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Estimating National and Foreign Trade Elasticities Using Generalized Transport Costs

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ABSTRACT

We introduce the definition of two distinct trade elasticities corresponding to imports from regions located in the same country (national elasticities) and foreign regions located in other countries (foreign elasticities). We resort to a three-tier nested CES utility structure to derive the corresponding demand gravity equations. In absence of tariffs within single markets, we identify and recover the elasticities through a precise measure of generalized transport cost that combines economic, engineering, and logistic criteria. Results using PPML estimation methods on EU trade data show that national elasticities double in value their foreign counterparts. Our estimates allow revisiting previous results on border effects, gains from trade, and CGEs.

JEL Classification: C21, C68, F12, F17, R41

1 | Introduction

Trade elasticities play a key role in modern trade theory by capturing the sensitivity of consumers' relative demand for foreign goods to changes in their relative prices (Hillberry and Hummels 2013). Trade elasticities not only allow for the estimation of the effect of price changes on trade flows but are also instrumental when analyzing a host of questions in international and regional economics including, inter alia, the hampering effect of frictions to trade such as border effects, the variations in gains-from-trade resulting from changes in trade barriers (Bergstrand, Larch, and Yotov 2015; Heid, Larch, and Yotov 2021) and trade policies (Allen, Arkolakis, and Takahashi 2020), or the economy wide results of broader policy simulations using spatial general equilibrium models (Blouri and Ehrlich 2020). Trade elasticities determine how trade liberalization and changes in transport costs affect the structure of output and input markets as well as the location of economic activity both between and within countries (Gallego and Zofío 2018). In the markets for goods, they determine the degree of competition, and how changes in trade costs affect the size distribution of firms, generally reinforced with selection effects (Burstein and Melitz 2013, Feenstra et al. 2018).

Existing econometric studies follow various strategies and specifications to estimate trade elasticities: gravity equations versus demand and supply systems, regression methods (e.g., OLS, GMM, Poisson pseudo maximum likelihood [PPML],...), data dimension (cross-section, time series or panel), industry aggregation (e.g. 2 or 3-digits), or geographical location and time (e.g., world regions, particular free trade areas,...). Reviews of this prolific literature and meta-analysis of the elasticities can be found in Head and Mayer (2014) and Bajzik et al. (2020). However, there is an area in which there has not been any progress. Specifically, for international models enhanced with a regional dimension, there exist few studies on trade elasticities between regions belonging to different countries. Indeed, none of them differentiate trade flows depending on whether origins and destinations belong to the same country (regional or national trade) or to different countries (international or foreign trade).

The main contribution of this study is the introduction of a framework for the joint estimation of foreign and national trade elasticities. By taking advantage of existing data on regional trade flows and transport costs both *between* and *within* countries, we can estimate these two levels of elasticities. Specifically, we estimate the trade elasticity of imports produced in regions located in *foreign* countries and a second *national* trade elasticity for goods produced in regions belonging to the same country of the importing region. We illustrate our model using data on the European Union (EU), including its 28 member states before Brexit and their subnational (NUTS2) entities. The EU was the first single market to be established, covering over 450 million people. It also exhibits a higher degree of integration of labor, capital and product markets than newer counterparts like the NAFTA/USMCA or Mercosur, thereby offering an interesting case study for our analysis.

To the best of our knowledge, this is the first time that the simultaneous estimation of both trade elasticities has been considered. Indeed, whether following the strategy of regressing trade flows on a measure of trade costs, or the ratio of imports to domestic consumption on the ratio of domestic prices to import prices, all studies surveyed in literature refer to the calculation of a single foreign trade elasticity (e.g., Francois and Martin 2013; Hillberry and Hummels 2013; Costinot and Rodríguez-Clare 2014; Head and Mayer 2014). Indeed, the comprehensive literature review by Bajzik et al. (2020; table 1), who systematically classify the estimated values of foreign elasticities of substitution according to different criteria, does not find any reference to this question. The reason is that the literature has never used these two geographical levels of data simultaneously. In other words, the estimation of foreign trade elasticities is normally carried out with data on trade flows between countries.

The underlying economic model from which we obtain our demand equations for national and foreign imports follows the standard approach in the trade literature regarding household and firm behavior. However, the representative consumer maximizes a three-tier utility function (rather than the usual two) which allows the definition of the national and foreign trade elasticities, and where the middle and lower tiers are characterized by an asymmetric constant elasticity of substitution (CES) among varieties. As for the characterization of the products' markets, our demand equations are compatible with the usual assumption of increasing returns, resulting in imperfect competition, and where the market structure is assumed to be that of monopolistic competition, thereby doing away with strategic behavior among firms. Once we consider the pricing rules obtained from profit maximization, we show in the Section 2 that the demand equations that allow differentiating between the two trade elasticities emerge quite naturally.[1]

In trade models where consumers' preferences are represented through CES utility functions, the own-price elasticity of imports is mathematically equivalent to the elasticity of substitution among varieties, which can be interpreted in terms of the Armington assumption. As in the literature based on this theoretical framework, we rely on the concept of own-price elasticity to identify the trade elasticities (in our case transport costs are the price-shifters driving the changes in national and foreign import demands), while the recovered values can be also interpreted as the elasticity of substitution between goods imported from regions within the same country (national trade elasticities) of from regions located in third countries (foreign trade elasticity).

From the own-price elasticity perspective, the question whether the elasticity is different between intranational and international trade is closely related to the question whether the sensitivity of trade flows to transportation costs is different at shorter distances and longer distances. This is the topic of a recent research studying intranational trade flows, which we enhance with the international dimension in our study, see Hillberry and Hummels (2008), Gallego and Llano (2014), or Díaz-Lanchas, Zofío, and Llano (2022). This literature focuses on the nonlinear (decreasing) effect of transport costs on trade, finding that the sensitivity of trade (or shipments) at short distances is greater than at long distances. Consequently, home-trade within regions presents a higher elasticity than regional trade within the same country (national trade), which, in turn, is larger than the elasticity of regional trade between different countries (international trade). A result that we generally confirm in terms of national and foreign elasticities considering their corresponding trade flows and transportation costs.

From the elasticity of substitution perspective, the Armington framework assumes that goods are perceived as differentiated by consumers depending on the location of origin with different varieties of the same good produced in each place. Whereas this assumption seems natural in the case of goods sourced from foreign countries, the case of goods produced in different regions within the same country requires further justification. First, several studies have shown that whether consumers differentiate products by origin resulting in marked home-bias depends on sociopolitical and idiosyncratic (dis)similarities among trade partners. For instance, Santamaría, Ventura, and Yeşilbayraktar (2023; p. 1) discuss the stylized facts of regional trade within the EU concluding that *(i) European regional trade has a strong home and country bias, (ii) geographic distance and national borders are important determinants of regional trade, but cannot explain the strong regional home bias and (iii) the home bias is heterogeneous across regions and seems to be driven by political regional borders*. In the same vein, Melitz (2008) stresses that trade flows are positively correlated with cultural proximity, which is measured through linguistic similarity. Although this author discusses international trade mainly, his conclusions can be extended to intranational trade for countries where several official languages coexist.[2]

To control for regional similarities/disparities both within and between countries we include in our gravity model an index reflecting the likelihood that individuals belonging to two different regions speak a common native language, both within the same country and internationally, see Gurevich et al. (2021). The inclusion of this variable demonstrates that cultural dis (similarity) among regions is a relevant factor driving trade within countries. In turn, the existence of these barriers to trade, reflecting border-effects, suggests that varieties imported from regions within the same country are not perfect substitutes for those produced locally in the home region (i.e., home trade using the terminology of Santamaría, Ventura, and Yeşilbayraktar 2023). This is consistent with the above-cited studies that suggest that in single markets like the European Union, NAFTA/USMCA, Mercosur, etc., there exist enough social, cultural, and political disparities between regions belonging to the same country to advance the existence of national elasticities—these differences being largest among regions speaking different native languages.[3]

Our study allowing for national trade elasticities addresses the relevance of considering intranational trade flows when estimating gravity equations (Yotov 2022) and explores the existence of "strong regional home bias", which can be evidenced in terms of various degrees of "cultural proximity" within countries. Additionally, it is expected that, within the same country, these differences are smaller than those existing with regions in foreign countries, which results in higher substitutability (price sensitivity) among national varieties than among foreign ones. The underlying reason is that national imports are supposed to be closer in the range of products and better known to consumers in the reference home region. However, a tentative study exploring this question by Bilgic et al. (2002) did not find conclusive evidence that national elasticities are larger than their foreign counterparts. In contrast to the conclusions drawn by these authors, who compare their results on national elasticities for the US with those on foreign elasticities obtained from other studies—using different theoretical models, estimation methods, and datasets—our results would confirm this hypothesis, concluding that the closer the geographical reach of trade, that is, national trade versus international trade, the higher the value of the elasticities.

Finally, the Armington assumption at the regional level is a distinctive feature of the so-called New Economic Geography (NEG) models, studying the location of economic activity within countries, Fujita, Krugman, and Venables (1999). Empirical research applying the NEG postulates to explain the distribution of economic activity across European regions demonstrates the validity of the Armington assumption at the subnational level; see Combes and Overman (2004) and Fingleton (2007).

Trade elasticities have been econometrically estimated in two different literatures. A first group of studies uses identification through tariffs acting as price shifters (Hertel et al. 2007). The second jointly models demand and supply, and uses very large panel datasets to address simultaneity bias by differencing over both time and cross-sectional dimensions (Feenstra 1994; Broda and Weinstein 2006). This method relies on an independent error structure between demand and supply and faces some computational difficulties (Soderbery 2015). In these models, transport-related costs are regarded as control variables and proxied by average freight rates between countries, or, most commonly, simple geographic distance. However, in a common market area, where tariffs are absent, identifying trade elasticities is challenging due to the lack of cross-country heterogeneity in formal trade barriers and, therefore, precise measures of transport costs represent the best alternative solution. This is the case in studies estimating trade elasticities for single countries where regions trade with each other—for example, see Morgan, Mutti, and Partridge (1989), Bilgic et al. (2002), Sato et al. (2018) and cites therein. In these models, detailed calculations of transport costs like those performed by Hillberry and Hummels (2008) and Díaz-Lanchas, Zofío, and Llano (2022) play a leading role in the identification and quantification of interregional trade elasticities.

In this study, we build upon this literature and identify both national and foreign elasticities using unique transport costs for the EU internal market. The definition of trade costs follows a generalized transport cost (GTC) approach, which calculates the minimum cost of shipping freight between any two locations along the least expensive route.[4] The methodology takes into account the economic costs of transportation and the choice of the optimal vehicle size, which depends on: (a) "freight curves," balancing fixed costs such as terminal times (handling costs) and variable costs (hauling costs) (McCann 2001); (b) the urban layout of the origin and destination in terms of population density; and (c) the type of commodity (cargo) transported. Here the transport engineering and logistics approach presented by Zofío et al. (2014) is enhanced to account for the existence of nonlinear shipping costs resulting from economies of distance and size. The aim is to reduce to a minimum the likely correlation between the transport costs and the error term in the demand equation, by making sure that the ad-valorem transportation costs control for the aforementioned technological, logistical, economic and infrastructure dimensions.

This information is then embedded in a geographical information system (GIS) representing the digitalized transportation network across the EU. Following Persyn, Díaz-Lanchas, and Barbero (2022), the generalized transportation cost between two regions is defined as the average of the optimal routes between a sample of centroids located in these regions. These centroids are identified using nighttime satellite imaging at a one squared km resolution, thereby accounting for the typically uneven distribution of population and economic activity within regions. Subsequently, the set of bilateral GTCs is aggregated and averaged by sector and type of vehicle specific weights. We therefore estimate a unique origin-destination matrix of ad valorem transport costs between all the EU regions. This matrix is then used in a gravity equation for regional and sectorial trade flows (Thissen et al. 2019).

We compare our joint estimates of national and foreign elasticities with a number of results in the literature. We remark that existing estimates of both elasticities are unrelated to each other, because the joint estimation of both figures has never been tackled. Our results show that at the highest-level of data classification, corresponding to "Agriculture, forestry and fishing," "Mining and quarrying" and "Manufacturing," national elasticities range between 4 and 11, while their foreign counterparts are roughly half in value standing between 2 and 5. These values are in line with those reported in recent literature for foreign trade elasticities among EU countries. At the country level, there are some recent estimates by Németh, Szabó, and

Ciscar (2011), Olekseyuk and Schürenberg-Frosch (2016), and Aspalter (2016). The range of elasticities in each of these three studies goes from around 2 to 5, in the interval of 3 and 4.2, and 0.3 and 3.7, respectively. Our results are also consistent with other studies where foreign elasticities for some European countries are considered (Welsch 2008; Imbs and Mejean 2010, 2015). Moreover, some of these studies not only reveal that trade elasticities exhibit a great deal of heterogeneity between sectors, but depend on the level of industrial aggregation, for example, when comparing two-digit individual sectors with their manufacturing aggregate. We explore this question empirically by estimating trade elasticities for different levels of industrial aggregation, finding consistent evidence that, indeed, grouping trade flows at higher statistical levels decreases the values of trade elasticities.

Knowledge of the sensitivity of consumers to price changes in imports from closely related (national) regions or farther related (foreign) regions is critical for the trade and regional modeling literature. A first example is the estimation of the *border effect* on international trade. Existing studies (Anderson and van Wincoop 2003) differentiate between national and international trade flows, yet consider a single trade elasticity. Another research field for which our results are highly relevant is the evaluation of *welfare gains from trade*—Hertel et al. (2007).

