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Scale Economies in European Trade

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ABSTRACT

Using the gravity framework, I study scale elasticities in European trade costs, which capture how much trade costs are negatively associated with trade volumes. Their presence implies that trade costs respond to the intensity and frequency of trade interactions and suggests that reducing fixed institutional trade barriers may generate positive effects on bilateral trade. Across nine manufacturing macro-sectors and over a forty-year time span, I find strong evidence of economies of scale in trade costs in Europe: on average, a 10% increase in bilateral trade volume is associated with a 1.07% reduction in trade costs. I find that the European Union expansion affected scale elasticities, consistent with an overall reduction in fixed trade costs, though this decrease is negligible. Country-specific institutional variables, such as the partner's level of corruption, play a role: exporting to the most corrupted country in the sample entails an 80% higher gain from additional trade volume than exporting to the least corrupted one.

1. Introduction

Is trade within the European Union (EU) frictionless? The European Economic Community (EEC) was created in 1957 as a customs union. Three decades later, European countries came together to form a single market. However, this did not remove all barriers for international trade: (Chen, 2004) and Nitsch (2000) highlight the negative impact of borders on trade flows within the EU, deeply in contrast with the concept of a single market. This could be related to regulatory and institutional frictions, which may act as hidden trade costs and depress cross-border economic exchange. In particular, Chen (2004) shows that the border effect is stronger for sectors with high technical barriers (health and security standards) that still lack complete harmonization within the Union, providing evidence for the existence of regulatory barriers for trade even within the EU. Assessing whether the creation and subsequent enlargement of the European Union have effectively facilitated intra-EU trade flows has important implications. In fact, it could help assess the effectiveness of integration policies. Moreover, a disaggregated analysis could identify the sectors where harmonization is most urgently needed.

In this paper, I will test whether the EU membership reduced trade costs when trading with fellow EU members focusing on the distance elasticity of trade. In particular, I will first establish the existence of scale elasticities in European trade, i.e. the fact that higher trade volumes are associated with lower trade costs. In simple terms, I test whether more frequent trade with the same partner is associated with lower per-transaction costs. Then, I will show whether scale elasticities have been affected by the EU expansion. Understanding how much trade costs fall when trade volumes rise helps assess whether European integration is truly reducing the frictions that still separate member states. My analysis adapts the Anderson et al. (2016) (from now on, AVY, 2016) model, which is the first to relax the assumption of *constant* iceberg trade costs and allows trade volumes to affect trade costs, to the European setting. Following AVY (2016), scale economies in international trade costs will be identified and measured in *relative* terms with respect to the intranational trade ones. This method requires data on both internal trade (production) and international trade. Scale elasticities arise whenever trade costs include a fixed component such as informational frictions, buyer–seller matching, regulatory barriers or institutional inefficiencies. Any mechanism that reduces this fixed component, such as harmonization of standards, repeated interactions, or improved legal institutions, should therefore lower scale elasticities. Scale elasticities can be used to examine whether the EU has reduced these frictions. To my knowledge, this is the first study to document robust evidence of scale elasticities in European trade costs and to assess the impact of the EU expansion on trade flows by testing for differences in the distance elasticity of trade between EU and non-EU countries.

My results can be summarized as follows. First of all, I estimate strong and significant scale elasticities in European trade for all the sectors considered. Their average magnitude is very similar to the one

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found by AVY (2016) for US–Canada trade: a 10% increase in trade volumes corresponds to a 1.07% decrease in trade costs. This suggests the existence of a fixed component in iceberg trade costs. Second, my results show that fixed trade costs have been slightly affected by the EU expansion for aggregate manufacturing trade. This means that the EU market is not really "single": if trade with a fellow EU member were the same as trade within a country, in fact, we would observe constant returns to scale in trade volumes for intra-EU trade. This finding contributes to the literature on the effects of the EU expansion on international trade, which includes evidence from Beltramo (2010), who documents a drop in trade costs, and from Nitsch (2000) and Chen (2004), showing that trade between EU countries is subject to frictions that have not been removed yet. Third, I show that institutional variables are crucial for scale elasticities. In fact, my results show that the gain from additional volume depends on the level of corruption and the quality of contract enforcement of the partner country even within the EU.

This paper belongs to the gravity literature in international trade. One of the strongest empirical results in economics is represented by the estimation of "gravity equations" (see Head and Mayer (2014) for a detailed review). Generally speaking, these models assume that trade flows between two regions depend positively on the size of both the origin and the destination but are negatively correlated with the distance between them. Microfoundations for such a specification, which may resemble the Newtonian gravity formulation in physics at first sight, was first provided in Anderson (1979). Very similar gravity equations arise from models making very different assumptions: from the Armingtonian extreme of Anderson and van Wincoop (2003) to the Ricardian model of Eaton and Kortum (2002), until more recent heterogeneous-firm contributions such as Chaney (2008). All these studies model trade costs as pair-specific "melting icebergs": in order for one unit of goods to reach a destination, $t_{i,j}$ units need to be shipped. However, they do not take a stand on the origin of such trade frictions, which can be thought as a "black box": they are a mixture of transportation, cultural, informational, and costly-enforcement costs (Anderson and van Wincoop, 2004). In empirical work, geographic (distance as the most popular) and institutional (common language, colonial history, etc.) dyadic variables are successfully used to proxy for them. Trade costs are usually introduced as a *constant* impediment to trade flows, in particular they are assumed to play the same role independently from the volume of goods and services traded (*i.e.* they are linear in trade flows). AVY (2016) are the first to relax this assumption: they show that, for the US–Canadian case, the elasticity of trade costs with respect to trade volumes is negative in 36 out of 56 sectors in their sample, whereas the remaining cases exhibit constant returns to scale. This means that, for the majority of the sectors considered, the trade costs are lower the higher the trade volume.

Relaxing the assumption of constant iceberg costs can be useful to understand the consequences of the EU expansion from a novel perspective. The previously cited studies by Chen (2004) and Nitsch (2000), in fact, focus on border effects within the EU. The AVY (2016) setup can instead be expanded to consider the effects of the EU expansion on the distance elasticity of trade, in order to show whether trade within the EU is indeed frictionless after controlling for border effects, which are not necessarily related to frictions. In fact, they could be a signal for home bias in consumers' preferences. Focusing on European data allows me to test for this hypothesis while keeping the specification as simple as possible: in fact, I will be assuming uniformity in the scale elasticity parameter across all dimensions apart from EU membership.[2]

In this paper, I show that the AVY (2016) model can be used as a relatively simple framework for analyzing the effect of the EU expansion on trade frictions. In fact, I will be following it in assuming a stylized trade cost function, in which trade costs are dependent on trade volume and bilateral barriers proxied only by distance and contiguity. Note that the latter variables are not time-varying, hence I will not be estimating whether their impact on trade costs (hence, on scale elasticities) varies over time (see, for example, Krautheim, 2012).

Departing from constant trade costs will allow me to study their actual meaning, *i.e.* to open the "black box". Scale economies, in fact, suggest the existence of a fixed component in iceberg trade costs and this paper tries to rationalize it. Should informational frictions play a role, one would expect the average gain from an increase in trade volume to be lower for more standardized goods (Rauch, 1999), hence we would observe lower scale elasticities for those commodities. In order to test for this hypothesis, I consider disaggregated data at the product level (SITC classification) and I show that the degree of product differentiation does not explain the magnitude of the estimated coefficients. On the other hand, my results show that European scale elasticities are linked to sector-specific variable costs and to country-specific institutional variables such as the level of corruption and the quality of contract enforcement. In fact, I prove that a 10% increase in trade volumes implies a 1.15% decrease in trade costs when trading with a partner with poor institutional level (high level of corruption) but implies a 0.64% decrease in trade costs when the partner's level of corruption is low.

This work also contributes to the trade literature on the distance elasticity. A growing body of recent work has highlighted that the distance elasticity of trade is a key parameter for understanding trade frictions and their welfare implications, and that its empirical measurement can be challenging. Yilmazkuday (2014) shows that standard gravity estimates may substantially mismeasure the elasticity of trade costs with respect to distance since they ignore the internal location of production. Yilmazkuday (2017) confirms the existence of an endogenous relation between trade and distance elasticity of trade. Furthermore, Yilmazkuday (2021) shows variations in the distance elasticity of trade translate into welfare changes. These contributions stress that distance remains a central gravity variable and that its empirical behavior is worth investigating.

