.



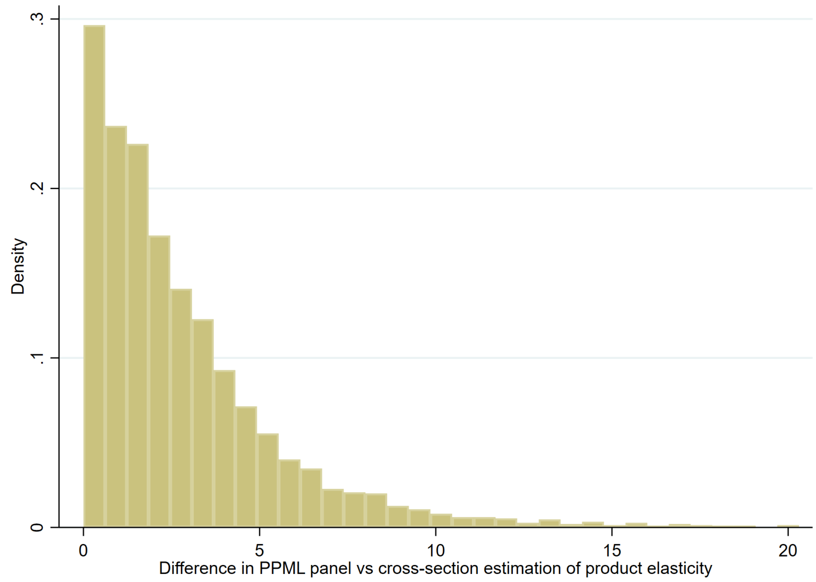
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure B6: The empirical distribution of trade elasticities ε_k: (i) baseline, and (ii) excluding country-pairs with specific tariffs.



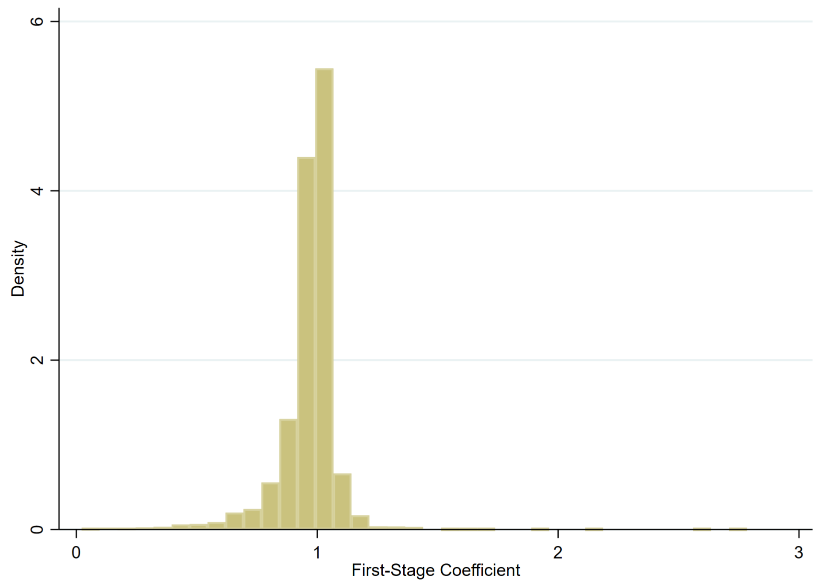
Note: The empirical distribution is calculated on HS-6 products with $\varepsilon_k < 0$.
Source: Authors' calculations.

Figure B7: Difference in PPML panel vs cross-section product-level trade elasticities.



Note: The figure shows the absolute value of the difference in trade elasticity estimated using PPML on panel (baseline) and cross-section (average across years). For the sake of readability we exclude products having panel or cross-section based elasticity larger than -25. *Source*: Authors' calculations.

Figure B8: The empirical distribution of the first-stage coefficient, i.e. the coefficient on τ_{ijkt}^{IV} in the first-stage regression.



Source: Authors' calculations.