These studies also require the estimation of dependable trade elasticities to determine the change in allocative efficiency or the welfare effect of an increase in available varieties. Ignoring that trade openness (in the form of changes in tariffs or transport costs in single markets) also triggers the reallocation of trade flows within countries, will certainly lead to different estimates, which can be controlled by incorporating national elasticities if interregional trade data is available.

Lastly, our results are also relevant for the correct calibration of *regional CGE model*s or, more broadly, *spatial general equilibrium models* and subsequent policy analyses. To the extent that these models adopt a single-valued elasticity of trade, their results will be biased, thereby compromising their reliability and the policy recommendations based upon them. Again, the welfare effects of trade (and transport) policies critically depend on their values.

Thanks to our proposal there is no need to adopt single-valued elasticities drawn from the international trade literature, since it is possible to define and calculate both levels of elasticities. Moreover, our estimated elasticities can be useful to all sorts of regional studies that routinely adopt values corresponding to international studies, neither differentiate between the two levels of import substitutability.

The remainder of the paper is organized as follows. In the next section we present the theoretical model underlying the specification of the gravity equation. In Section 3, we discuss the specific econometric specification of the gravity equations and the estimation strategies. In Section 4, we present the data related to trade flows and generalized and iceberg transport costs. Section 5 presents our estimates of foreign and national trade elasticities for individual sectors and different levels of statistical aggregation and provides robustness checks. Finally, we conclude by stressing the novelty of the results and their relevance for trade theory and regional modeling.

2 | The Model: A Gravity Specification for National and Foreign Trade Elasticities

We start from a standard import CES demand equation underlying the gravity equation for nondomestic goods. Household preferences are modeled as a triple nested utility function. The upper tier utility for the representative consumer in a region d corresponds to

$$U_d = U\left(Q_d^1, \ldots, Q_d^c, \ldots, Q_d^C\right), \tag{1}$$

which aggregates the $c = 1, \ldots, C$ quantities of commodities demanded. Commodities are grouped into sectors based on products' similarity as done in international statistical classifications, for example, agriculture, manufacturing, services, etc.

The amount consumed of each commodity c is a composite of horizontally differentiated varieties of the same good that may be produced domestically in region d itself or imported either from regions within the same country (*national* trade), or from regions situated in foreign countries (*foreign* trade). With this structure in mind, the middle tier of the utility function is expressed by way of the following CES specification:

$$Q_d^c = \left[b_{Dd}^c QD_d^{c\,\frac{\phi^c-1}{\phi^c}} + b_{Nd}^c QN_d^{c\,\frac{\phi^c-1}{\phi^c}} + b_{Fd}^c QF_d^{c\,\frac{\phi^c-1}{\phi^c}}\right]^{\frac{\phi^c}{\phi^c-1}}. \tag{2}$$

New to the literature, Equation (2) differentiates domestic (local or intraregional) consumption from (intra)national and foreign (international) trade. Therefore, Q_d^c is the result of aggregating the varieties domestically (D) produced within region d, QD_d^c, those imported from the rest of the regions within the same nation (N), QN_d^c, and those imported from foreign regions located in other countries (F), QF_d^c. In Equation (2), the parameters b_{Dd}^c, b_{Nd}^c, and b_{Fd}^c represent preference weights specific to each source; that is, domestic, nationally imported, and internationally imported. Following Feenstra et al. (2018), the parameter $\phi^c > 1$ can be interpreted as the elasticity of substitution between domestic (local) and imported goods (either national or foreign), among these alternative sources of good c consumed in region d. These authors propose a model that allows identifying the elasticity of substitution ϕ^c between domestic and foreign goods (i.e., considering imports as a single *aggregate* over foreign countries), and differentiate it from the elasticity of substitution between goods imported from individual countries—corresponding to σ_F in the lowest tier of the utility function below. They refer to the former and the latter as macro and micro elasticities of substitution. Our approach differs from theirs because, having the extra regional dimension, we separate between the elasticity of substitution between goods imported from regions within the same country (giving rise to national or interregional trade), and regions located in foreign countries. That is, we distinguish between national suppliers and foreign suppliers. Since our contribution focuses on the introduction of the two elasticities of substitution, national and foreign, we do not pursue here the estimation of ϕ^c.[5] As in the rest of the literature, we assume that ϕ^c is equal across the European Union importing regions, $d = 1, ..., D$.

Finally, in the lowest tier, the individual varieties having a national ($n = 1, ..., R$) or foreign ($f = 1, ..., S$) origin enter the utility function as follows:

$$QN_c^d = \left[\sum_{n=1}^{R} b_{nd}^c q_{nd}^{c\,\frac{\sigma_N^c - 1}{\sigma_N^c}}\right]^{\frac{\sigma_N^c}{\sigma_N^c - 1}}, \tag{3}$$

$$QF_c^d = \left[\sum_{f=1}^{S} b_{fd}^c q_{fd}^{c\,\frac{\sigma_F^c - 1}{\sigma_F^c}}\right]^{\frac{\sigma_F^c}{\sigma_F - 1}}, \tag{4}$$

where q_{nd}^c and q_{fd}^c are the quantities consumed in region d imported from region n belonging to the *same* country, and from region f located in *other* foreign countries, respectively. In this level, b_{nd}^c and b_{fd}^c are the preference parameters for each of the varieties imported from national or foreign regions, and σ_N and σ_F are the common (micro)elasticities of substitution among varieties sourced from each group of regions. Dropping (intra)national trade flows in Equation (2) and the associated subnest (3), collapses the model into the standard international trade specification in which the national elasticity of substitution (σ_N) does not exist, for example, Feenstra et al.'s (2018). In such setting QD_d^c aggregates local and national consumption, and σ_F is identified as the foreign elasticity of substitution between goods produced in other countries.

We now determine the demands for the national and foreign imported goods of the representative consumer maximizing Equation (2), conditional on the expenditure on each type of commodity depending on its *origin*, EO_d^c, $O = N,F$, coming from the upper-level utility function (1) In this case the optimal sourcing of imports from different exporters, n or f, according to Equations (3) and (4), results in the following demand equations[6]:

$$q_{nd}^c = b_{nd}^{c\;\sigma_N} \frac{p_{nd}^{c\;-\sigma_N^c}}{P_{Nd}^{c\;1-\sigma_N^c}} EN_d^c, \text{ and} \tag{5}$$

$$q_{fd}^c = b_{fd}^{c\;\sigma_F} \frac{p_{fd}^{c\;-\sigma_F^c}}{P_{Fd}^{c\;1-\sigma_F^c}} EF_d^c. \tag{6}$$

Assuming that the relevant market structure corresponds to monopolistic competition.[7] destination prices in the numerator correspond to the following specifications:

$$p_{nd}^c = p_n^c\left(1 + \tau_{nd}^c\right) = \left(\frac{\sigma_N^c}{\sigma_N^c - 1}\right) c_n^c\left(1 + \tau_{nd}^c\right), \text{ and,} \tag{7}$$

$$p_{fd}^c = p_f^c\left(1 + \tau_{fd}^c\right) = \left(\frac{\sigma_F^c}{\sigma_F^c - 1}\right) c_f^c(1 + \tau_{fd}^c,), \tag{8}$$

where $p_n^c = \left(\frac{\sigma_N^c}{\sigma_N^c - 1}\right) c_n^c$ and $p_f^c = \left(\frac{\sigma_F^c}{\sigma_F^c - 1}\right) c_f^c$ are factory-gate (mill) prices in the region of origin. They depend on the marginal cost of production c_o^c, $o = n, f$ (e.g., labor requirements in terms of salary, energy prices, and so on), and on $\sigma_N/(\sigma_N - 1)$ and $\sigma_F/(\sigma_F - 1)$, which are the mark-ups reflecting the degree of market power under monopolistic competition. In addition, consumer prices p_{nd}^c and p_{fd}^c at the destination region d depend on τ_{nd}^c and τ_{fd}^c which correspond to the ad valorem (or iceberg) transport costs between the exporting and importing region in the same (n) or different country (f).

Finally, the overall price indices over the imported commodities are:

$$P_{Nd}^c = \left(\sum_{n=1}^{N} b_{nd}^{c\;\sigma_N} (p_{nd}^c)^{1-\sigma_N}\right)^{1/(1-\sigma_N)}, \text{ and}$$

$$P_{Fd}^c = \left(\sum_{f=1}^{F} b_{fd}^{c\;\sigma_F} \left(p_{fd}^c\right)^{1-\sigma_F}\right)^{1/(1-\sigma_F)}.$$

3 | Econometric Specification and Estimation of Trade Elasticities

We express the demand Equations (5) and (6) in value terms by multiplying both sides by destination prices. In a monopolistic competition framework, the aggregate import value can be related to the exports of the individual firm h multiplied by the number of symmetric firms m operating in the exporting industry; i.e., $V_{od}^c = p_{od}^c m_o^c q_{hod}^c = p_{od}^c q_{od}^c$, $o = n, f$. Then, multiplying Equation (5) by (7) as presented in the second equality, and taking natural logs of the resulting equation, yields the following gravity equation for (intra)national trade:

$$\begin{aligned} \ln V_{nd}^c = {} & \sigma_N^c \ln b_{\text{nd}}^c + \ln m_n^c + \left(1 - \sigma_N^c\right) \ln\left(\frac{\sigma_N^c}{\sigma_N^c - 1}\right) \\ & + \left(1 - \sigma_N^c\right) \ln\left(c_n^c\right) + \left(1 - \sigma_N^c\right) \ln\left(1 + \tau_{nd}^c\right) \\ & + \left(\sigma_N^c - 1\right) \ln P_{Nd}^c + \ln EN_d^c. \end{aligned}$$

Similarly, we get the gravity equation for foreign (international) trade by multiplying Equation (6) by (8):

$$\begin{aligned} \ln V_{fd}^c = {} & \sigma_F^c \ln b_{fd}^c + \ln m_f^c + \left(1 - \sigma_F^c\right) \ln\left(\frac{\sigma_F^c}{\sigma_F^c - 1}\right) \\ & + \left(1 - \sigma_F^c\right) \ln\left(c_f^c\right) + \left(1 - \sigma_F^c\right) \ln\left(1 + \tau_{fd}^c\right) \\ & + \left(\sigma_F^c - 1\right) \ln P_{Fd}^c + \ln EF_d^c. \end{aligned}$$

The econometric identification of the elasticities of import substitution relies on the cross-sectional variation of delivered prices induced by trade costs. In our single market setting characterizing the EU, delivered prices corresponds to mill prices plus the trade margins, of which ad valorem transport costs represent the largest proportion, and excluding non-transport related costs since there are no additional trade barriers such as tariffs.

3.1 | (Intra)National and Foreign (International) Trade Elasticities by Sector

The above specifications can be estimated separately for each type of trade flow (either national or foreign) and sector c. The standard econometric strategy followed by authors like Hummels (2001) and Hertel et al. (2007) exploits the fact that all variables except the bilateral preferences and transportation costs: $b^c_{od}, \tau^c_{od}, o = n, f$, are either importer or exporter specific. Denoting by a^c_n and a^c_d the vectors of exporter and importer regional fixed effects, results in the following specification for national trade flows:

$$\ln V^c_{nd} = a^c_n + a^c_d + \sigma^c_N \ln b^c_{nd} + (1 - \sigma^c_N) \ln(1 + \tau^c_{nd}), c = 1, ..., C, \tag{9}$$

whereas including exporter's fixed effect for foreign countries a^c_f, corresponds to the international trade flows:

$$\ln V^c_{fd} = a^c_f + a^c_d + \sigma^c_F \ln b^c_{fd} + (1 - \sigma^c_F) \ln(1 + \tau^c_{fd}), c = 1, ..., C. \tag{10}$$

Unobservable characteristics such as quality and other commodity characteristics are the same in each destination to which an exporter $o(= n, f)$ sells to, and therefore can be captured by the fixed effects. The commodity-specific preference parameters b^c_{od} capture other idiosyncratic characteristics such as taste that may affect trade between the importer and exporter. It is customary to include bilateral dyadic characteristics such as distance, plus border controls (for intraregional and intracountry trade flows), and adjacency (contiguity) proxies. Additionally, we include a variable capturing the cultural proximity between regions to determine if both intranational and international flows are larger when the trading partners share a common native language. This variable, elaborated by Gurevich et al. (2021) following Melitz and Toubal (2014), corresponds to an index measuring the likelihood that two individuals belonging to two different regions share a common native language.[8] As a result, the preference parameters are specified as follows: $b^c_{od} = Dist\cdot^{\delta^c_1}_{od}\ Language^{\delta^c_2}_{od} e^{(\delta^c_3 Intra.+\delta^4_c Adj.)}$.