The paper proceeds as follows. Section 2 outlines the model, taken from AVY (2016), and the estimating equation. Section 3 describes the data. Section 4 presents the baseline results and shows the existence of scale economies in European trade, including their response to the EU expansion. Section 5 investigates the determinants and dynamics of scale elasticities. Section 6 discusses the results and Section 7 concludes.

2. The model

The baseline model is taken from AVY (2016), who allow bilateral trade costs $t_{i,j,t}$ to be a function of trade volumes $V_{i,j,t}$ as follows

$$t_{i,j,t} = \tau_{i,j}\left(\frac{r_{i,t}}{r_{j,t}}\right)^{\rho} V_{i,j,t}^{\phi_{i,j}} \tag{2.1}$$

where $\tau_{i,j}$ is the traditional iceberg cost and $r_{i,t}$ and $r_{j,t}$ represent the appreciation of currencies i and j with respect to a base period. The exponent ρ is the pass-through elasticity. Trade volume in physical terms V_{i,j_t} is defined as

$$V_{i,j_t} = \frac{X_{i,j,t}}{t_{i,j,t}}\frac{r_{i,t}}{r_{j,t}} \tag{2.2}$$

where $t_{i,j}$ discounts for the iceberg costs encountered in the shipment and $\frac{r_{i,t}}{r_{j,t}}$ takes into account the fact that $X_{i,j,t}$ is expressed in monetary terms and the nominal exchange rate may not be unitary.

$\phi_{i,j}$ is the crucial parameter, as it represents the elasticity of trade costs with respect to the trade volumes. Economically, it measures how much the trade costs fall when countries ship more, suggesting that fixed trade frictions are spread over a larger number of transactions.

[2] Considering non-European countries would imply an additional departure from the uniformity assumption. In fact, trade with non-European countries does entail higher scale elasticities, most likely due to lower trade volumes, as I will show in Section 4.

$\phi_{i,j}$ is assumed to be equal to $B_{i,j}\phi$, where $B_{i,j} = 1$ if i and j are two countries separated by a border and zero otherwise. In other words, since $\phi_{i,j}$ is zero in case of internal trade, scale economies in international trade costs will be estimated *relatively* to the ones in intranational trade costs. If $\phi_{i,j}$ is positive, trade costs are increasing in trade volumes. If $\phi_{i,j}$ is negative, instead, trade becomes cheaper the higher the trade volume (increasing returns to scale), whereas we get constant returns to scale and we are back to the traditional formulation in case ϕ equals zero. In the latter case, we are back to the original gravity model: it is nested in this specification, so that it will be for the data to tell whether scale economies in international trade do exist.

Microfounded gravity models, as Anderson and van Wincoop (2003), show that the trade flow between i and j in sector k ($X^k_{i,j}$) can be expressed as

$$X^k_{i,j} = Y^k s^k_i b^k_j \left(\frac{t^k_{i,j}}{\Pi^k_i P^k_j}\right)^{1-\sigma_k} \tag{2.3}$$

where Y^k is the total of world shipments, s^k_i is the share of world shipment coming from origin i ($s^k_i = \frac{Y^k_i}{Y^k}$) and b^k_j is the share of world shipment arriving to destination j from all possible origins ($b^k_j = \frac{E^k_j}{Y^k}$). $t^k_{i,j}$ represents the bilateral "iceberg" trade cost: for each unit shipped, only $\frac{1}{t^k_{i,j}}$ reaches the destination. Π^k_i and P^k_j represent respectively the outward and the inward multilateral resistance terms, taking into account that bilateral trade depends on trade frictions that importer and exporter face when trading with all their trade partners.[3]

Gravity is usually estimated taking the following formula to the data:

$$X^k_{i,j,t} = c_t x^k_{i,t} m^k_{j,t} (t^k_{i,j})^{1-\sigma_k} \tag{2.5}$$

up to an i.i.d. error, where $c_t = Y^k_t$ is a constant. The elements $x^k_{i_t} = \frac{s^k_{i,t}}{(\Pi^k_{i,t})^{1-\sigma_k}}$ and $m^k_{j,t} = \frac{b^k_{j,t}}{(P^k_{j,t})^{1-\sigma_k}}$ are controlled for empirically via fixed-effects.[4]

In the previous expression, trade costs $t^k_{i,j}$ represent a *constant* barrier to trade flows: in order for one unit of good to reach destination j, $t^k_{i,j}$ units need to be shipped *independently* from any pair-specific variable, including the trade volume between the two trade partners. One could imagine, instead, that trade costs are increasing in trade volumes due to congestion (Anderson and Bandiera, 2006) or that there are economies of scale in trade costs because of the existence of a fixed-cost component. Chaney (2014) suggests that the export behavior of firms is the result of the creation of a network, whose links are created by pair specific buyer–seller investments. Aggregating the links across countries would imply bilateral scale economies in trade costs.

Solving the system of Eqs. (2.1) and (2.2) jointly with the gravity equation (2.3) gives the following modified gravity equation that can be estimated to test for the existence of scale economies in trade costs:

$$X^k_{i,j,t} = (c_t x^k_{i,t} m^k_{j,t})^{\frac{1+\phi_{i,j}}{1+\sigma\phi_{i,j}}} (\tau_{i,j})^{\frac{1-\sigma}{1+\sigma\phi_{i,j}}} \left(\frac{r_{i,t}}{r_{j,t}}\right)^{\frac{(\rho-\phi_{i,j})(1-\sigma)}{1+\sigma\phi_{i,j}}} \tag{2.6}$$

In this paper, given that the units of interest are 28 European countries, I decided not to consider destination-specific scale elasticity.[5] I will start with assuming uniformity in the scale elasticity, i.e. I will impose that the elasticity parameter is the same across all destinations (for each sector k). In Section 4.1 I will check the validity of this hypothesis by testing whether scale elasticities are differentiated for *large* and *small* countries. Such a partition of the sample will be defined alternatively in terms of population or GDP. Note that this assumption, together with the one of uniformity across destinations of the exchange rate pass-through parameter ρ and the non-directionality of the border effect, implies that the exchange rate appreciation term (in log) will be perfectly collinear with the multilateral resistance terms and hence absorbed by the fixed effects included in the regression. The main focus of the paper being on scale elasticities, I made these assumptions for tractability. Moreover, notice that the dataset I will be using for estimating scale economies in the European setting is at the country-level.[6] From now on, I will be dropping the superscript k to ease the notation. All regressions will be nonetheless run at the sector level, unless otherwise specified.

Eq. (2.6) is taken to the data using the following expression

$$\begin{aligned} X^k_{i,j,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST_{i,j} + \\ &\delta CONTIGUITY_{i,j} + \zeta EXCH\_RATE_{i,j,t} + \beta_{BORDER} B_{i,j} \\ &+ \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,t} \end{aligned} \tag{2.7}$$

where the coefficients correspond to the structural parameters of the model in the following fashion[7]:

$$\begin{aligned} \alpha_1 &= \gamma_1(1-\sigma) \\ \alpha_2 &= \frac{\gamma_1(1-\sigma)}{1+\sigma\phi} \\ \delta &= \frac{\gamma_2(1-\sigma)}{1+\sigma\phi} \\ \zeta &= \left(\frac{(\rho-\phi)(1-\sigma)}{1+\sigma\phi}\right) \end{aligned}$$

In fact, where β_{BORDER} represents the direct effect on trade of being separated by an international border.

Notice that either one of the distance variables $INTERNAL\_DIST_{i,i}$ and $INTERNAT\_DIST_{i,j}$ will always equal zero: in case of internal trade (*i.e.* $B_{i,j} = 0$), $INTERNAT\_DIST_{i,j}$ will equal zero, whereas in case of international trade (*i.e.* $B_{i,j} = 1$) $INTERNAL\_DIST_{i,j}$ will equal zero. This will allow to test whether the effect that distance, the empirical proxy for the trade costs, has on the trade flow is differentiated in case of internal or international trade, which is exactly what the existence of scale economies would imply. In fact, it is possible to check for economies (diseconomies) of scale by checking whether the difference between α_1 and α_2 is statistically different from zero. In particular, in case of economies of scale, we will have that $\phi < 0$ and

[3] Multilateral resistance terms can be written as

$$(\Pi^k_{i,t})^{1-\sigma_k} = \sum_j \left(\frac{t^k_{i,j}}{P^k_{j,t}}\right)^{1-\sigma_k} b^k_{j,t} \qquad (P^k_{j,t})^{1-\sigma_k} = \sum_j \left(\frac{t^k_{i,j}}{Pi^k_{i,t}}\right)^{1-\sigma_k} s^k_{i,t} \tag{2.4}$$

[4] Fally (2015) showed that estimating Eq. (2.5) using importer-time and exporter-time fixed effects for $m^k_{j,t}$ and $x^k_{i_t}$ respectively is equivalent to solving the system represented by Eqs. (2.4) when the Pseudo-Poisson Maximum Likelihood (PPML) estimator is used. The latter was proposed by Santos-Silva and Tenreyro (2006) in order to correct for the biases that heteroskedasticity and zero trade figures in the data may cause.

[5] AVY (2016) analyze US states and Canadian provinces so that there are three possible types of trade flows: between two US states, between two Canadian provinces or between a US state and a Canadian province. This setup allows the authors to consider nation-specific scale elasticities.

[6] For this reason, I have only one observation representing the overall internal trade flow (i.e. Italy–Italy trade) for each sector. The AVY (2016) work, instead, deals with data at the provincial and state level and include multiple observations that correspond to internal flows: for example, trade between Massachusetts and Maine and trade between Iowa and Montana are both considered cases of internal trade.

[7] AVY (2016) show that, since the fixed effect terms enter Eq. (2.4) in a non-linear fashion, it is possible to approximate them using a Taylor's Series that gives us the following:

$$\left(\frac{1+\phi_{i,j}}{1+\sigma\phi_{i,j}}\right) log(x^k_{i,t} m^k_{j,t}) = \eta_{i,t} + \theta_{j,t} + \beta_{BORDER} B_{i,j} \tag{2.8}$$

Table 1
Estimated coefficients.

	(1) Chemicals	(2) Food	(3) Machines	(4) Metals	(5) Minerals	(6) Other	(7) Textiles	(8) Vehicles	(9) Wood–Paper
Internal_Dist	−0.187***	−0.281***	−0.120***	−0.241***	−0.411***	−0.462***	−0.130***	−0.0660**	−0.312***
	(−11.53)	(−21.28)	(−6.11)	(−15.34)	(−30.83)	(−26.03)	(−4.19)	(−2.29)	(−21.57)
International_Dist	−1.138***	−1.235***	−1.024***	−1.046***	−1.213***	−1.359***	−1.235***	−0.765***	−1.077***
	(−63.61)	(−58.27)	(−51.73)	(−44.68)	(−50.84)	(−59.69)	(−51.52)	(−30.08)	(−57.56)
Exch. rate	0.0596	0.0333	0.0359	−0.00933	−0.0444	−0.0111	−0.0630	0.0521	0.0231
	(0.00)	(0.00)	(0.00)	(−0.00)	(−0.00)	(−0.00)	(−0.00)	(0.00)	(0.00)
Border	3.610***	2.637***	3.739***	2.372***	1.987***	3.844***	5.321***	2.149***	1.950***
	(30.85)	(19.83)	(21.85)	(16.02)	(13.41)	(20.36)	(22.92)	(9.86)	(15.84)
Contiguity	0.191***	0.500***	0.137***	0.551***	0.517***	0.167***	0.437***	0.248***	0.623***
	(8.93)	(20.25)	(6.82)	(23.67)	(21.93)	(6.38)	(11.82)	(9.48)	(27.33)
N	25 138	25 189	25 162	25 057	25 189	25 162	25 162	25 162	25 189
R2	9.8e−01	1.0e+00	9.8e−01	9.9e−01	1.0e+00	9.8e−01	9.4e−01	9.9e−01	9.9e−01
p1	0.0e+00	0.0e+00	9.e-253	0.0e+00	0.0e+00	3.e-216	3.e-191	4.0e−90	0.0e+00

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

therefore that $|\alpha_1| < |\alpha_2|$. Moreover, I can get an estimate of the scale elasticity ϕ by using the above expressions for the α_s coefficient:

$$\phi = \frac{1}{\sigma}\left(\frac{\alpha_1}{\alpha_2} - 1\right).$$

3. Data

Following AYV, in this paper I assume constant returns to scale for internal trade and measure possible gains (losses) from additional trade volume on international trade costs *relative* to intranational trade costs. As a consequence, retrieving scale elasticities requires measures of bilateral as well as internal flows reported using the same sectoral classification. To this extent, this is in line with the work by Novy (2013), Jacks et al. (2011) and Chen and Novy (2011), in which trade costs are directly inferred from trade flows. However, while the dataset of Jacks et al. (2011) covers more than a century, it lacks the sectoral dimension: observations are aggregate at the country-pair level. Chen and Novy (2011), instead, construct a very detailed production-trade database for 163 manufacturing sectors for EU countries, but it covers a very short time period (1999–2003). I decided to employ the very recent Trade and Production dataset *TradeProd*, by Mayer et al. (2023), which provides harmonized data for 165 countries and nine industrial sectors (corresponding to ISIC 2digits) across the 1966–2020 period. A sector list is reported in Table 7 in Appendix.

Distances are population-weighted and follow the CEPII notes by Mayer and Zignago (2011).[8] Exchange rate data at annual frequency come from the World Bank website.[9]

Data on the level of corruption and on the quality of contract enforcement in a given country are available from the WGI database (Worldwide Governance Indicators).[10] The database covers the period from 1996 and reports the so-called *control of corruption* index, which *"reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests"* as well as the *rule of law* index, which *"reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence"*. Their frequency is biannual before 2002 and becomes annual from 2003 onwards. The indexes range from approximately −2.5 (weak) to 2.5 (strong) governance performance. For instance, the most corrupted country in the sample is Romania in 1998 (−0.649), whereas the least one is Denmark in 2006 (2.459).

Table 2
Estimated scale elasticities.

Sector	ϕ	S.E.
Aggregate	−0.107***	0.001
Chemicals	−0.119***	0.002
Food	−0.110***	0.001
Machines	−0.126***	0.003
Metals	−0.110***	0.002
Minerals	−0.094***	0.001
Other	−0.094***	0.002
Textiles	−0.128***	0.004
Vehicles	−0.131***	0.005
Wood–Paper	−0.101***	0.002

My analysis will focus only on those European countries which became members of the European Union. One possible concern could be that the sample period includes the introduction of the Euro, which happened in 2001. Frankel and Rose (2002) among many others show that the introduction of a common currency has significant effects on trade and income and this fact could alter the meaning of the estimated coefficients. Nonetheless, including the whole sample in the regressions does not alter the magnitude of the results, therefore I decided to consider the entire 1980–2020 period.[11] Moreover, analyzing the whole sample allows me to consider the EU expansion up until Brexit.

4. Results

The results for the period 1980–2020 are reported in Table 1. As expected, the estimated coefficient $\hat{\delta}$ is positive for all sectors: being adjacent increases the trade flow between two countries. The opposite holds for the estimated coefficients associated with the distances variables ($\hat{\alpha_1}$ and $\hat{\alpha_2}$): they are negative and significant at the 1% level for all sectors: the higher the distance between trade partners, the lower the trade flow.