Rather than estimating the sector-specific elasticities of trade for national and foreign goods separately, that is, using split subsamples corresponding to each class of trade flows, a first estimation strategy pools both levels of trade flows. This implies that a single specification of the gravity equation can be implemented in such a way that σ^c_N and σ^c_F can be recovered simultaneously from the estimated parameters. This is achieved by defining a specification that includes simultaneously both levels of trade flows, qualifying national trade flows and frictions. The associated parameter effectively captures the additional (marginal) effect on imports when trade is intranational (Intracountry_{od}) rather than international, which constitutes the reference category in the regression. Considering this estimation strategy results in the following specification:

$$\begin{aligned} \ln V^c_{od} = {} & \alpha_0 + \alpha^c_o + \alpha^c_d + \beta^c_f \ln(1 + \tau^c_{od}) \\ & + \beta^c_n \ln(1 + \tau^c_{od}) \times \text{Intracountry}_{od} \\ & + \beta^c_1 \ln Distance_{od} + \beta_2 \ln Language_{od} \\ & + \beta^c_3 Intraregion_{od} + \beta^c_4 Intracountry_{od} \\ & + \beta^c_5 Adj.\ region_{od} + \beta^c_6 Adj.\ country \\ & + \varepsilon_{od}, \quad o = n, f, \quad c = 1, ..., C. \end{aligned} \tag{11}$$

Here α^c_d and α^c_o are the importing and exporting region specific fixed effects; $Intraregion_{od}$ and $Intracountry_{od}$ are dummy variables which equal one if the trade flow takes place within the same region and country respectively; while $Adj.\ region_{od}$ and $Adj.\ country_{od}$ are dummy variables indicating if the flow takes place between adjacent regions within the same country or between adjacent regions of different countries. Distance is included as a proxy for the bilateral taste parameter. The presence of this variable implies that the identification of the elasticity parameter will solely depend on how trade flows react to differences in trade costs apart from physical distance such as infrastructure, technological, logistic, and economic variables affecting trade. As explained in the next section, the ad-valorem (iceberg) transport cost included in the estimation is based on a precise measure of generalized transport costs (GTC) at the sectoral level for each origin-destination pair, $GTC^c_{od}, o = n, f$. As for the language variable, it is intended to capture if both intranational and international trade flows are driven by cultural (dis)similarity between regions. A positive and significant value of this variable would imply that socio-political and cultural differences drive trade flows even within countries, validating the hypothesis that national elasticities exist as goods imported from the same country cannot be considered perfect substitutes of those produced domestically in the home region.

Finally, note that the interaction between the iceberg transport cost and the $Intracountry_{od}$ variable allows differentiating between foreign and national trade flows and estimate the β^c_f and β^c_n parameters. The foreign and national elasticities of trade can be identified from these parameters: i.e., $\sigma^c_F = 1 - \beta^c_f$ and $\sigma^c_N = 1 - (\beta^c_f + \beta^c_n)$. The joint estimation of σ^c_F and σ^c_N in Equation (11), in comparison to individual regressions for both elasticities as in Equations (9) and (10), presents the advantage of testing whether the gap between the national and foreign trade elasticities is statistically significant or not, which is one of the main objectives of this study. In section 5 we report whether these two elasticities are statistically different.

We estimate Equation (11) using a computationally improved version (Larch et al. 2019; Correia, Guimarães, and Zylkin 2020) of the PPML estimator (Santos Silva and Tenreyro 2006, 2010, 2015).

3.2 | Pooling (Intra)National and Foreign (International) Trade Flows by Sectors

Estimating Equation (11) yields sector-specific trade elasticities that require running individual regression for each sector. However, it is possible to better the econometric reliability of the results by pooling all sectoral data into a single regression. This is achieved using sector-specific dummies capturing the particularities of trade flows in commodities belonging to the same sector. As a result, the remaining coefficients other than this intercept and the specific effects of transport costs are common across all commodities. It is worth mentioning that both the individual specifications for each sector and the pooled specification for all sectors are consistent with the theory. However, the latter is more advantageous from an econometric perspective because having a larger sample size improves the efficiency of the estimates.

In the following specification we follow this strategy by including sector fixed effects, α^c, and sectoral dummies that are interacted with the transportation costs corresponding to both (intra)national and foreign trade flows: D^c_{od}, $c = 1, ..., C$.

$$\begin{aligned} \ln V^c_{od} = {} & \alpha_0 + \alpha_d + \alpha_o + \alpha^c + \beta^c_f \ln(1 + \tau^c_{od}) \times D^c_{od} \\ & + \beta^c_n \ln(1 + \tau^c_{od}) \times Intracountry_{od} \times D^c_{od} \\ & + \beta_1 \ln Distance_{od} + \beta_2 \ln Language_{od} \\ & + \beta_3\, Intraregion_{od} + \beta_4\, Intracountry_{od} \\ & + \beta_5 Adj.\ region_{od} + \beta_6 Adj.\ country_{od} \\ & + \varepsilon_{od}, \quad o = n, f, \quad c = 1, ..., C. \end{aligned} \tag{12}$$

As before, the foreign and national elasticities of trade are identified from the parameters associated with the bilateral variation in transportation costs: that is, $\sigma^c_F = 1 - \beta^c_f$ and $\sigma^c_N = 1 - \left(\beta^c_f + \beta^c_n\right)$.

3.3 | Measuring Trade Elasticities at Different Levels of Data Aggregation

Models (11) and (12) account for different $c = 1, ..., C$ sectors corresponding to different levels of aggregation. In our case, we estimate the elasticities at a 2-digit industrial disaggregation of the Statistical Classification of Products by Activity (CPA, version 2.1), which is an exact mapping of the 2-digit (division) classification of the Standard Goods Classification for Transport Statistics (NST 2007, revision 2)—see Table 1. This results in the definition of 14 different sectors. As reported by Head and Mayer (2014) and Bajzik et al. (2020), elasticity values may vary widely across sectors. Since the results of the models regarding the gains-from trade and welfare effects brought about by policy simulations may be sensitive to a disparity of values, for example, Engler and Tervala (2018), modelers usually prefer to use parameters that are common for higher levels of aggregation. This requires estimates for higher classification levels (i.e., one-digit). Consequently, although our preferred estimates are those distinguishing between 14 sectors, for practitioners, we also provide estimates for the main three CPA categories (macro-sectors) of tradable goods: A ("Agriculture, forestry and fishing"), B ("Mining and quarrying") and C ("Manufacturing"), as well as one single estimate for the national and foreign elasticities.

Our strategy to obtain these estimates avoids aggregating trade flows and averaging frictions across pairs of regions and sectors because it may lead to aggregation and inference bias in log-linear models like the gravity equation, Lewbel (1992). On the contrary, we rely on three dummies identifying the macro-sectors for the pooling-data approach: D^c_{od}, $c = 1, ..., 3$. The advantage of this method is that, first, it exploits the existing heterogeneity between all pairs of trade flows and iceberg transport costs; second, it provides econometric consistency across the different levels of aggregation because it does not change the sample data of trade flows as the same number of observations is used in the different sectors-level regressions. It

TABLE 1 | Trade sectors and correspondence between the CPA 2.1 and the NST 2007 classifications.

CPA 2.1	NST 2007	Description CPA 2.1
CPA_A01	01	Products of agriculture hunting and related services
CPA_A02_A03	01	Products of forestry, logging, and related services. Fish and other fishing products, aquaculture. Products, support services to fish.
CPA_B	02–03	Mining and quarrying
CPA_C10-C12	04	Food products beverages and tobacco products
CPA_C13-C14-C15	05	Textiles wearing apparel and leather products
CPA_C16-C17-C18	06	Wood and products of wood and cork except furniture, articles of straw … Paper and paper products. Printing and recording services
CPA_C19	07	Coke and refined petroleum products
CPA_C20-C21-C22	08	Chemicals and chemical products. Basic pharmaceutical products and pharmaceutical preparations. Rubber and plastic products
CPA_C23	09	Other non-metallic mineral products
CPA_C24	10	Basic metals
CPA_C25	10	Fabricated metal products except machinery and equipment
CPA_C26-C27-C28	11	Computer electronic and optical products. Electrical equipment. Machinery and equipment nec
CPA_C29-C30	12	Motor vehicles trailers and semi-trailers. Other transport equipment
CPA_C31-C32	13	Furniture and other manufactured goods

Note: The correspondence tables between the two classifications are presented at the Eurostat's RAMON site: https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ramon.

also ensures that the estimates for higher-level sectors can be interpreted as a mean of lower levels, thereby preventing the problems signaled above.

4 | Data and Transport Costs Methodology

The estimation of the trade elasticities through Equations (11) and (12), according to the previous sectoral classification and three levels of aggregation, uses the latest available year of the trade flows database between for EU regions corresponding to 2013. The data included in the estimations can be grouped in three categories: (1) Trade flows (quantity and values); (2) generalized transport costs and associated iceberg values; and (3) ancillary control (dummy) variables regarding contiguity (adjacency), which capture border effects when administrative boundaries are considered at the time of segmenting trade flows into national and foreign trade flows.

4.1 | Trade Flows

Trade data between EU regions comes from the latest calculations of the Joint Research Centre (European Commission) and PBL Netherlands following the methodology proposed by Thissen et al. (2019). These authors estimate a probabilistic trade flows matrix to construct the interregional trade flows for all 267 (NUTS-2) EU regions. The methodology relies on 2013 national supply and use tables (SUTs), which are an update of the information of Eurostat SUTs, classified according to NACE Rev. 2. A general discussion of the methods can be found in Lecca et al. (2018).[9] In a first step, interregional SUTs for 240 NUTS2 regions are estimated using the constrained quadratic minimization procedure by combining the regional Social Accounting Matrices and considering Thissen et al. (2019) data on interregional trade flows as priors. In a second step, trade flows for the missing EU regions are estimated. The result is a regional trade matrix that is consistent with the regional SUTs and as close as possible to the main European transport data. We filter this trade matrix for extreme regional outliers (the Finnish island FI20, and the Portuguese islands PT20 and PT30) to finally get a complete matrix with 264 NUTS2 regions.[10]

This matrix is then decomposed into the 14-sectors included in the analysis. However, these trade flows are valued as FOB using factory-gate (mill) prices. Equations (11) and (12) are based on import flows inclusive of all types of iceberg transport costs, corresponding to a CIF denomination of (destination) prices. To convert FOB-denominated flows into CIF values, we need to incorporate nonobservable costs related to transport freight insurances.

To this aim, we collect data from the International Transport and Insurance Costs of Merchandise Trade (ITIC) database created by the OECD. This database estimates the insurance costs between pairs of OECD countries. It is expressed as a CIF-to-FOB ratio for pairs of countries and sector such as (CIF value-FOB value)/(CIF value). In the case of flows between regions located in different countries, we sum this ratio to the bilateral iceberg transport cost by sector and interact both with the trade flows in FOB prices to finally obtain import flows in CIF denominated prices. Nevertheless, we cannot get from the ITIC database an equivalent insurances' costs measure for pairs of regions belonging to the same country. On the contrary, we assume that the same insurance costs' structure exists for all pair of flows within the same country. Therefore, we calculate a sectorial average CIF-to-iceberg transport cost ratio for each country when trading internationally. This ratio estimates the relevance of insurance's costs over iceberg values for each country and sector. We, then, apply this ratio of CIF-to-iceberg transport costs to all pairs of regions within the same country and sector as in the case of international flows. In particular, we sum the CIF-to-iceberg transport cost ratio to the intranational iceberg transport costs and trade flows in FOB prices to finally get intranational trade flows in CIF prices. Throughout the analysis, trade flows refer to these calculated values of import (CIF) flows.[11]

4.2 | Generalized Transport Costs

The calculation of the transport costs entering our econometric specification enhances existing approaches based on the minimal cost route between an origin and a destination. It considers the existing distance and time costs from a transport engineering and logistics perspective and the actual road network—see Combes and Lafourcade (2005) and Zofío et al. (2014). Persyn, Díaz-Lanchas and Barbero (2022) employ this methodology to calculate a data set of generalized transport costs (GTCs) for the EU regions. However, their GTCs do not allow for the choice of the optimal type of vehicle used in transportation, depending on shipping distance, degree of urbanization between the origin and destination, and the type of commodity transported.[12]

This differentiation is crucial in models estimating trade elasticities for several reasons. First, "freight curves" determine the optimal vehicle size depending on the shipping distance between an origin i and destination j, $dist._{ij}$ (Jansson and Shneerson 1982; McCann 2001). Specifically, "freight curves" identify the vehicle size that minimizes the cost per ton and per unit distance (i.e., €/ton/km). Second, coupled with distance, are the topological characteristics of the transportation network. The most salient feature is the road type, such as expressways, national or local roads, streets, and so on, and the most limiting factor restricting the type of vehicle is whether the itinerary passes through urban areas, whose physical characteristics and regulations (based on risk or environmental concerns) only allow for small vehicles (i.e., light vehicles or two axle trucks). This is relevant since short distance shipments within urban areas and conurbations represents the largest proportion of intraregional trade (see Hillberry and Hummels 2008, and Díaz-Lanchas, Zofío, and Llano 2022) and are normally performed with this type of vehicles whereas, for intermediate and longer distances, medium size vehicles (i.e., 3–4 axle trucks) and heavy duty vehicles (i.e., articulated trucks with 5–6 axles) are preferred. Third, the type of vehicle employed for the shipment depends crucially on the commodity transported (e.g., whether the cargo is dangerous, liquid or solid bulk, palletized, containerized, etc.).

Both "freight curves" determining the optimal size (s) of the vehicle depending on distance, $s(dist._{ij})$, human settlement patterns such as the degree of urbanization between the origin i and destination j, $urb._{ij}$, along with the type of commodity, c, determine the optimal choice of vehicle employed when establishing the distance and time costs underlying the GTC. This results in a specific selection of representative vehicles that we employ when calculating the GTCs. Consequently, vehicle specification, v, is a function of the previous variables: $v(s(dist._{ij}),urb._{ij},c)$.