Scale (dis)economies in trade costs will be present if $\hat{\alpha_1}$ and $\hat{\alpha_2}$ are statistically different: this would mean that the internal distance plays a different role than the international one, *i.e.* that there exist scale elasticities in trade costs when an international border needs to be

[8] The CEPII database reports trade flows for Belgium and Luxembourg as if they were a unique country. For this reason, I recomputed distances following the CEPII notes.
[9] http://data.worldbank.org/indicator/PA.NUS.FCRF
[10] http://data.worldbank.org/data-catalog/worldwide-governance-indicators
[11] I will test for Eurozone specific scale elasticities in Section 4.2

crossed. Table 2 reports the estimated scale coefficient $\hat{\phi}$ for each sector considered, obtained using the following formula:

$$\hat{\phi} = \frac{1}{\sigma}\left(\frac{\hat{\alpha_1}}{\hat{\alpha_2}} - 1\right)$$

Trade costs exhibit economies of scale for all the 9 sectors considered, and the estimated $\hat{\phi}$ is statistically significant at the 1% level for all of them. This suggests that part of what firms pay to access foreign markets behaves like a fixed cost: once they start trading, additional exchanges are associated with lower average trade costs. There is cross-sectoral variation in the coefficients, ranging from 1.31% in case of Vehicles to 0.94% in case of Minerals. The average $\hat{\phi}$ is −0.107: a 10% increase in trade volumes corresponds to a 1.07% decrease in trade costs. This result is similar to the one found by AVY (2016), as they show that a 10% increase in trade volumes would lower trade costs from US to Canada and from Canada to US by respectively 1.2% and 0.6% (they estimate direction-specific scale elasticities).

Notice that scale elasticities have been computed after assuming a value for σ, the constant elasticity for substitution parameter. As in AVY (2016), I assumed a common value of 6.13 for all sectors, corresponding to the median σ reported in the meta-analysis by Head and Mayer (2014). However, it has been shown that the elasticity of substitution across varieties varies substantially across products. In particular, Broda and Weinstein (2006) estimate product-specific σ employing a novel grid search algorithm, in response to estimation issues arising from previous work by Feenstra (1994). Chen and Novy (2011) employ the Broda and Weinstein (2006) method to estimate sector-specific coefficients on European data for 163 manufacturing sectors classified according to the NACE system over a subset of the time period included in this paper (1999–2003). Their estimates can be used to compute sector-specific values for σ at the ISIC 2-digits classification used in the TradeProd database.[12] Results obtained using such sector-specific CES coefficients are reported in Table 8 in Appendix. They appear to be qualitatively similar to the baseline ones.

Since I found significant economies of scale for the vast majority of the sectors included in my sample, I represent trade costs using a simple function, which includes both a fixed (F) and a variable (c) component:

$$t = \frac{F}{v} + c$$

where t is the unitary trade cost and v is the trade volume. This formulation is consistent with the literature: Roberts and Tybout (1997), among others, proved empirically the existence of fixed trade costs, which have been assumed as a crucial determinant in the decision of exporting in theoretical papers (Melitz, 2003). Then, it is possible to write the scale elasticity parameter ϕ as follows:

$$\phi = \frac{\partial t}{\partial v}\frac{v}{t} = -\frac{F}{F + vc} \tag{4.1}$$

Provided that fixed costs of exporting are non-null, the scale parameter ϕ will be negative.[13] Note that ϕ is decreasing in F: $\frac{\partial \phi}{\partial F} = -\frac{vc}{(F+vc)^2}$: the higher the fixed trade cost, the higher will be the absolute value of the scale elasticity, and increasing trade volumes will entail a higher gain in lowering trade costs. On the other hand, an increase in trade volumes will move the scale elasticity closer to zero: $\frac{\partial \phi}{\partial v} = \frac{cF}{(F+vc)^2}$. This will result in bigger markets exhibiting lower scale coefficients in absolute value.

The fact that ϕ depends on trade volumes could explain why the sector-specific scale elasticities I estimate do not align with those obtained by AVY (2016). For instance, they find constant returns to scale for Wood Products and Petroleum Refineries whereas the $\hat{\phi}$ I estimate for those sectors are negative and significant. This could be given by the relative size of sectors in North America, probably very different than in Europe. In fact, both Wood Products and Petroleum Refineries are characterized by very high and concentrated trade volumes in the US–Canadian trade and this could be responsible for driving the elasticity very close to zero.

Further research, analyzing the sectoral composition of European trade and comparing it to the North American one, will hopefully shed light on this puzzle. As a matter of fact, this finding poses a challenge to the assumption of uniformity of the scale parameter that I initially made. For this reason, in the next section I will show that uniformity is surely an approximation, which however does not seem too strong to be made.

4.1. Country size and scale elasticities

So far I assumed uniformity in the scale elasticity, *i.e.* I imposed that the gain from trade volumes is the same across all country-pairs and can vary only across the sectoral dimension. However, the high degree of cross-sectoral variation in the estimated coefficients, together with a comparison of the coefficients with the one by AVY (2016), seem to suggest that uniformity may be too strong of an assumption. In this section, I will slightly modify the model and test its validity, allowing scale elasticities to differ depending on country size. In particular, I partition the sample in two subgroups, *big* and *small*, according to two different criteria: population and GDP.[14] Countries are then divided in two groups depending on whether their size is above (*big*) or below (*small*) the sample median. Therefore, I am now assuming that the scale parameter is the same across destinations having the same country size (for each sector k).

Country size seems the most natural dimension to challenge the assumption of uniformity with. In fact, if uniformity is not a good approximation, I will observe lower scale elasticities (in absolute value) for larger countries. First of all, this would happen because trade volumes v are higher for larger markets, hence the scale elasticity should be closer to zero for them (see Section 4). Moreover, should trade result from the creation of buyer–seller links a' la (Chaney, 2014), the probability of finding a buyer in a specific area needs to be scaled by the size of that location: firms are more likely to export to countries where there are more potential business contacts to be made. Since the creation of such contacts involves only the extensive margin of trade, in my setting this would correspond to scaling the fixed component of trade costs, making it less costly to export to bigger markets (and, again, shifting the elasticity closer to zero). For both these reasons, uniformity across all country pairs could be rejected by the data, and perhaps the scale coefficients could be lower (in absolute value) for bigger destinations.

The model will be modified as follows

$$\begin{aligned} X^k_{i,j,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST\_BIG_{i,j} + \\ &\alpha_3 INTERNAT\_DIST\_SMALL_{i,j} + \delta_1 CONTIG\_BIG_{i,j} \\ &+ \delta_2 CONTIG\_SMALL_{i,j} + \\ &\zeta_1 EXCH\_RATE\_BIG_{i,j,t} + \zeta_2 EXCH\_RATE\_SMALL_{i,j,t} \\ &+ \beta_{BORDERB} B\_BIG_{i,j} \\ &\beta_{BORDERS} B\_SMALL_{i,j} + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,t} \end{aligned} \tag{4.2}$$

[12] However, matching the Nace Rev. 1 classification with the ISIC 2-digits is a non-trivial procedure. I was able to perform a one-to-one match for 79 Nace1 sectors, corresponding to 18 ISIC 3-digits sectors. For each of these 18 ISIC code, I computed the simple average of σ across the Nace1 codes I could merge (if more than one). The obtained sector specific sigmas exhibit cross-sectoral variation, ranging from 3.87 (Pottery) to 14.65 (Transport equipment). I then aggregated at the ISIC 2-digits level using trade shares as weights. For the remaining sectors, I assumed $\sigma = 6.13$.

[13] Note that I took an agnostic perspective when testing for the existence of scale elasticities, as the estimating equation allows for decreasing returns to scale ($\phi > 0$) as well.

[14] These variables being time-varying, I considered their average over the sample for each country. Data on population and GDP (at constant 2010$ prices) were collected from the WorldBank website.

and therefore I will be able to back out the following parameters

$$\phi_{BIG} = \frac{1}{\sigma}\left(\frac{\alpha_1}{\alpha_2} - 1\right) \qquad \phi_{SMALL} = \frac{1}{\sigma}\left(\frac{\alpha_1}{\alpha_3} - 1\right)$$

Table 9 in the Appendix reports the estimated scale elasticities in aggregate terms, *i.e.* obtained using bilateral trade flows at the country level disregarding the sectoral dimension. Note that the coefficients have basically the same magnitude. Not having found compelling evidence for the rejection of the uniformity assumption, I will maintain it in the remainder of the analysis, in order to ease the notation and the interpretation of the coefficients. All regressions will be run sector by sector, thus allowing heterogeneity in economies of scale across industries.