4.2.1 | "Freight Curves" and Optimal Vehicle Size

McCann (2001) relies on an inventory optimization approach to prove that, under very general conditions, the optimal size of a vehicle increases with the haulage distance and weight. The choice of optimal vehicle size based on distance hinges upon a balance between costs with respect to haulage distance, and transport engineering and handling costs, determined through logistics. Haulage costs refer to the annual direct costs (associated with distance and time) and ancillary indirect costs related to a specific vehicle. For illustrative purposes and taking the Spanish case as a reference in 2018, the average annual cost of operating a heavy-duty vehicle, HDV, corresponding to a 40 tons articulated truck with five axles and a 13.6-m trailer 4 m high—the typical "workhorse" of the European road freight industry—is 127,646.89€/year. Handling costs refers to time costs associated with loading, unloading, and docking operations (the latter including also the time spent in administrative paperwork upon arrival to and departure from the terminal). While haulage costs are variable by depending on distance,[13] handling costs are fixed and related to single legs.[14]

The relationship between optimal vehicle size and distance is driven by the trade-off between distance related costs expressed in euros per ton per km, which are lower the larger is the vehicle as it can carry a larger payload cargo (e.g., the maximum payload cargo of the HDV is 25 tons), and handling operations whose time costs per ton are higher the larger is the vehicle (as presented above). Based on transport engineering and logistics data, this relationship is observed for the case of road freight transportation. Supporting Information S1: Appendix B portraits the cost-lines and freight curves for road transportation. We update the cost data for the HDV presented in Zofío et al. (2014: table 1) and enlarge the menu of trucks to include four additional vehicles decreasing in size (i.e., from the largest reference vehicle, *Veh.* 5, to the smallest vehicle, *Veh.* 1), as well as handling times from Burdzik, Ciesla, and Sladkowski (2014). Table 2 presents the set of critical distance thresholds (d_1, ..., d_4) that identify the distance at which each vehicle is optimal by minimizing the transportation cost. The optimality of each vehicle for a given freight distance depends on the fixed cost associated with handling operations that is increasing in vehicle size—column (d), and variable costs corresponding to the hauling distance that are decreasing in vehicle size—column (e). The thresholds reported in the last column (f) represent the distance at which each vehicle becomes optimal. Results show that up to 10 km, the small vehicle is the best choice. The difference between two successive thresholds shows the distance range in which a given size is optimal, that is, that between the lower and upper thresholds. For example, the rigid vehicle with three axles, $Veh._3$, is optimal in the 18 km range between 25 and 43 km. Finally, aggregating consecutive thresholds yields the distance at which a given vehicle becomes optimal. For the HDV, the cumulated distances show that it is the optimal vehicle choice for shipments longer than 150 km (see also Figure B1b in Supporting Information S1: Appendix B). The relevance of the engineering and logistics approach in determining in a precise way these freight curves is to establish the concave relationship between transportation costs and distance, which is preserved by the calculated generalized transportation costs and iceberg costs. In turn, this curvature translates into a convex relationship between trade flows (imports) and iceberg costs, ultimately implying that trade elasticities are decreasing in distance, which constitutes one of the main findings of our study, that is, national trade elasticities are larger than their foreign counterparts.

Given these results, and the proximity of the distance thresholds, it seems unnecessary to consider all five types of vehicles when calculating the generalized transport costs, thereby reducing the computing time necessary to perform the analysis. Therefore, we consider three types of vehicles (shaded in gray in Table 2): small vans up to 10 km, the intermediate rigid (three axles) truck, which is optimal between 35 and 150 km, and the largest HDV, which is the vehicle of choice for shipments longer than 150 km. To ease the comparison between the costs corresponding to each type of vehicle accounting for whether they are variable (depending on distance or time) or fixed, we present in Appendix A their corresponding factors of

TABLE 2 | Distance thresholds for optimal vehicle sizes: handling and hauling costs.

	Maximum Payload (a)	Time costs (b)	Handling (c)	Handling (d) = (c) × (b)/(a)	Hauling (e)	Distance (f)
Vehicle	Tons	€/h	Hours	€/ton	€/km/ton	km
HDV (five axl.)	25.0	30.4	3.5	4.3	0.050	72.0
Rigid (four axl.)	22.3	27.7	3.2	3.9	0.058	43.0
Rigid (three axl.)	16.0	24.9	2.1	3.3	0.073	25.0
Large (two axl.)	9.5	22.7	0.9	2.2	0.114	10.0
Small (two axl.)	6.0	21.0	0.4	1.3	0.206	

Note: Maximum payload, time cost and hauling cost are calculated based on information from the Observatory for Road Freight Road Transportation, MFOM (2018). Handling times for the HDV are reported by Burdzik, Ciesla, and Sladkowski (2014). These include docking, loading, and unloading operations. *Source*: Own calculations based on Burdzik, Ciesla, and Sladkowski (2014) and MFOM (2018).

proportionality with respect to the reference HDV considered by Persyn, Díaz-Lanchas, and Barbero (2022).

4.2.2 | Freight Transportation in Urban Areas

As anticipated, besides the existence of optimal vehicles for alternative distances, $s(d_{ij})$, there are further constraints that limit the use of the above reference vehicles. These constraints refer to road infrastructure (in particular the urban grid or layout) and regulatory legislation (national, regional or city ordinances with respect to traffic congestion, safety, air pollution, and so on). For this reason, the calculation of GTCs requires to combine vehicle optimality with respect to distance and the reality of the geographical location in terms of their degree of urbanization. This accounts for the complex relationship between the spatial and functional structure of city logistics where the degree of urbanization interacts with various forms of transport infrastructure, see Giuliano et al. (2019). Although cities present a variety of forms and levels of density, each associated with specific urban logistic patterns, the available geographical information from the Global Human Settlement Layer (GHSL) project of the European Commission allows us to differentiate between three urbanization patterns.[15] The so-called GHS model classifies human settlement according to specific rules of population, built-up density, and contiguity of grid cells. Using satellite information, the GHSL method generates raster data of one square km resolution that differentiates between urban centers, urban clusters, and rural areas.

Combining the information of optimal vehicle size by distance, city logistics, and degree of urbanization for distances in the range between 10 and 150 km, the choice of the representative vehicle corresponds to the origin-destination matrix presented in Table 3 (for distances shorter than 10 km and longer than 150 km, the preferred vehicles are the small two axle truck and the HDV, respectively).

4.2.3 | Costs by Commodity

The last dimension in the determination of the optimal vehicle is to account for the type of commodity that is being transported. The choice of vehicle depends on the commodity or, more generally, the physical characteristics of the transported cargo in terms of weight and volume. Thus, the standard HDV is the vehicle of choice if the commodity can be transported in standard euro pallets (Burdzik, Ciesla, and Sladkowski 2014). If perishable goods are transported, it is necessary a temperature-controlled body made of insulated material and designed to carry temperature-sensitive products (chilled or frozen). If liquids, gases, or powders (bulk cargo) are transported, a tank fitted to a chassis is required. Other examples include the transportation of vehicles or containers that require "skeletal" trailers. Modifications of the above are also necessary in the case of hazardous materials, wide loads, and so on.

This variety of commodities results in substantial differences in costs across vehicles. Therefore, when calculating the GTCs associated with a given economic sector where the cargo presents specific characteristics, one needs to control for the costs associated with the choice of vehicle required for transportation. How this is achieved can be easily exemplified for the case of sector "C19" in the Statistical Classification of Products by Activity in the European Union, Version 2.1, (CPA 2.1), corresponding to "Coke and refined petroleum products." The European Commission provides a matrix relating the CPA 2.1 to the Standard Goods Classification for Transport Statistics, 2007 (NST 2007), according to which shipments are classified in the European Freight Road Transportation survey (ERFT). This survey allows us to ultimately identify the type of cargo and associated vehicle. Reading the matrix of correspondences, sector "C19" in the CPA 2.1 presents a one-to-one match with division 07 in the NST 2007: "Coke and refined petroleum products." Hence tabulating the data on commodities transported in the ERFT classified according to the NST 2007 and their associated type of cargo, one finds that for this particular sector the cargo corresponds mainly to liquid goods in bulk, 90.2% (of which 82.4% are dangerous—gasoline, gas, and so on—and the remaining 7.8% are nondangerous), and solid goods in bulk, 9.8% (of which 5.9% are dangerous—solid or waxy refined petroleum products—and the rest, 3.9%, are not).[16] Using the ERFT surveys for 2011–2014 we are able to match the commodity transported and corresponding vehicle.

Appendix B presents the commodity factors that either increase or decrease the transportation cost for each type of commodity,

TABLE 3 | Representative vehicles combining optimal size, city logistics, and urban patterns.

		Destination j		
10 km < $dist._{ij}$ ≤ 35 km		**Urb. center**	**Urb. cluster**	**Rural**
Origin i	Urb. center	Small	Small	Small
	Urb. cluster	Small	Small	Rigid
	Rural	Small	Rigid	Rigid
		Destination j		
35 km < $dist._{ij}$ ≤ 150 km		**Urb. center**	**Urb. cluster**	**Rural**
Origin i	Urb. center	Rigid	Rigid	Rigid
	Urb. cluster	Rigid	Rigid	HDV
	Rural	Rigid	HDV	HDV

Note: Small vehicle: two axles. Rigid vehicle: three axles. Heavy duty vehicle (HDV): five axles.

taking as reference the standard HDV. For example, while the cost of the HDV is 1.251 €/km, that of a tanker increases to 1.590 €/km (the annual costs in 2018 are 143,062.89 €/year, and assuming that it covers 90.000 km/year then the cost is 1.590 €/km). Hence, the commodity factor between these two vehicles is $f^c = 1.280$. Because commodities belonging to a given NST 2007 classification are transported with a combination of vehicles (e.g., dangerous and non-dangerous), economic factors are the average of the cost of the different vehicles weighted by the share of shipments transported by each type of vehicle.

4.2.4 | Calculating the Generalized Transport Costs

We denote by GTC_{ij}^{v} the generalized transport cost corresponding to the least cost itinerary I_{ij}^{v*} among the set of possible routes, I_{ij}^{v}, of moving vehicle v between origin i and a destination j. The itineraries are comprised of different arcs a_c, with an associated set of physical and legal attributes (i.e., maximum legal speed), $\mathbf{x}_{a_c}$. The primary physical attributes of an arc are its distance, $dist._a$, road type, r_a, and gradient (steepness), g_a. The arc speed, s_{a_c}, is derived from these properties, and thereby it is possible to determine the time it takes to cover it, $t_{a_c} = dist._a / s_{a_c}$.

The generalized transport cost for a given good c, $GTC_{ij}^{c,v}$, corresponds to the solution to the following problem:

$$GTC_{ij}^{c,v} = f^c\ GTC_{ij}^{v} = f^c \min_{I_{ij} \in \mathbf{I}_{ij}} \left(DistC_{ij}^{v*} + TimeC_{ij}^{v*} \right) + Taxes_{ij}^{v} + Vignette_{ij}^{v} + Handling_{ij}^{v}, \tag{13}$$

where

$$DistC_{ij}^{v} = \sum_{a \in I_{ij}} \left(\sum_{k} f_{ak}^{vd} e_{ak}^{d} \right) d_a = \sum_{a \in I_{ij}} \left(fuel_a^{v} + toll_a^{cv} \right) d_a + (tireCS^{v} + maintCS^{v}) \left(fuel_a^{v} d_a \right), \tag{14}$$

$$TimeC_{ij}^{v} = \sum_{a \in I_{ij}} \left(\sum_{k} f_{ak}^{vt} e_{ak}^{v} \right) t_a = \sum_{a \in I_{ij}} \left(1 + amortFinCS_v^{a} + insurCS_v^{a} + ind\ CS \right) \left(t_a lab_{ij}^{v} \right). \tag{15}$$

Compared to Persyn, Díaz-Lanchas and Barbero (2022), the GTC in Equation (13) has been enhanced by allowing for the choice of the optimal type of vehicle depending on distance, urban characteristics, and commodity transported, $v(s(dist._{ij}), urb._{ij}, c)$.[17] Thus, the original distance and time costs of the HDV considered by these authors, e_d^{ak} and e_{ak}^{t} (where k denotes cost per km), are modified by applying the individual vehicle factors corresponding to distance and time costs: f_{vd}^{ak} and f_{vd}^{ak} (Appendix B), thereby obtaining the new costs at the arc level $e_{ak}^{vd} = f_{ak}^{vd} e_{ak}^{d}$ and $e_{ak}^{vd} = f_{ak}^{vd} e_{ak}^{d}$. Last, the origin-destination GTC is qualified to account for the commodity transported c. As presented in Equation (13) $GTC_{ij}^{c,v}$ is the result of multiplying the baseline GTC_{ij}^{v}, corresponding to the vehicles of choice, by the commodity factor f^{c}.

The final generalized transport cost between two regions o and d is calculated as the arithmetic mean of the GTC between I centroids belonging to region o, indexed by $i = 1, ..., I$, and J centroids belonging to region d, indexed by $j = 1, ..., J$ (each centroid drawn from a one square km population density grid). The final GTC for a given commodity c corresponds to: $\mathrm{GTC}_{od}^{c,v} = \frac{1}{IJ} \left(\sum_i \sum_j GTC_{ij}^{c,v} \right)$. In the above calculations, it is possible to identify the GTC associated with each type of vehicle that is used between each centroid pair, $GTC_{ij}^{c,v}$. Once the average is taken, we can recover the percentage shares associated with each one of the three vehicles, $s_{od}^{v} \geq 0$, $\sum_{v=1}^{3} s_{od}^{v} = 1$. Finally, as a result of the region-specific distance and time costs, the bilateral generalized transport costs are asymmetric; i.e., $GTC_{od}^{c,v} \neq GTC_{do}^{c,v}$.

4.3 | Iceberg (Ad Valorem) Transport Costs

The last step in estimating the iceberg transport costs takes advantage of the GTC calculations when defining the ad valorem transportation cost between any two regions for each trade sector. Matching sectorial trade flows with their corresponding generalized transport costs $GTC_{od}^{c,v}$, we define the iceberg transport cost τ_{od}^{c} as follows:

$$\tau_{od}^{c} = \frac{F_{od}^{c} \sum_{v=1}^{3} \left(\frac{s_{od}^{v}}{L_{od}^{v}} \right) GTC_{od}^{c,v}}{V_{od}^{c}} = \frac{\sum_{v=1}^{3} \left(\frac{s_{od}^{v}}{L_{od}^{v}} \right) GTC_{od}^{c,v}}{P_o^{c}}, \quad s_{od}^{v} \geq 0, \sum_{v=1}^{3} s_{od}^{v} = 1, \quad o = n, f, \tag{16}$$

where F_{od}^{c} (tons) and V_{od}^{c} (€) are the quantity and value of the trade flows in origin; $GTC_{od}^{c,v}$ (€/veh.) is the generalized transport cost for each vehicle size, calculated as in Equation (13); s_{od}^{v} are the shares of each vehicle in the bilateral shipments between regions; and, finally, L_{od}^{v} (tons/veh.) is the average load of the shipments. The information on vehicles shares s_{od}^{v} and average loads L_{od}^{v} is obtained from the European Freight Road Transportation (ERFT) survey by segmenting the sectoral shipments according to the maximum permissible laden weigh and calculating the ratio of actual payload to maximum payload. The numerator in expression (16) calculates the number of vehicles necessary to ship the quantity F_{od}^{c} according to the current distribution of vehicles, by multiplying the number of required vehicles by their generalized transport cost. Subsequently, the transport cost is related to the value of the shipments, yielding the ad valorem value.

As the second equality in Equation (16) shows, the ad valorem aggregated transport cost can be related to the unit price in origin corresponding to each sector P_o^{c}. We rely on Eurostat Community External Trade Statistics (COMEXT) database that allows the calculation of unit prices at the national level. COMEXT gives detailed statistics on external trade for each EU member state by type of product and export and import source. For each CPA 2.1 sector and country of origin unit prices are calculated as $P_{od}^{c} = \sum_D F_{od}^{c} / \sum_D V_{od}^{c}$; that is, tons and value are aggregated for all combined EU states.[18]

Table 4 summarizes the information on the iceberg transport costs τ_{od}^{c} by CPA sector, as well as the variables $GTC_{od}^{c,v}$ and P_{od}^{c} entering their calculation. The information is differentiated in terms of the elasticities of interest: foreign (international flows between countries) and national (interregional trade flows within countries). As expected, both generalized transport costs and unit prices are in general larger for international trade flows than national ones, resulting in larger iceberg transport costs. To illustrate the relationship between the iceberg transport costs and its components, we have calculated the average values of these three variables by quintiles of $GTC_{od}^{c,v}$. Results are reported in Appendix C, along with the boxplots chart of the distribution of the iceberg transport costs by the same quintiles. Both the iceberg and generalized transport costs are increasing in distance, but unit prices tend to be stable in accordance with Table 4.[19] Given the spatial distribution of economic activity within the EU, region-pairs in higher distance-quintiles tend to be more peripheral and less developed. This may explain why unit prices do not monotonically increase when considering trade within higher GTC quintiles as was found by Behrens and Brown (2018) for Canada.

4.4 | Language and Control and Variables

The index of common native language capturing cultural (dis) similarity among regions—both domestically and internationally—has been elaborated by Gurevich et al. (2021) following previous work by Melitz and Toubal (2014). It is defined as a continuous index in the [0,1] interval reflecting the likelihood that two people selected at random from regions *o* and *d* will speak the same native language. The positive and significant effect of this variable on intranational trade reflects that there exist cultural differences between regions belonging to the same country that drive internal trade flows. Finally, ancillary variables such as geographical distances and adjacency are included in the analysis to capture idiosyncratic characteristics. Distances and contiguity between regions and countries, are computed using the Geodata on Administrative Units provided by Eurostat GISCO.

5 | Results

5.1 | Individual Estimation of National and Foreign Elasticities by Sector

Following Hertel et al. (2007), we report first the ancillary results obtained from estimating the foreign and national trade elasticities for each of the 14 sectors individually—Equation (11). These results are presented to stress the robustness of those obtained with the pooled regression, which exhibit econometric advantages and therefore constitute our reference model. Table 5 presents their values as well as those of their underlying parameters used to calculate their magnitude, shown in the first two rows, and test their statistical significance. There are 11 sectors for which the foreign elasticity of substitution, $\sigma_F^c = 1 - \beta_f^c$, is significantly different from one, with values that range between $\sigma_F^{A02-A03} = 0.996$ ("Products of forestry" and "Fishing") and $\sigma_F^{C25} = 48.964$ ("Fabricated metal products").[20] In 8 out of the 11 sectors, foreign elasticities present values in line with those reported in the previous literature for *international* trade flows using the same sector-by-sector estimation strategy; that is, $\sigma_F^c < 4$.[21] Combining the results obtained for the β_f^c and β_n^c parameters we can recover the elasticity corresponding to national trade, $\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$. Note that, regardless of the statistical significance of its underlying parameters, σ_N^c can be statistically different from one. Altogether, there are 12 sectors for which the national elasticities of substitution are statistically significant, exhibiting a positive sign. National elasticities σ_N^c range between $\sigma_N^{C31-C32} = 2.439$ ("Furniture" and "Other manufactured goods") and $\sigma_N^{C25} = 49.004$ ("Fabricated metal products").

The third rows in both panels of Table 5 summarize if foreign and national elasticities differ from each other statistically and, if they do, what is the direction of the inequality; that is, whether $\sigma_F^c = \sigma_N^c$. Looking at the statistical significance of the trade elasticity, in six sectors national trade elasticities are greater than their foreign counterparts, $\sigma_F^c < \sigma_N^c$, while in another six sectors the hypothesis that they are equal, $\sigma_F^c = \sigma_N^c$, cannot be rejected. This latter figure includes the relevant outcome when both elasticities are equal but clearly different from 1 (five cases), Moreover, in only two cases, foreign elasticities are greater than national elasticities, $\sigma_F^c > \sigma_N^c$, but this includes sector C29–30 exhibiting the wrong sign. Therefore, we conclude that the individual sector-by-sector estimations reported in Table 5 suggest that the national elasticities tend to be larger than their foreign counterparts when they are statistically different. This is confirmed by the median value of the national elasticities across all sectors standing at 6.634, more than doubling the median of the elasticities for international trade at 2.465. A result that is later confirmed in the following section reporting the results from the pooled estimation.

As for the rest of the control variables, they present the expected sign and significance. The estimated parameter for the log of distance (ln*Distance*) is always negative and generally significant. As for the language variable (ln*Language*) reflecting cultural (dis)similarity across regions, it is clearly positive when statistically significant—a result further confirmed in the pooled regression, showing that there exist idiosyncratic differences both between regions belonging to the same country or to different countries. This implies that socio-political and cultural differences drive intranational trade flows, supporting the hypothesis that products imported from regions within the same country cannot be considered as perfect substitutes of those domestically produced in the home region, which justify the definition and measurement of national elasticities. Additionally, those associated with the regional and national border dummies capturing trade within the same region and/or country ($Intraregion_{od}$ and $Intracountry_{od}$), as well as geographical adjacency ($Adj.\ region_{od}$ and $Adj.\ country_{od}$), are also in general positive and significant. Correlation coefficients are also high in the range 0.730 and 0.932.

Finally, given our preference for the pooled approach to estimate the trade elasticities, as justified in the econometric Section 3.2, we do not pursue here the sector-by-sector strategy to estimate higher-level elasticities for each of the three higher levels of the CPA classification: A (Agriculture, forestry and fishing), B (Mining and quarrying), and C (Manufacturing).

TABLE 4 | Iceberg, generalized transport costs and unit prices.

CPA	$\bar{\tau}^c_{od}$	$\bar{\tau}^c_{fd}$ Foreign	$\bar{\tau}^c_{nd}$ National	$\overline{GTC}^c_{od}$	$\overline{GTC}^c_{fd}$ Foreign	$\overline{GTC}^c_{nd}$ National	$\bar{P}^c_{od}$	$\bar{P}^c_{fd}$ Foreign	$\bar{P}^c_{nd}$ National
CPA_A01	0.343	0.359	0.145	2259	2388	670	427	431	375
CPA_A02-A03	0.832	0.874	0.315	2259	2388	670	137	139	121
CPA_B	1.236	1.302	0.423	2690	2844	791	26	25	30
CPA_C10-C12	0.180	0.189	0.068	2140	2262	636	723	729	652
CPA_C13-C15	0.081	0.085	0.029	2015	2130	600	2606	2609	2567
CPA_C16-C18	0.131	0.136	0.058	2018	2133	602	1167	1183	959
CPA_C19	0.219	0.231	0.071	2489	2632	740	681	683	653
CPA_C20-C22	0.477	0.503	0.153	2171	2295	646	343	341	375
CPA_C23	0.318	0.335	0.113	2410	2548	712	572	577	512
CPA_C24	0.307	0.322	0.126	2113	2234	629	421	421	414
CPA_C25	0.016	0.017	0.006	2113	2234	629	8159	8142	8361
CPA_C26-C28	0.093	0.097	0.036	2112	2233	630	2245	2246	2235
CPA_C29-C30	0.139	0.147	0.046	2063	2180	616	1678	1680	1653
CPA_C31-C32	0.730	0.768	0.261	2017	2133	601	249	249	253

Note: Average values. Own elaboration.

TABLE 5 | Sectoral foreign and national elasticities of trade, individual sectors.

Variable	A01	A02–A03	B	Sector C10–12	C13–14–15	C16–17–18	C19
$\sigma_F^c = 1 - \beta_f^c$	1.020	0.996	2.805***	1.731	13.222**	5.364*	0.637
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	8.128***	0.702	3.171**	24.234***	7.483	10.103*	7.099***
$\sigma_F^c >=< \sigma_N^c$	<	=	=	<	>	<	<
β_f^c	−0.0196	0.004	−1.805**	−0.731	−12.220**	−4.364	0.363
	(0.936)	(0.511)	(0.756)	(1.822)	(6.571)	(2.986)	(1.079)
β_n^c	−7.108***	0.294	−0.367	−22.500***	5.739	−4.739*	−6.496***
	(1.333)	(0.696)	(1.278)	(6.701)	(7.596)	(3.079)	(2.181)
ln*Distance*	−0.214	−0.457***	−0.285**	−0.302**	−0.365***	−0.519***	−0.345***
	(0.156)	(0.155)	(0.116)	(0.150)	(0.091)	(0.089)	(0.064)
ln*Language*	0.098	−0.015	−0.054	0.0753	0.273**	0.221**	0.0563
	(0.062)	(0.100)	(0.133)	(0.102)	(0.116)	(0.088)	(0.066)
Intraregion	2.635***	1.897***	2.079***	2.059***	0.530*	2.073***	1.226***
	(0.554)	(0.395)	(0.265)	(0.384)	(0.320)	(0.258)	(0.235)
Intracountry	3.213***	4.154***	3.497***	3.953***	1.859	1.006	3.915***
	(0.313)	(0.878)	(1.059)	(0.878)	(1.343)	(0.860)	(0.575)
Adj. Region	1.001***	0.664***	1.002***	0.841***	0.291***	0.448*	0.574***
	(0.156)	(0.163)	(0.236)	(0.136)	(0.102)	(0.180)	(0.125)
Adj. Country	−1.367***	0.205	−0.765	−0.709	−0.266	−0.700	−0.502
	(0.396)	(0.565)	(0.729)	(0.737)	(0.881)	(0.440)	(0.385)
R^2	0.897	0.899	0.870	0.932	0.863	0.889	0.917
N° Observations	69,696	68,644	69,696	69,696	69,696	69,696	69,169

Variable	C20–21–22	C23	C24	Sector C25	C26–27–28	C29–30	C31–32
$\sigma_F^c = 1 - \beta_f^c$	2.608***	2.321***	3.624**	48.964***	3.600***	3.133***	1.897***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	2.924***	11.180***	6.168***	49.004**	8.947*	−5.029**	2.439***
$\sigma_F^c >=< \sigma_N^c$	=	<	<	=	=	> (Wrong)	=
β_f^c	−1.608***	−1.321	−2.624***	−47.960***	−2.600***	−2.133**	−0.897***
	(0.547)	(0.900)	(0.781)	(10.942)	(1.027)	(0.976)	(0.257)
β_n^c	−0.317	−8.859***	−2.544*	−0.040	−5.346	8.162***	−0.542
	(0.653)	(2.591)	(1.255)	(18.365)	(4.795)	(2.390)	(0.611)
ln*Distance*	−0.183*	−0.195	−0.085	−0.383***	−0.273***	−0.460***	−0.326***
	(0.094)	(0.161)	(0.099)	(0.105)	(0.076)	(0.067)	(0.058)
ln*Language*	−0.016	0.133***	0.086*	0.081***	0.0736**	0.079**	0.135***
	(0.04)	(0.047)	(0.051)	(0.030)	(0.030)	(0.032)	(0.030)
Intraregion	0.593**	2.560***	0.839**	1.497***	1.329**	1.185***	1.188***
	(0.260)	(0.415)	(0.355)	(0.329)	(0.255)	(0.253)	(0.231)
Intracountry	3.058***	2.917***	2.746***	3.165***	1.753***	0.498	1.798***
	(0.347)	(0.566)	(0.552)	(0.332)	(0.319)	(0.346)	(0.272)
Adj. Region	0.226*	1.115***	0.297**	0.747***	0.641***	0.548***	0.587***
	(0.120)	(0.198)	(0.121)	(0.117)	(0.140)	(0.125)	(0.100)