4.2. Scale elasticities and the EU expansion

The process of creation and expansion of the EU has been continuing for several decades: from the creation of the European Coal and Steel Community (ECSC) in 1951, followed by the creation of the European Economic Community (EEC) in 1957, to the accession of the last member state to join (Croatia, 2013). The European Union incorporated the pre-existing European Communities in 1993, according to the provisions of the Maastricht Treaty. Table 10 in the Appendix tracks the expansion of the European Union over time.

The main purpose of the creation of the EEC was to promote economic integration among member states. The EEC was indeed established as a customs union. However, this measure was considered insufficient and this led to the Single Market Programme, starting from 1992. It is established that *"The Union shall comprise a customs union which shall cover all trade in goods and which shall involve the prohibition between Member States of customs duties on imports and exports and of all charges having equivalent effect, and the adoption of a common customs tariff in their relations with third countries"*..[15] Quantitative restrictions on imports and exports between member states are also prohibited.[16]

Apart from tariff and non-tariff barriers, trade costs comprise obstacles such as information costs and legal costs (Anderson and van Wincoop, 2004). Joining the EU should decrease the asymmetry between countries with respect to these frictions as well: for example, cross-border insolvency disputes involving member states are regulated by the EU Insolvency Regulation, which was adopted in 2000. We expect common membership to facilitate trade. In particular, fixed trade costs should be lower when trade partners are both EU members, exactly because they share a common set of laws and practices. Therefore, the gain from an increase in trade volumes, which could be considered a proxy of the frequency at which transactions take place, should be lower. As a consequence, scale elasticities should be lower as well when both countries belong to the EU.

4.2.1. Testing for european union elasticities

In the second specification, I will consider a version of Eq. (2.7) that allows me to take into account possible differences implied by the expansion of the European Union. In particular

$$t_{i,j,t} = \tau_{i,j}\left(\frac{r_{i,t}}{r_{j,t}}\right)^{\rho_j} V^{\phi_{i,j,t}}$$

The main difference with Eq. (2.5) is given by the fact that the scale elasticity coefficient is now time-varying. In fact, I am assuming that

$$\phi_{i,j,t} = B_{i,j}[\phi_1 + \phi_2 U_{i,j,t}]$$

where $U_{i,j,t}$ takes value 1 if i and j are separated by a non-EU border at time t, *i.e.* if at least one of the two is not a member of the European Union at time t. As a consequence, $\phi_{i,j,t}$ will equal 0 in case of internal trade, it will equal ϕ_1 in case of trade between EU members and it will equal $\phi_1 + \phi_2$ if at least one of the two countries is not a EU member. This will allow me to see whether scale economies in trade costs are independent from the EU membership or are affected by it. Notice the t subscript: the same couple of countries will have a different scale coefficient at different points in time as the EU expands. Fig. 3 in the Appendix depicts the example of Spain, which became a member in 1986.

I estimate the following equation

$$\begin{aligned} X^k_{i,j,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST\_EU_{i,j,t} + \\ &\alpha_3 INTERNAT\_DIST\_NONEU_{i,j,t} + \delta_1 CONTIGUITY\_EU_{i,j} + \\ &\delta_2 CONTIGUITY\_NONEU_{i,j} + \zeta_1 EXCH\_RATE\_EU_{i,j,t} + \\ &\zeta_2 EXCH\_RATE\_NONEU_{i,j,t} + \beta_{BORDEREU} B_{i,j}(U_{i,j,t} = 0) + \\ &\beta_{BORDERNONEU} B_{i,j}(U_{i,j,t} = 1) + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,t} \end{aligned} \tag{4.3}$$

where the coefficients correspond to the structural parameters of the model in the following fashion:

$$\alpha_1 = \gamma_1(1-\sigma)$$
$$\alpha_2 = \frac{\gamma_1(1-\sigma)}{1+\sigma\phi_1}$$
$$\alpha_3 = \frac{\gamma_1(1-\sigma)}{1+\sigma(\phi_1+\phi_2)}$$
$$\delta_1 = \frac{\gamma_2(1-\sigma)}{1+\sigma\phi_1}$$
$$\delta_2 = \frac{\gamma_2(1-\sigma)}{1+\sigma(\phi_1+\phi_2)}$$
$$\zeta_1 = \left(\frac{(\rho-\phi_1)(1-\sigma)}{1+\sigma\phi_1}\right)$$
$$\zeta_2 = \left(\frac{(\rho-\phi_1-\phi_2)(1-\sigma)}{1+\sigma(\phi_1+\phi_2)}\right)$$

It is possible to test for economies (diseconomies) of scale by checking whether the differences between α_1 and α_2 and α_1 and α_3 are statistically different from zero. In case of economies of scale, we will have that $\phi_1 < 0$ and $\phi_1 + \phi_2 < 0$ therefore that $|\alpha_2| < |\alpha_3|$. Moreover, α_2 and α_3 will be statistically different when ϕ_2 is statistically different from zero, *i.e.* when economies of scale are different when at least one of the trade partners is not a member of the EU. We can also back out the scale elasticities ϕ_1 and ϕ_2 using the expressions for the α_s coefficients. In fact,

$$\phi_1 = \frac{1}{\sigma}\left(\frac{\alpha_1}{\alpha_2} - 1\right)$$
$$\phi_2 = \frac{\alpha_1}{\sigma}\left(\frac{1}{\alpha_3} - \frac{1}{\alpha_2}\right)$$

4.2.2. Results

The estimated ϕ_1 and ϕ_2 are reported in Table 3. Aggregating across all goods, I find a statistically significant reduction in the absolute value of scale elasticities when at least one of the trade partners is not an EU member. In theory, this pattern is consistent with a decline in fixed trade costs induced by the EU expansion. However, the magnitude of this change is far too small to imply constant returns to scale. In other words, even though scale elasticities move slightly closer to zero, they remain negative, indicating that the European Union does not yet operate as a frictionless single market.[17]

Breaking down the results by sectors, however, reveals heterogeneity: only a minority of sectors (Machines, Textiles, and Vehicles) display a reduction in the absolute value of scale elasticities when crossing the EU border. Interestingly, these sectors rank above the median in terms

[15] Article 28 TFEU

[16] Articles 34 to 36 TFEU

[17] An alternative interpretation is that any reduction in fixed trade costs may have been almost fully offset by contemporaneous increases in trade volumes.

of their average *"weight-to-value"* ratio, i.e., kilograms shipped per euro of trade, across all country pairs and years. This suggests that the EU expansion may have lowered fixed trade costs specifically for goods that are heavier to transport, while having negligible effects for lighter or higher-value products.[18]

As a robustness check, I can see whether the scale elasticities are larger when considering trade with non European countries. In particular, I will consider USA, Russia, China and Japan. Results are reported in Table 4. The estimated coefficient χ_1 refers to intra-European trade whereas $\chi_1 + \chi_2$ refers to trade with one of the non-European countries considered. If χ_2 is statistically significant we can conclude that the scale effects are significantly different when considering extra-European trade flows. Clearly, we expect scale economies to be either unchanged or greater in absolute value when trading with one of these extra-European countries. On average, this is exactly what I find: trade between European countries entail scale economies whose magnitude is 1.09%, whereas trade with an extra-European destination entails scale economies that are about 9.2% higher ($\chi_1 + \chi_2$=-0.109–0.01=-1.19%). For six sectors, the estimated $\hat{\chi}_2$ are significant and negative: gains from increases in volume are bigger when at least one country is not European. This is likely due to lower trade volumes when trading with countries that are much farther away than European ones.

Table 3
Estimated scale elasticities — EU expansion.

Sector	ϕ_1	ϕ_2
Aggregate	−0.129***	0.005***
	(0.002)	(0.001)
Chemicals	−0.142***	0.005***
	(0.002)	(0.001)
Food	−0.134***	0.002***
	(0.001)	(0.000)
Machines	−0.153***	0.003***
	(0.003)	(0.001)
Metals	−0.132***	0.006***
	(0.002)	(0.001)
Minerals	−0.114***	0.006***
	(0.002)	(0.001)
Other	−0.112***	0.014***
	(0.002)	(0.001)
Textiles	−0.163***	−0.000
	(0.005)	(0.002)
Vehicles	−0.164***	0.000
	(0.007)	(0.000)
Wood–Paper	−0.120***	0.004***
	(0.002)	(0.001)

Table 4
Estimated scale elasticities — Extra European countries.