(Continues)

TABLE 5 | (Continued)

Variable	C20–21–22	C23	C24	Sector C25	C26–27–28	C29–30	C31–32
Adj. Country	0.360	0.621**	0.808***	0.152	0.307**	0.253	0.615***
	(0.220)	(0.273)	(0.302)	(0.157)	(0.128)	(0.163)	(0.122)
R^2	0.769	0.908	0.888	0.919	0.809	0.731	0.869
N° Observations	69,696	69,696	69,696	69,696	69,696	69,696	68,644

Note: Importer and exporter fixed effects; country-pair clustered standard errors in parenthesis. Significance of the trade elasticities indicates that they are different from one. The inequality between trade elasticities (<) depends on the significance of the marginal effect β_n^c.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

5.2 | Pooled Estimation of National and Foreign Elasticities

The standard method of estimating trade elasticities sector-by-sector can be compared to that of pooling the trade data as presented in Equation (12). This specification includes the interaction between the transportation costs and their corresponding sectors to identify foreign elasticities of trade and, once again, a dummy variable capturing whether the trade flow takes place between regions within a country to identify national elasticities of trade. Contrary to Equation (11) the advantage of this specification is that it yields a single value for the common variables that control for distance, border and adjacency effects, while allowing for a larger number of observations and thus more efficient parameter estimation.

Table 6 reports the results for sectoral elasticities. Now all foreign and national elasticities exhibit the expected positive sign. They are also significantly different from 1. As in Table 5 the third row summarizes whether foreign elasticities of trade $\sigma_F^c = (1 - \beta_f^c)$ differ from their national counterparts $\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$. Under this specification, we now find that foreign and national trade elasticities are in most cases statistically different from each other. This is the case in 9 of the 14 sectors, with national elasticities being consistently greater than foreign elasticities ($\sigma_F^c < \sigma_N^c$). Regarding the common variables, they present the expected sign and significance, including distance and common native language. In addition, the R^2 is rather high at 0.823. As opposed to the split-sample approach of Hummels (2001) and Hertel et al. (2007) previously used, we remark that this estimation strategy seems to be the appropriate one when recovering the two levels of trade elasticities corresponding to foreign and national goods. The former approach producing less precisely estimated parameters. It is perhaps not surprising that the less efficient split-sample (sector-by-sector) approach struggles to produce precise parameter estimates in a context where there are no tariffs. In this latter case, the identification of elasticities rather hinges on relatively small differences in interregional transport cost caused by geography, infrastructure and other factors affecting trade flows, after controlling for solely physical distance. Also, this estimation strategy does not yield negative values.

The results obtained for higher-level elasticities resulting from differentiating all trade flows into the three main NACE categories are reported in Table 7. For each of the three sectors: A ("Agriculture, forestry and fishing"), B ("Mining and quarrying") and C ("Manufacturing"), we observe that the estimated national elasticity is always significantly larger than the national one. Finally, we estimate the single elasticity for both foreign and national trade flows, without differentiating among sectors. These global results are shown in the last column of Table 7. Once again, the estimated values are reasonable from the perspective of own-price elasticity or elasticity of substitution. We now proceed to discuss the numerical values of the sectoral and higher-level elasticities considering previous results obtained in the literature.

5.2.1 | Foreign Elasticities of Trade

Foreign elasticities of trade at the two-digit CPA sectoral level (Table 6), range between sector C31–32 (including "Furniture" and "Other manufactured goods"), $\sigma_F^{C31\_32} = 1.575$, and sector C25 "Fabricated metal products except for machinery and equipment," $\sigma_F^{C25} = 154.967$.[22] However, beyond this last elasticity value, the rest of elasticities are one order of magnitude smaller, as the next value corresponds to sector C16–18 (including "Wood," "Paper," and "Printing products"), $\sigma_F^{C16\_18} = 13.620$. For comparison purposes with the traditional (split-sample) estimation approach presented in the previous section, the median value of foreign elasticities is now 4.468. This figure is slightly higher than the value of 3.8 reported by Bajzik et al. (2020) in their meta-analysis of foreign trade elasticities, accounting for publication bias and study quality. Foreign trade elasticities are smaller than 7 in 10 sectors (out of 14), with their corresponding national counterparts doubling again their value when they are statistically different. These values of foreign elasticities for trade between EU countries are in line with those reported in recent literature relying on international trade flows from projects such as GTAP (World data), the Michigan model (US), USAGE (US), and MONASH (Australia). In these latter projects the identification of elasticities is based on tariffs as well as on time series or cross-sectional analyses. Comparing our results to those surveyed in table 1 by Hillberry and Hummels (2013; 1221) for multicountry (including some EU countries or the block as a whole) and single-country models, their range of elasticities is [0.9, 34.4]. As the level of sectoral aggregation is similar to ours, we confirm that our estimates of comparable (foreign) trade elasticities are in accordance with those calculated in previous studies (see also Table 1 in Hertel et al. 2007).

There are also a few studies calculating trade elasticities between EU countries using different econometric approaches and for specific sectors; that is, Németh, Szabó and Ciscar (2011), Welsch (2008) and Olekseyuk and Schürenberg-Frosch (2016). The first two focus on energy intensive sectors. Németh,

TABLE 6 | Sectoral foreign and national elasticities of trade, pooled sectors.

Variable	A01	A02–03	B	Sector C10–12	C13–14–15	C16–17–18	C19
$\sigma_F^c = 1 - \beta_f^c$	4.931***	3.568***	3.816***	13.036***	12.754***	13.620***	6.687***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	7.273***	3.141**	6.261***	22.633***	13.858*	27.807***	5.537***
$\sigma_F^c >=< \sigma_N^c$	=	=	<	<	=	<	=
β_f^c	−3.931***	−2.568***	−2.816***	−12.040***	−11.750***	−12.620***	−5.687***
	(0.957)	(0.670)	(0.967)	(2.668)	(3.630)	(2.220)	(1.398)
β_n^c	−2.342	0.427	−2.445***	−9.597**	−1.104	−14.190***	1.150
	(2.598)	(1.315)	(0.848)	(3.867)	(7.398)	(4.197)	(1.860)

Variable	C20–21–22	C23	C24	Sector C25	C26–27–28	C29–30	C31–32
$\sigma_F^c = 1 - \beta_f^c$	1.437***	6.147***	3.524***	154.967***	4.004***	2.910***	1.575***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	1.862*	10.943***	9.312***	124.380***	29.417***	24.400***	2.866***
$\sigma_F^c >=< \sigma_N^c$	<	<	<	=	<	<	<
β_f^c	−0.437	−5.147***	−2.524***	−154.000***	−3.004**	−1.910*	−0.575**
	(0.332)	(0.764)	(0.614)	(16.556)	(1.369)	(1.014)	(0.254)
β_n^c	−0.425*	−4.797*	−5.789***	30.590	−25.410***	−21.490***	−1.291*
	(0.383)	(2.498)	(2.087)	(31.441)	(8.512)	(5.498)	(0.749)
Common variables for all sectors	ln*Distance*	ln*Language*	*Intra region*	*Intra country*	*Adjacent Region*	*Adjacent Country*	
	−0.126***	0.092**	1.990***	2.349***	0.714***	−0.037	
	(0.044)	(0.038)	(0.245)	(0.376)	(0.103)	(0.213)	
R^2				0.823			
N° Observations				975,744			

Note: Importer, exporter and sector fixed effects; Country-pair clustered standard errors in parenthesis.
Significance of the trade elasticities indicates that they are different from one. The inequality between trade elasticities (<) depends on the significance of the marginal effect β_n^c.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Szabó, and Ciscar (2011) report short and long-term trade elasticities for 1995–2005 and the range of comparable elasticities between imports originating in two different countries for seven energy-intensive sectors is [0.8, 2.8]. These values are particularly low in light of the elasticities reported by Hillberry and Hummels (2013) for comparable energy sectors and our own estimates, with just two elasticities below their upper bound: $\sigma_F^{C20–21} = 1.437$ and $\sigma_F^{C31–32} = 1.575$.[23] On their part, Olekseyuk and Schürenberg-Frosch (2016) estimate country-specific elasticities from trade data between eight EU countries for selected manufacturing sectors in the period 1995-2011. The range of elasticities for the manufacturing sectors considered in their study is [0.300; 3.670]. As for the panel data results, their pooled fixed effects estimations yield trade elasticities in the range [0.320, 2.430]. Focusing on the goodness of fit, we highlight that the number of sectors for which trade elasticities exhibit the right sign and are statistically significant is substantially lower than in our case.

Moving up to the three sectors results in Table 7, we observe that the effect of considering the main categories is a reduction in the value of the elasticities, with higher-level elasticities ranging now from $\sigma_F^C = 1.760$ ("Manufacturing") to $\sigma_F^A = 4.867$ ("Agriculture, forestry, and fishing"). Therefore, considering higher-level classifications of commodities brings the value to the lower bound of the sectoral elasticities. This supports the hypothesis that, because intra-industry diversity decreases with an increasing level of sectoral grouping, more "aggregated" data should yield smaller elasticities—and vice versa.

Altogether, we conclude that our results for foreign trade elasticities are above those previously estimated for EU countries only, but in the range of those obtained in international studies, including countries of several world regions; that is, Hillberry and Hummels (2013) and Hertel et al. (2007). This suggests that the joint estimation of national and foreign elasticities in single-market areas like the EU could bring their values to the levels observed in most studies. This result is reinforced by the fact that our estimates of foreign trade elasticities are also greater for higher levels of sectoral aggregation (see MacDaniel 2003, Jovanovic 2013, Imbs and Mejean 2015, and Bajzik et al. 2010).

TABLE 7 | Higher-level foreign and national elasticities of trade, pooled sectors.

Sector Variable	A Agriculture, forestry, and fishing	B Mining and quarrying	C Manufacturing	All sectors
$\sigma_F^c \;= 1 - \beta_f^c$	4.867**	2.979***	1.760***	2.131***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	11.044***	5.706***	5.355***	4.640***
$\sigma_F^c >=< \sigma_N^c$	<	<	<	<
β_f^c	−3.867***	−1.979**	−0.760***	−1.131***
	(0.642)	(0.936)	(0.265)	(0.405)
β_n^c	−6.176***	−2.727***	−3.595***	−2.509**
	(1.626)	(0.883)	(0.969)	(0.606)
ln*Distance*		−0.332***		−0.351***
		(0.035)		(0.046)
ln*Language*		0.0974**		0.098***
		(0.035)		(0.039)
Intraregion		1.583***		1.568***
		(0.252)		(0.254)
Intracountry		2.449***		2.335***
		(0.370)		(0.206)
Adj. Region		0.669***		0.688***
		(0.126)		(0.124)
Adj. Country		0.106		0.098
		(0.166)		(0.212)
R^2		0.758		0.811
N° Observations		975,744		975,744

Note: Importer, exporter and sector fixed effects; Country-pair clustered standard errors in parenthesis. Significance of the trade elasticities indicates that they are different from one. The inequality between trade elasticities (<) depends on the significance of the marginal effect β_n^c.
$^*p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

5.2.2 | National Elasticities of Trade

As for the national elasticities of trade, our results indicate considerable variability across sectors. Half of the sectors exceed a value of 10. In this case, the median national trade elasticity is 10.128. Generally, as in the case of foreign elasticities, it is observed that the smaller elasticities correspond to sectors with relative low value added and/or producing relatively less differentiated varieties (or more homogenous products). Beyond the lowest value $\sigma_N^{C20-22} = 1.862$ (including "Chemicals," "Pharmaceutical" and "Rubber products"), sectors A01 ("Agriculture"), A02–A03 ("Products of forestry" and "Fishing"), B ("Mining and quarrying"), and C19 ("Coke and refined products") exhibit elasticities below 8. Only sector C31–32 (including "Furniture" and "Other manufactured goods") escapes this general characterization. On the contrary, values of trade elasticities above 10 can be found in sectors producing goods with higher value added and heterogeneous characteristics—except the largest value obtained for sector C25, "Fabricated metal products," standing at $\sigma_N^{C25} = 124.280$ (the same remarks discussed for the foreign elasticity apply here). Sector C10–12 (including "Food products" "Beverages," and "Tobacco," C12), all equipment related goods comprised in sector C26-28 ("Computer," "Electronic," and "Machinery"), sector C16-18 ("Wood," "Paper," and "Printing products"), as well as transport related products C29–30 ("Motor vehicles," and "Other transport equipment"), show elasticities above 20, thereby doubling the median and average elasticity of low value added and homogenous sectors.

These sectoral differences in the values of national trade elasticities are also found in their foreign trade counterparts since both series highly correlate: $\rho(\sigma_F^c, \sigma_N^c) = 0.964$. Although it might seem counterintuitive, the fact that both foreign and national trade elasticities are smaller for low-value added and homogenous goods and, therefore, greater for high value added and heterogeneous goods is in line with the results reported in Hertel et al. (2007) and Olekseyuk and Schürenberg-Frosch (2016). For instance, table 1 in Hertel et al. (2007, p.622) summarizes the elasticity values adopted in the GTAP project, which follow similar sectoral patterns, i.e., the smallest values are found precisely in chemical, rubber and plastic products, along with petroleum and coal products, while the highest valued correspond to motor vehicles and transport equipment, as in our case. Olekseyuk and Schürenberg-Frosch (2016) offer an appealing explanation for these results. They suggest that for some of these low value-added and homogenous sectors the relative trade costs are very high or require special logistic investments. An example may be cement (included in subsector C23.5, "Cement, lime and plaster"), which is a quite homogeneous product, yet its market structure is characterized by high market power as a result of firm concentration and the existence of entry barriers related to ownership of essential facilities—or privileged access to them through long term contracts, for example, quarries, mines—or the need to make large investments (e.g., those required for handling and storage). This translates into low effective competition which may cause importers to become locked in with specific suppliers over longer time periods, and prevents switching import origins even if prices change significantly. At the other end of the spectrum, cars or vehicles are quite heterogeneous, but transport costs are relatively low compared to the value of the product, there is no need for buyers to make specific investments for handling, and switching costs are almost nonexistent.

As for the results of the national elasticities at higher grouping levels, we observe once again that the "aggregation" process results in a significant reduction in their values. In particular, the elasticities range between $\sigma_N^C = 5.355$ ("Manufacturing") and $\sigma_N^A = 11.044$ ("Agriculture, forestry, and fishing"). As for the highest level of grouping, the overall national elasticity stands at $\sigma_N = 4.640$. Interestingly, these values are similar to the estimates obtained in the empirical literature for foreign trade elasticities based on the standard two-tier utility function, and focused on the estimation of higher-level elasticities—Hertel et al. (2007, p.622). Indeed, the values reported in Table 7 are those similarly adopted in an array of studies from theoretical simulations of New Economic Geography, trade policy evaluations in New Trade Theory, to complex empirical regional CGE models. In all these domains the single elasticity parameter is normally assumed to be in the range between 4 and 5; for example, see Fujita, Krugman and Venables (1999) for NEG models, Anderson and van Wincoop (2003) for NTT, and Lecca et al. (2018) for the RHOMOLO model of the European Commission.

In general, from our results we confirm the hypothesis that national elasticities are greater than foreign elasticities. This result may be a consequence of the fact that (intra)national trade faces fewer non-price related trade restrictions than international trade (even within single markets like the EU). At the same time, the goods (varieties) produced in regions within the same country are better known to consumers and, therefore, exhibit higher substitutability. Furthermore, we confirm that sectors producing general goods with relatively low valued added and product differentiation, exhibit lower elasticities of substitution and vice versa.

5.2.3 | Robustness Checks

The set of results reported in Tables 5–7 suggest their consistency across sample sizes (smaller for the individual sector regressions considering model (11)) and different sectoral levels of aggregation. To give further validity to our results we perform two additional robustness checks. First, we consider an alternative specification of the effect of cultural (dis)similarity by considering international trade only. That is, rather than considering differences in common native language both within and between countries, as we do in our baseline specifications, in the alternative model we interact the language index with a dummy variable of international trade (i.e., cultural (dis)similarity applies only to trade between regions belonging to different countries). Appendix E shows that all β_f^c and β_n^c the coefficients as well as the foreign and national trade elasticities derived from them change marginally at the decimal points, and the same is observed for the effect of language on trade that remains significant at a similar value. Since the coefficient of the language variable does not change from considering cultural (dis)similarity for all trade flows (Table 6) to international trade flows only (Appendix E), we conclude that the effect for intranational trade flows is of comparable magnitude. Moreover, changing the definition of the dummy to interact the language variable with intranational trade confirms this result. Therefore, cultural (dis)similarity within countries does have an effect on trade flows, implying that imports from regions within the same country are greater (smaller) the closer (farther) are the regions culturally, and suggesting that products imported from regions within the same country are perceived as differentiated from those produced domestically in the home regions. Note that this result is achieved by considering all trade flows within the EU, which includes countries that exhibit large regional heterogeneities (see Endnotes [3] and [4]).

A second robustness check swaps physical distance and the iceberg costs, thereby considering the former as the main transport cost measure from which to recover trade elasticities. Results for this regression are presented in Appendix F. All the coefficients β_f^c and β_n^c as well as the foreign and national trade elasticities derived from them present similar signs and statistical significance to those reported in Table 5. However, their magnitude is far more reduced. Moreover, with the exceptions of sector C10–12 and C25, we cannot reject the hypothesis of equal values for both elasticities, that is, $\sigma_F^c = \sigma_N^c$, implying that the specification cannot capture the higher sensitivity of trade in short distances (national elasticities) over long distance (foreign trade). Note that in this regression the coefficient for the iceberg transport cost is larger than its counterpart when physical distance is used as control variable as in Table 5. This corroborates that our measure of iceberg transport cost embeds relevant information regarding the technological, logistic, infrastructure, and economic variables driving imports. That is, iceberg transport costs capture all these relevant dimensions apart from physical distance, which ultimately determines the differences between trade elasticities across sectors and flows (national vs. foreign).

6 | Conclusions

This study introduces the theory and practice on the simultaneous estimation of two trade elasticities, differentiating between imports from regions within the same country and international imports. This estimation of trade elasticities at the national and foreign levels have not been undertaken in the literature because it requires compatible data on international and interregional trade flows, and a reliable measure of transport costs. As this is not normally the case, this relevant qualification of the trade literature has remained unexplored. We develop a three-tier theoretical model based on the CES utility function specification that provides the microeconomic foundation for the gravity equations from which national and foreign elasticities of substitution can be identified. The equations are then econometrically estimated through the PPML method using EU trade data at the regional level. Identification relies on the calculation of generalized transport costs, as opposed to international trade models where tariffs serve this purpose. We calculate a very detailed matrix of the minimum freight costs between regions that accounts for the actual road infrastructure, optimal vehicle size depending on shipping distance, urban layout, and type of cargo. Coupled with information on average loads and unit prices, this allows us to calculate specific origin-destination ad valorem (iceberg) transportation costs. Such a detailed methodology for calculating interregional iceberg transport costs has never been brought into the trade literature related to the estimation of trade elasticities, despite the potential aggregation biases that might appear when estimating intranational transport costs (Agnosteva, Anderson, and Yotov 2019).

We explore alternative estimation strategies based on the traditional sector-by-sector estimation of both sets of elasticities as well as pooling the data by sectors to take advantage of larger sample sizes. The results from the individual estimations are unsatisfactory as both sets of elasticities are imprecisely estimated. The results are improved by adopting the pooled regression, as all elasticities exhibit the predicted sign, sensible magnitudes and, more importantly, are statistically significant. In the most reliable specification, the median value for the national trade elasticities is 10.1, while those for foreign trade elasticity drops to 4.5. Consequently, from our research, we conclude that national trade elasticities double in general the magnitude of their foreign counterparts. Reasons may be that consumers are better informed about local goods.

We also provide estimates of both sets of parameters at more aggregated levels and find that national trade elasticities decrease in value. This is particularly acute in the manufacturing sector, whose values are about a third of the median value of the 10 individual sectors that it comprises: 5.355 versus 13.858. The same differences resulting in lower values are observed for the foreign trade elasticities. Finally, the values of our single national and foreign trade elasticities, standing at 4.640 and 2.131, are similar to those reported in the existing literature, which gives credibility to our lower-level results.

Our estimates of national and foreign trade elasticities can be incorporated into a wide array of regional models that currently borrow these values from the international trade literature. A first example is the estimation of border effects when considering data at a subnational level. These studies differentiate between international and national trade flows, but do not make a distinction about how consumers perceive and differentiate between foreign and national goods (e.g., Anderson and van Wincoop 2003). Also, the estimation of welfare gains from trade when considering both international and national trade flows could lead to biased results if a single trade elasticity is considered, De Sousa et al. (2012). Finally, CGE regional models based on the postulates of New Economic Geography should consider the asymmetry in consumers behavior depending on the origin of imported trade flows, national or foreign. Ignoring the different degrees of substitutability would result in wrong assessments of the changes in both international and national trade flows resulting from unexpected shocks (e.g., Brexit) or intended policies. In this regard, a promising line of research would address how the methodological improvements that we propose qualify the results obtained from alternative policy experiments within the existing and our newly analytical framework. One key experiment would be the determination of the effects of infrastructure investments, on regional trade, gross domestic product and, ultimately, social welfare.

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Data Availability Statement

The data that support the findings of this study are available in TEDAM: EU Regional Datasets at https://data.jrc.ec.europa.eu/collection/id-00154. These data were derived from the following resources available in the public domain:—RHOMOLO-IO dataset 2013, https://data.jrc.ec.europa.eu/dataset/9559442f-a88e-484b-934d-fa4bbd5e6663—Regional Transport Costs, https://data.jrc.ec.europa.eu/dataset/63298e74-c905-4c46-84ac-596e18e4fb17.

Endnotes

[1] Recently, making use of international trade data only, Feenstra et al. (2018) propose a theoretical framework that allows identifying the *macro* trade elasticity of substitution between domestic and foreign goods (considering imports as a single aggregate over foreign countries), and differentiate it from the *micro* elasticity of substitution between goods imported from individual countries. This is different from our approach that considers national and foreign elasticities by differentiating between the regions of origin. We compare both approaches in section 2.

[2] "*Thus, if we compare a country with many large language groups, like South Africa, with another with only one, like Venezuela, linguistic barriers favor domestic trade more in Venezuela than South Africa*" (Melitz 2008; p. 672). In the EU, examples of multilingual countries are Spain (Spanish, Basque, Catalan and Galician), Belgium (Dutch, French, and German), UK (English and Welsh), Hungary (Hungarian, Beás, Romani,…), and so on. Alternatively, examples of countries with regions speaking the same native language are Germany, Austria, Northern Switzerland, and Northeastern Italy; or France, Southern Belgium and Eastern Switzerland.

[3] We acknowledge that the current political NUTS-2 administrative division is not specifically based on geographical or cultural differences, and therefore trade flows based on this classification may not correlate with the perceived heterogeneity in preferences between regions belonging to the same or different countries, weakening the empirical identification of national and trade elasticities justified on the ground of alternative substitutability levels for varieties imported from these different sources. However, Santamaria et al. (2023) consider that political boundaries embed these differences, thereby inducing a strong home-bias effect.

[4] Given the overwhelming dominance of road freight transportation in the EU (over 85% of all freight), and the impossibility of setting an EU wide intermodal freight transportation model due to the lack of

reliable statistics, we focus on this mode of transportation to calculate trade costs. Indeed, since 1999 non-road transportation modes, mainly train and inland waterways, has stalled. Mostly due to a low containerization rate, deterioration in the quality of services of intermodal transport, and improvements in the efficiency and quality of road transport services, Janic (2007).

[5]Aspalter (2016) adopts Feenstra et al.'s (2018) approach (available as working paper since 2014) to estimate the macro- and micro-elasticities of substitution, ϕ^c and σ_F, for 15 EU countries using a panel data of trade flows for 2692 product (manufacturing) categories over the period 1995–2012.

[6]Supporting Information S1: Appendix A presents the mathematical derivations of the demand equations, the optimal prices, and the gravity equations.

[7]The final econometric specification that allows the identification of the trade elasticities associated with the trade costs does not differ between perfect competition or monopolistic competition. That is, the equilibrium condition under perfect competition corresponds to the simplest case where marginal revenue equals price, and the profit maximizing condition for the firms requires that prices equal marginal cost. It is possible to show that solving the model under this condition, i.e., obtaining the counterparts to Equations (5) and (6), yields the same gravity equation. Therefore, we assume the general case corresponding to monopolistic competition.

[8]Further information can be found on the Domestic and International Common Language Database (DICL) of the US International Trade Commission: https://www.usitc.gov/data/gravity/dicl.htm.

[9]The Eurostat tables account for the distribution of re-exports over the origin and destination countries, ensure consistency in bilateral trade (i.e., import trade flows are consistent with export trade flows), and, finally, assure that exports and imports of all regions add up to the national aggregates found in the country tables (i.e., top-down compatibility).

[10]In Supporting Information S1: Appendix C, we provide further statistics on the NUTS2 population and trade characteristics considered in our database. As seen, the typical region in our data set has about 1.5 million inhabitants and has far more national imports than international imports (median EU ratio of 4.03).

[11]For further details, in Supporting Information S1: Appendix D, we include specific information at the sectorial level on the FOB exports flows and CIF imports flows and the average CIF-to-FOB ratio for each sector. As seen, the differences between FOB and CIF flows are small as a result of having insurance's cost ratios which are indeed small and in the range of 0.037 (sector C24) and 0.078 (sector C23). Nevertheless, we consider that the use of CIF imports flows is appropriate and consistent with the theoretical setup in Equations (11) and (12).

[12]They assume that all freight flows are carried by a heavy-duty reference articulated truck with 40 tons maximum authorized mass and five axles, the work-horse in European freight road transportation.