Sector	χ_1	χ_2
Aggregate	−0.109***	−0.01***
	(0.002)	(0.001)
Chemicals	−0.122***	−0.004***
	(0.002)	(0.001)
Food	−0.110***	−0.002*
	(0.001)	(0.001)
Machines	−0.125***	−0.006***
	(0.004)	(0.001)
Metals	−0.109***	−0.007***
	(0.002)	(0.001)
Minerals	−0.092***	0.003
	(0.001)	(0.003)
Other	−0.095***	−0.007***
	(0.003)	(0.002)
Textiles	−0.121***	0.002
	(0.003)	(0.002)
Vehicles	−0.131***	−0.007**
	(0.006)	(0.004)
Wood–Paper	−0.101***	0.002
	(0.002)	(0.002)

5. Investigating scale elasticities

In order to understand the sectoral differences among the scale elasticities that I estimated, I compare the main results (Table 2) with an indicator of *tradability* at the industry level obtained by Holmes and Stevens (2014).[19] I refer to *tradability* as the inverse measure of the elasticity of the distance adjustment term η that the authors estimate, which measures how sensitively iceberg costs respond to transportation frictions: products with low tradability exhibit a rapid decline in the distance adjustment term (high elasticity η), so that costs rise quickly with distance and sales are limited to local markets. In other words, tradability measures how strongly distance restricts a product's potential market reach. The correlation between such a measure of tradability and the scale elasticities that I estimate is strong (−0.79): the lower the tradability, the lower the scale elasticity is in absolute value, meaning that there is a smaller role for trade volumes to reduce trade costs for those goods that are intrinsically harder to trade. Fig. 1 shows this relationship. Note that the tradability measure was obtained on US data on production, and that Holmes and Stevens (2014) find that sectors with high η are indeed harder to trade due to high variable transportation costs. The negative correlation with the scale elasticity ϕ that I estimate in this paper confirms my results and the goodness of the structural form of Eq. (4.1). Moreover, this suggests that scale elasticities depend on the structural tradability of the goods considered.

5.1. Scale elasticities over time

So far, I exploited the time-dimension of my dataset only to the extent in which it corresponded to the progressive expansion of the EU, in order to investigate a possible discontinuity in the scale elasticity parameter. I reduced a dynamic problem, in which the distance elasticity of trade could vary over time because of the EU expansion, to a static one, in which I considered only the (time-varying) EU membership of countries as a possible source of discontinuity, to simplify the analysis. One could wonder whether scale elasticities vary over time and, if so, whether it happens differently for different sectors. Such an analysis is possible by estimating Eq. (2.6) separately for separate years and sectors. The results, presented in Fig. 2, show that there is no clear trend in the evolution of scale elasticities over time and that, for the majority of the sectors considered, we reject the hypothesis that the scale elasticity in the last year of the sample is statistically different from the scale elasticity at the beginning of the sample. The scale elasticities remain stable over time, supporting the view that they are sector-specific structural features.

5.2. Product differentiation

In Section 4, I showed that the estimated ϕs exhibit a strong cross-sectoral variation. This could be due to differences in the size of markets, as I previously discussed, but it could also be a consequence of different product characteristics, responsible for different parameters in the trade cost function assumed in Section 4. For instance, the degree of product homogeneity could play a role in this respect. Rauch (1999) shows that proximity and cultural links such as common language and colonial ties have stronger effects in the market for differentiated goods.

[18] The *"weight-to-value"* ratio is computed using Eurostat trade data (available from 1988 onward), which report product-level volumes (in tons) and values. The construction of the sector-level measure follows (Chen, 2004), who constructs a sector-specific variable averaged across all country pairs i, j.

[19] I built a simple average of the values of η at the NAICS level reported by Holmes and Stevens (2014) to get a value of tradability at the ISIC 2-digit level of disaggregation

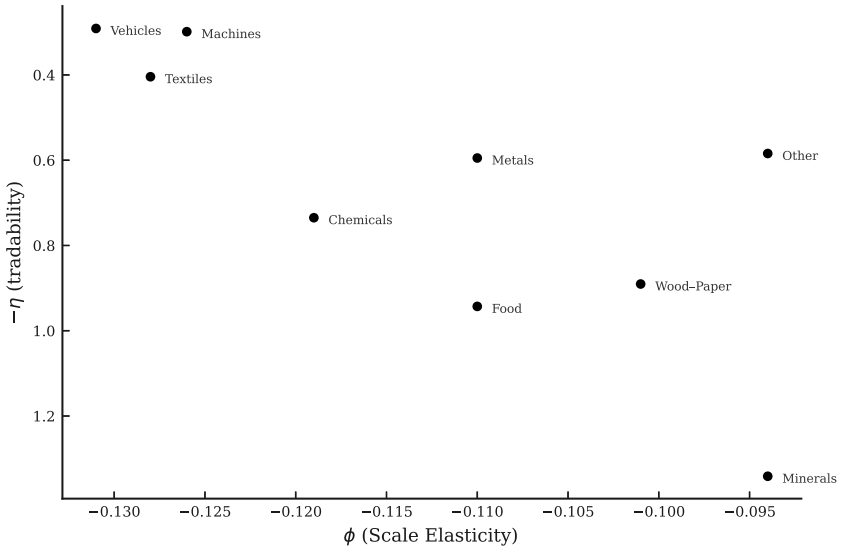

Fig. 1. Relationship between scale elasticity ϕ and tradability across sectors.

This finding provides empirical evidence for the existence of a "search" model of international trade: when goods are not homogeneous, but differ along dimensions such as quality, prices are not completely informative and markets are substituted by *networks*: exchanges happen after a buyer–seller connection has formed (Chaney (2014) develops a model on the formation of such networks). For this reason, cultural links and proximity play a greater role for these commodities.

If scale effects are the consequence, in aggregate terms, of the existence of buyer–seller links a' la (Chaney, 2014) and if informational asymmetries play a role in this respect, ϕ should be higher (in absolute value) when products are differentiated, because the creation of a relationship between buyer and seller is crucial when there are some non-standardized characteristics of the good, such as its quality. On the other hand, the fixed costs due to the creation of such links should be negligible for goods traded in organized markets. Therefore, I expect the scale coefficient to be lower (in absolute value) for those commodities.

I consider the more conservative classification by Rauch (1999), who divides goods in three categories according to their SITC Rev.2 classification: homogeneous goods traded in organized exchanges, homogeneous goods not traded in organized exchanges, but characterized by the presence of a "reference price", and differentiated goods.[20]

I will run regression (2.7) interacting the $INTERNATIONAL\_DIST$ variable with a dummy taking different values according to the different degree of homogeneity of the product considered. The estimating regression is as follows:

$$\begin{aligned} X^k_{i,j,k,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST_{i,j} + \\ &\alpha_3 (INTERNAT\_DIST_{i,j} \times DEGREE\_HOMOG_k) + \\ &\delta CONTIGUITY_{i,j} + \zeta EXCH\_RATE_{i,j,t} + \beta_{BORDER} B_{i,j} \\ &+ \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,k,t} \end{aligned} \tag{5.1}$$

The estimated ϕs are all statistically significant, showing that scale economies in trade costs are at work for all the three categories of goods considered (see Table 11 in the Appendix). However, my results show that the relationship between the degree of product homogeneity and the scale coefficient is opposite with respect to my prior. In fact, scale economies in trade costs are larger for homogeneous goods, for which frictions should be minimal. A plausible explanation could be that the volume of goods traded in organized exchanges is smaller than the volume of differentiated goods, possibly compensating for the difference in fixed trade costs. In any case, the data do not support the claim that the degree of product homogeneity explains the cross-sectoral variation in a manner consistent with the existence of informational frictions.