[13]Annual costs per unit of distance are obtained through dividing by the yearly number of kilometers covered by the vehicle (e.g., for the HDV it is assumed that it travels 102,000 km per year fully loaded, resulting in 1.251 €/km).

[14]For our reference HDV, assuming that it is fully loaded with standard euro pallets, it takes about 3 h and a half to complete the whole handling cycle corresponding to docking, loading, and unloading logistics, Burdzik, Ciesla, and Sladkowski (2014).

[15]See Global Human Settlement (GHS) project: European Commission: https://ghsl.jrc.ec.europa.eu/data.php.

[16]In the European Freight Road Transportation survey, the specific goods-related variables (A3) are the type of good and vehicle, A3_1 (Type of goods, NST 2007), A3_3 (Classification of dangerous goods) and A3_4 (Type of cargo). The matching between the type of cargo and the most suitable vehicle comes from the information provided by the Spanish Observatory of Freight Road Transportation, MFOM (2018).

[17]For a detailed discussion of each component of the distance and time economic costs e^d_{ak} and e^v_{ak} (in € per km), see Persyn, Díaz-Lanchas, and Barbero (2022). The main component of the distance cost is fuel cost ($fuel_a$), which is computed as the fuel price at origin (in € per liter) multiplied by the fuel consumption of the reference vehicle along the optimal itinerary. For international shipments we consider country prices according to the length of the different country legs. Toll costs ($toll_a$) are also specific to each region and itinerary because of differences in nation-wide tolling policies (e.g., either through vignettes, or a country-wide electronic toll), and different fares per road-segment. The main time cost is the labor cost of the driver ($t_a lab^v{}_{ij}$). The hourly wage cost $lab^v{}_{ij}$ from Eurostat is multiplied by the time (in hours, t_a) it takes to cover the optimal itinerary minimizing costs. Labor costs also correspond to the average wages at origin and destination. The remaining costs are proportional to the cost shares (CS) of these main components, based on the cost structures provided by the Spanish Observatory of Freight Road Transportations in 2018 (MFOM 2018).

[18]Even following this approach, we encounter outliers associated with measurements errors. Therefore, we follow similar strategies to those applied in the literature by filtering the data; for example, Hertel et al. (2007) and Behrens and Brown (2018). Specifically, we rely on the interquartile range rule. For each CPA sector and by $GTC^{c,v}_{od}$ quintiles, we exclude unit values and iceberg transport costs that are smaller and greater than one and a half times the interquartile range of their distributions, $1.5 \times \text{IQR} = 1.5\times$ (75th percentile − 25th percentile).

[19]We complete the presentation of the iceberg transport costs in Appendix D by depicting the same graphs for each CPA sector.

[20]Although the standard errors of the foreign elasticities σ_F coincide with those of their associated parameter β_f, we have tested whether the values differ from 1.

[21]Following Head and Mayer (2014), this value is well below 6 representing the upper bound for a reasonable estimate of foreign-foreign (macro) trade elasticities, see Bajzik et al. 2020, p. 4).

[22]This latter value represents an extreme case resulting from the large concentration of trade at short distances regarding both its extensive and intensive margins (i.e., in physical units and value, respectively). The large decline in trade flows in very short distances, coupled with very low iceberg values due to the high unit prices reported in Eurostat's COMEXT database (see Table 4 and Appendix D), ultimately explains the high sensitivity of trade flows to transport costs in this sector.

[23]Previously, and focusing also on energy-intensive sectors, Welsch (2008) estimates elasticities for four European countries and 17 sectors with values ranging between 0.04 and 3.68.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Appendix A
See Table A1.

TABLE A1 | Cost factors for selected vehicles depending on size.

Economic costs	Vehicle		
	HDV (five axles) Large	**Rigid (three axles) Medium**	**Small (two axles) Small**
Variable costs			
Distance			
Fuel	1.000	0.611	0.317
Tire	1.000	0.911	1.041
Maintenance	1.000	1.282	1.121
Time			
Labor	1.000	1.000	1.000
Amort&Fin	1.000	0.626	0.296
Insurance	1.000	0.715	0.623
Indirect	1.000	0.571	0.445
Fixed costs			
Handling	1.000	0.752	0.309
Tax	1.000	0.910	0.849
Vignette	1.000	0.600	0.600

Note: The standard Heavy Duty Vehicle (HDV) costs reported in Persyn, Díaz-Lanchas, and Barbero (2022), corresponding to a 40-ton articulated truck, are the baseline for the remaining vehicles.

Appendix B
See Table B1.

TABLE B1 | Costs factors for selected vehicles depending on cargo.

Costs	Standard HDV	Liquid/solid bulk food	Liquid/solid tanker dangerous	Tanker gas	Liquid/ solid bulk	Carrier vehicles	Container (skeletal)
Variable	1.000	1.313	1.270	2.226	1.345	1.222	0.997
Tax	1.073	1.173	1.163	1.058	1.142	0.893	1.073
Vignette	1.087	1.150	1.797	1.000	1.190	1.000	1.087
Handling	1.000	1.000	1.000	1.000	0.000	1.000	1.000

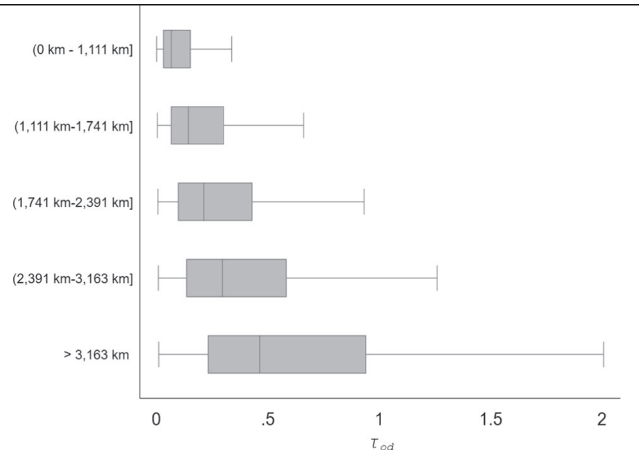
Source: Own elaboration based on Zofío et al. (2014) and MFOM (2018).

Appendix C

See Table C1.

TABLE C1 | Iceberg, generalized transport costs and unit prices by quintiles of $GTC_{od}^{c,v}$.

Variable / Distance	$\overline{\tau}_{od}^{c}$	$\overline{GTC}_{od}^{c,v}$	$\overline{P}_{od}^{c}$
(0 km–1,111 km]	0.111	689	1,438
(1,111 km–1,741 km]	0.222	1,428	1,484
(1,741 km–2,391 km]	0.319	2,060	1,449
(2, 391 km–3,163 km]	0.435	2,752	1,386
> 3,163 km	0.735	4,096	1,183

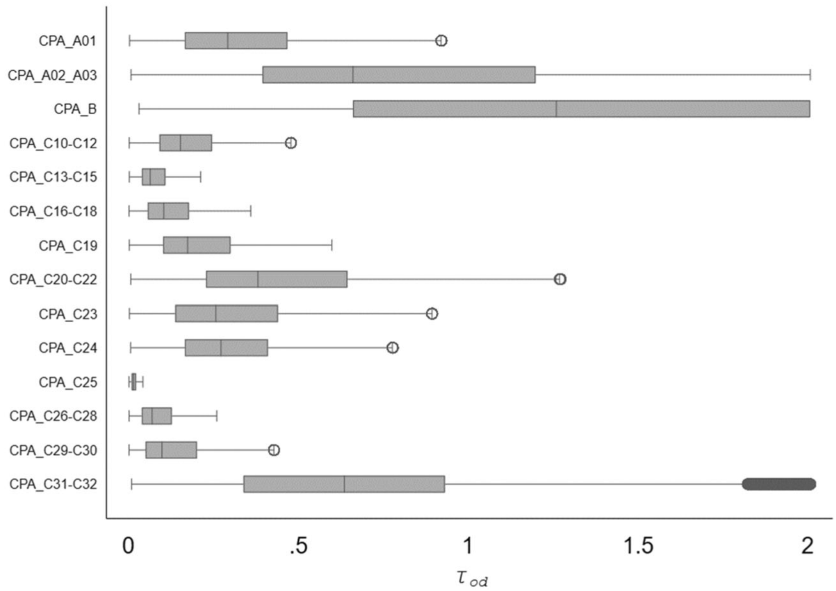


Note: Average variables. *Source*: Own elaboration.

Appendix D

See Table D1.

TABLE D1 | Distributions of iceberg transport costs by sector, τ_{od}^{c}.



Source: Own elaboration.

Appendix E

See Table E1.

TABLE E1 | Sectoral foreign and national elasticities of trade including index of native common language for international trade flows only, pooled sectors.

Variable	Sector A01	A02–03	B	C10–12	C13–14–15	C16–17–18	C19
$\sigma_F^c \;= 1 - \beta_f^c$	4.951***	3.577***	3.823***	13.071***	12.829***	13.669***	6.715***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	7.276***	3.142**	6.264***	22.634***	13.861*	27.815***	5.544***
$\sigma_F^c >=< \sigma_N^c$	=	=	<	<	=	<	=
β_f^c	−3.951***	−2.577***	−2.823***	−12.070***	−11.830***	−12.670***	−5.715***
	(0.959)	(0.671)	(0.967)	(2.687)	(3.633)	(2.220)	(1.403)
β_n^c	−2.325	0.435	−2.441***	−9.572**	−1.032	−14.150***	1.172
	(2.598)	(1.315)	(0.848)	(3.871)	(7.381)	(4.198)	(1.864)

Variable	Sector C20–21–22	C23	C24	C25	C26–27–28	C29–30	C31–32
$\sigma_F^c \;= 1 - \beta_f^c$	1.452***	6.168***	3.546***	155.339***	4.065***	2.934***	1.587***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	1.865*	10.945***	9.319***	124.470***	29.426***	24.389***	2.871***
$\sigma_F^c >=< \sigma_N^c$	=	<	<	=	<	<	<
β_f^c	−0.452	−5.168***	−2.546***	−154.300***	−3.065**	−1.934*	−0.587**
	(0.336)	(0.769)	(0.618)	(16.613)	(1.382)	(1.018)	(0.257)
β_n^c	−0.414	−4.778	−5.773***	30.870	−25.360***	−21.450***	−1.284*
	(0.984)	(2.500)	(2.088)	(31.485)	(8.519)	(5.500)	(0.751)
Common variables for all sectors	ln*Distance*	ln*Langauge*	*Intra region*	*Intra country*	*Adjacent region*	*Adjacent country*	
	−0.125***	0.090**	1.992***	2.328***	0.715***	−0.029	
	(0.044)	(0.039)	(0.245)	(0.391)	(0.103)	(0.212)	
R^2				0.823			
$N°$ Observations				975,744			

Note: Importer, exporter and sector fixed effects; Country-pair clustered standard errors in parenthesis. Significance of the trade elasticities indicates that they are different from one. The inequality between trade elasticities (<) depends on the significance of the marginal effect β_n^c.

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Appendix F

See Table F1.

TABLE F1 | Sectoral foreign and national elasticities of trade using physical distance as transport cost, pool of sectors.

Variable	Sector A01	A02–03	B	C10–12	C13–14–15	C16–17–18	C19
$\sigma_F^c = 1 - \beta_f^c$	1.261***	1.133***	1.117***	1.423***	1.028***	1.390***	1.241***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	1.425***	1.250***	1.395***	1.551***	1.148***	1.636***	1.299***
$\sigma_F^c >=< \sigma_N^c$	=	=	<	=	=	<	=
β_f^c	−0.261***	−0.133	−0.117	−0.423***	−0.028	−0.390***	−0.241***
	(0.111)	(0.123)	(0.125)	(0.114)	(0.103)	(0.104)	(0.107)
β_n^c	−0.163	−0.116	−0.277**	−0.129	−0.120	−0.246**	−0.058
	(0.117)	(0.127)	(0.129)	(0.110)	(0.107)	(0.107)	(0.107)

Variable	Sector C20–21–22	C23	C24	C25	C26–27–28	C29–30	C31–32
$\sigma_F^c = 1 - \beta_f^c$	0.775***	1.313***	0.948***	1.441***	1.027***	1.003***	0.872***
$\sigma_N^c = 1 - (\beta_f^c + \beta_n^c)$	0.959***	1.525***	1.176***	1.436***	1.295**	1.359***	1.138***
$\sigma_F^c >=< \sigma_N^c$	<	<	<	=	<	<	<
β_f^c	−0.225**	−0.313***	−0.052	−0.441***	−0.028	−0.003	0.128
	(0.104)	(0.104)	(0.102)	(0.093)	(0.092)	(0.094)	(0.105)
β_n^c	−0.184*	−0.212**	−0.228**	0.006	−0.268***	−0.356**	−0.266***
	(0.109)	(0.105)	(0.104)	(0.099)	(0.101)	(0.105)	(0.111)
Common Variables	Ln*Iceberg*	Ln*Language*	*Intra Region*	*Intra Country*	*Adjacent Region*	*Adjacent Country*	
	−3.124***	0.108***	1.546***	3.144***	0.708***	0.092	
	(0.387)	(0.037)	(0.277)	(0.799)	(0.127)	(0.215)	
R^2				0.829			
$N°$ Observations				975,744			

Note: Importer, exporter, and sector fixed effects; country-pair clustered standard errors in parenthesis. Significance of the trade elasticities indicates that they are different from one. The inequality between trade elasticities (<) depends on the significance of the marginal effect β_n^c.
$^*p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.