Using a similar approach, I explored the *weight-to-value ratio* as a possible product characteristic directly affecting scale coefficients, as well as regulatory barriers such as non-tariff barriers and technical barriers to trade, which are heterogeneous across products and could rationalize the cross-sectoral variation obtained from the main regression. Results are not reported for reasons of space. In any case, none of the dimensions considered seems to explain the result, pointing again at differences in volumes as important determinants for scale elasticities. Further research on this topic will hopefully provide some additional insights.

5.3. Corruption

Institutional variables such as the level of corruption have been shown to affect international trade flows. Anderson and Marcouiller (2002) show that corruption acts as a hidden tax, whose negative impact on international trade has about the same magnitude as the one of tariffs. Some studies provide evidence on how corruption can be pervasive at some countries' customs (see Parayno, 1999 for Philippines). More recently, Dutt and Traca (2010) proved that there exist a non-linear relationship between corruption and trade: when the tariff level is low, corruption harms trade (extortion effect), whereas it enhances it when the level of protection is higher (evasion effect).

Scale elasticities measure the extent to which higher flows are reflected in lower trade costs. If the level of corruption affected trade costs, I would expect it to increase their fixed component and hence to increase scale elasticities as well (in absolute value). To check for this hypothesis, I will run the following regression

$$\begin{aligned} X^k_{i,j,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST_{i,j} + \\ &\alpha_3 INTERNAT\_DIST_{i,j} \times CORRUP_{j,t} + \gamma CORRUP_{j,t} \\ &+ \delta CONTIGUITY_{i,j} + \\ &\zeta EXCH\_RATE_{i,j,t} + \beta_{BORDER} B_{i,j} + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,k,t} \end{aligned} \tag{5.2}$$

[20] Note that the Rauch classification involves goods and not sectors. For this reason, I will use the more disaggregated Eurostat dataset, available at the product-level, and I will focus on the period from 1996 to 2013.

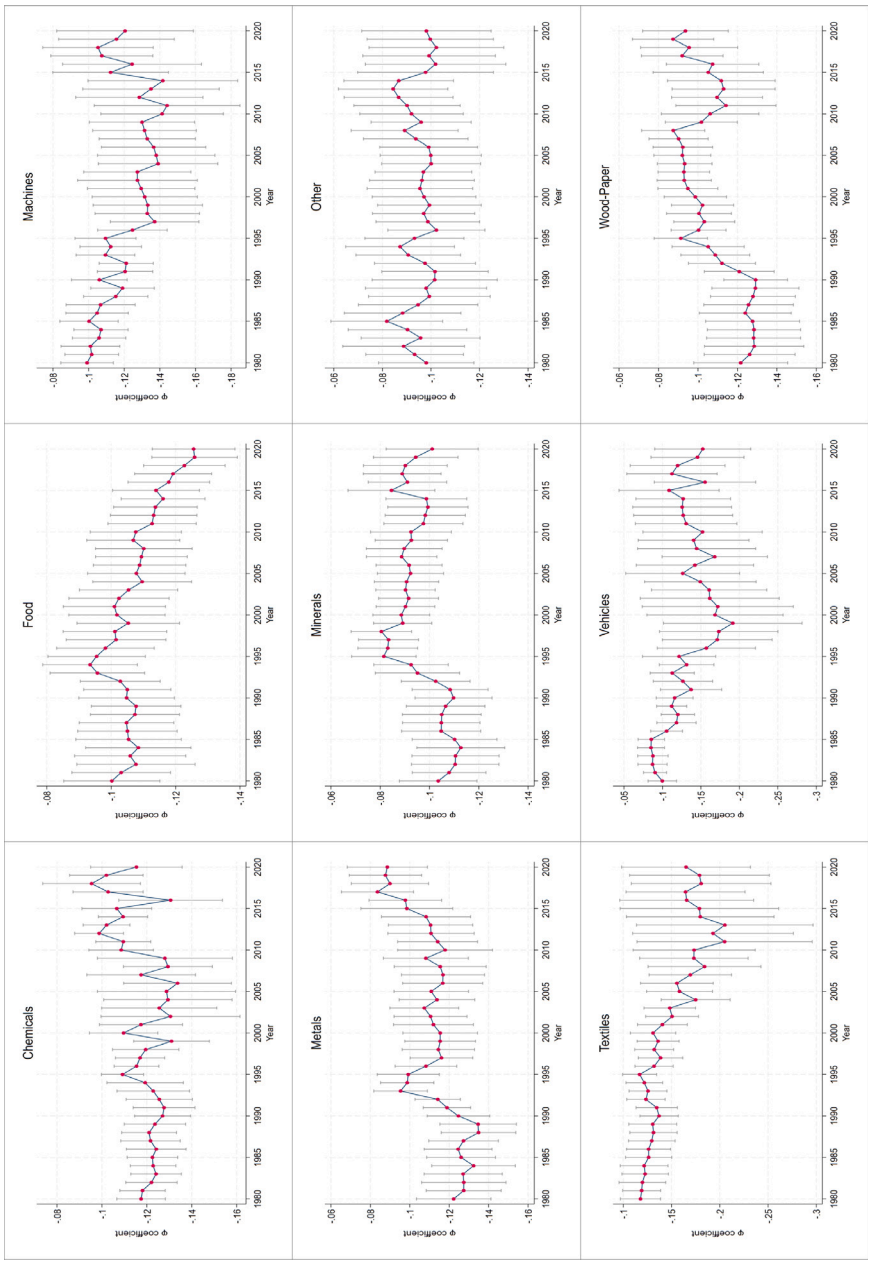

Fig. 2. Scale elasticities over time.

Column (1) of Table 5 reports the results. The corruption index is absorbed by the importer-time fixed effect that controls for one of the multilateral resistance terms, hence this equation does not measure the direct effect of corruption on trade. Interestingly, the interaction with the $INTERNATIONAL\_DIST$ variable is positive and significant: this means corruption is associated with a stronger negative relationship between distance and trade (recall that the corruption index is negative for country whose level of governance is weak). As a consequence, scale elasticities are higher (in absolute value) the higher the level of corruption measured in the importing country. This suggests that institutions could be associated with the fixed component of trade costs: in weaker institutional environments, repeated interactions help firms overcome frictions.

To give an idea of the magnitude of the estimate, consider the following example: selling manufacturing goods to Romania in 1998 (whose corruption index, −0.649, is the highest in the regression subsample) entails a scale elasticity of 1.15%, whereas exporting the same additional quantity to Denmark in 2006 (2.459 is the corruption index) implies a substantially smaller gain in terms of cost reduction (0.64%). The rationale is that higher trade volumes could reflect a higher number of transactions, which are likely most beneficial towards trade costs reductions when the level of corruption of customs officials (that we could consider a fixed cost) is high.[21]

The level of corruption does not need to be the only variable affecting the distance elasticity of trade. Rather, it is likely that the quality of contract enforcement and property rights also play a role, since they are determinants of bilateral aggregate trade frictions (Anderson and van Wincoop, 2004). Column (2) provides support for this hypothesis, reporting the coefficients obtained substituting the "rule of law" index to

[21] This analysis assumes the general level of corruption of a country, measured by the WGI index, to be positively correlated with the one of customs officials.

Table 5
Institutional variables.

	(1)	(2)	(3)	(4)
Internal_Dist	−0.302***	−0.309***	−0.307***	0.316***
	(−21.90)	(−22.20)	(−22.04)	(−23.78)
International_Dist	−1.088***	−1.119***	−1.108***	−1.203***
	(−59.75)	(−61.33)	(−59.07)	(−60.63)
Corruption_Imp × Internat_Dist	0.0608***		0.0246***	0.0114***
	(26.41)		(3.10)	(3.76)
Rule of law_Imp × Internat_Dist		0.0817***	0.0506***	
		(26.12)	(4.63)	
Recovery rate insolvency_Imp × International_Dist				0.00280***
				(24.16)
N	16 038	16 038	16 038	12 177
R2	0.99	0.99	0.99	0.99

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6
Institutional variables & EU membership.

	(1)	(2)
Internal_Dist	−0.294***	−0.299***
	(−21.62)	(−21.77)
International_Dist	−1.085***	−1.114***
	(−59.47)	(−60.88)
Corruption_Imp × Internat_dist × Bothmembers	0.0598***	
	(26.50)	
Corruption_Imp × Internat_dist × (1-Bothmembers)	−0.00542	
	(−0.80)	
Rule of law_Imp × Internat_dist × Bothmembers		0.0774***
		(25.47)
Rule of Law_Imp × Internat_dist × (1-Bothmembers)		0.00321
		(0.42)
N	16 038	16 038
R2	0.99	0.99

t statistics in parentheses.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

the corruption one in the previous regression. The results show that the absolute gain from additional trade volume increases when exporting to the country exhibiting the lowest perception of institutional quality (Croatia in 2006) as compared to the country with the highest one (Finland in 2014), going from 0.12% to 0.10%. When both indexes are included in the regression (Column (3)), however, the coefficient on the "corruption" one declines. This may simply be due to its very high correlation with the *rule of law* index (correlation coefficient of about 0.93). For robustness, I considered an alternative indicator for the quality of contract enforcement: the recovery rate in case of insolvency (in cents on the dollar), available from the *doing business* website (http://www.doingbusiness.org), which includes country-level indicators on the easiness of engaging in economic activity for the period 2005–2020. Such recovery rate is strongly correlated with the rule of law index, the correlation coefficient being 0.79, but it is more weakly correlated with corruption ($\rho = 0.80$). Column (4) shows that both the corruption level and the contract enforcement quality affect the estimates of scale elasticities.

To further investigate the relationship between institutions and trade costs, I exploit the time dimension of the data and estimate Eq. (5.2) separately for each year. This approach allows me to examine whether the impact of institutional variables on distance elasticity evolves over time and to assess whether improvements in institutional quality are reflected in changes in the estimated coefficients. Fig. 4 (Panel A) reports the evolution over time of the coefficient on the interaction between corruption and distance. The estimates remain relatively stable over the sample period, indicating that the association between corruption and distance elasticity does not vary substantially over time. This pattern emerges despite improvements in institutional quality and increasing trade volumes, which would, in principle, reduce the importance of institutional frictions. By contrast, Fig. 4 (Panel B) shows that the coefficient on the interaction between rule of law and distance displays a declining trend over time, suggesting that improvements in legal institutions are associated with a reduced impact of institutional frictions on trade costs. Taken together, these results point to heterogeneous dynamics across institutional dimensions: while broader measures such as corruption exhibit persistent cross-country differences, more specific aspects related to contract enforcement appear to play a more direct role in shaping the evolution of trade frictions.[22]

The impact of institutional quality on the distance elasticity is weakly related to the EU membership (see Table 6). The interaction term is positive and highly significant for pairs in which both countries are EU members ($Bothmembers = 1$), while it becomes small and statistically insignificant when at least one partner is not in the EU ($Bothmembers = 0$). The differences in the coefficients do not translate into economically meaningful differences in scale elasticities. For instance, consider a good being sold from Czech Republic to its neighboring country, Poland, either in 2003 or in 2009. The index of corruption in Poland was 0.38 in 2003 and 0.37, basically unchanged, in 2009. Given the estimated coefficients, a 10% increase in imports from Czech Republic implied a 1.9% decrease in trade costs in 2003, when none of the country was a EU member, and a 1.8% decrease in 2009, when both countries were EU members (they both joined in 2004). I conclude that scale economies are closely associated with institutional quality and this was not mitigated significantly by the EU expansion. A possible explanation for this limited effect is that EU integration reduces average trade frictions without fully eliminating cross-country heterogeneity in institutional quality. In particular, part of the institutional convergence may take place before formal accession, as candidate countries are required to satisfy minimum institutional standards under the Copenhagen criteria. As a result, EU membership per se may not generate a sharp discontinuity in the impact of institutions on trade costs. This interpretation is consistent with the idea that institutional convergence is gradual and may already be reflected in trade patterns prior to accession.

Focusing on the EU dimension, institutional indicators display gradual convergence over time. As shown in Figure 5 in the Appendix, Western and Northern European countries consistently exhibit higher

[22] There is evidence of convergence in institutional quality across European countries. For corruption control, dispersion declines over time (σ−convergence) and a regression of changes on initial levels yields a negative and significant coefficient ($\beta = -0.243, p = 0.006$). For rule of law, while dispersion remains broadly stable, β-convergence is observed ($\beta = -0.144, p < 0.001$), indicating that countries with initially weaker institutions improve more over time.

levels of corruption control, while Central and Eastern European countries start from lower levels but improve over time. Comparing pre- and post-accession averages for later entrants shows higher institutional quality after accession, although this improvement appears gradual rather than driven by a discrete break, consistent with the pre-accession requirements of the Copenhagen criteria. Additional evidence from the 2004 enlargement (Tables 12 and 13 in the Appendix) shows that both corruption (column 1) and rule of law (column 2) remain lower for Eastern European countries after accession, although convergence is observed. In both cases, institutional variables remain associated with lower trade at longer distances, but the magnitude of this relationship declines in the post-accession period. Overall, these findings suggest that EU integration reduces average trade frictions while leaving residual cross-country heterogeneity in institutional quality, helping explain the limited impact of EU expansion on scale elasticities.

It is possible to interpret the interaction terms in Tables 5 and 6 by computing the *threshold values* of the institutional variables for which the effect of distance on trade becomes zero. In fact, the total marginal effect of distance on trade can be written as:

$$\frac{\partial \ln X_{ij}}{\partial \text{distance}} = \alpha_{\text{dist}} + \beta_{\text{int}} \cdot Z_j,$$

where Z_j is the institutional variable of interest (corruption, rule of law, or insolvency recovery rate). The effect of distance changes sign when this derivative is equal to zero:

$$\alpha_{\text{dist}} + \beta_{\text{int}} Z_j = 0 \qquad \Rightarrow \qquad Z_j^* = -\frac{\alpha_{\text{dist}}}{\beta_{\text{int}}}.$$

This value Z_j^* represents the institutional threshold above (or below) which the impact of distance on trade switches from negative to positive. Using Column (1) of Table 5, it is possible to get the following threshold values

$$Z^*_{\text{corruption}} \approx 17.9, \qquad Z^*_{\text{rulelaw}} \approx 13.7, \qquad Z^*_{\text{recovery}} \approx 429.0.$$

Since corruption and rule of law range approximately between −2.5 and 2.5, and the recovery rate ranges between 0 and 100, these thresholds values lie far outside the empirical support. This implies that distance *always* reduces trade, regardless of the institutional quality of the importing country. In other words, institutional variables affect only the *magnitude* of the negative distance effect, not its sign. Countries with weaker institutions face larger fixed trade costs; as a consequence, an additional increase in trade volume generates larger reductions in trade costs (stronger scale elasticities). Improving institutional quality reduces the marginal cost of distance but does not turn the effect of distance positive.

Very similar conclusions can be drawn when distinguishing between EU members and non-members[23]: the effect of distance remains negative in all empirically relevant cases. Institutional quality shifts the magnitude of the distance effect but never reverses it. Countries with low-quality institutions or weak contract enforcement benefit the most from scale economies: a higher number of transactions leads to proportionally larger reductions in trade costs. Institutional reforms such as anti-corruption policies, judicial and administrative improvements can thus substantially lower fixed trade costs and mitigate the effects of distance. EU membership contributes to reducing frictions but does not fully neutralize geographic barriers; institutional convergence remains essential for deeper integration.

6. Discussion

This section summarizes the main empirical findings and describes their implications for European trade policy. First, the results confirm the presence of economically meaningful scale elasticities in European trade costs. All nine manufacturing sectors display negative scale elasticities, whose magnitude remains stable over time. These findings reinforce the idea that fixed components of iceberg costs play a central role in shaping bilateral trade flows. Second, the analysis shows that the expansion of the European Union has only marginally reduced fixed trade costs. Scale elasticities for intra-EU trade remain significantly negative: the European Single Market is still far from frictionless in practice. Third, institutional quality is strongly associated with scale elasticities. Countries with weaker governance, higher corruption, or lower recovery rates in insolvency tend to exhibit larger gains from additional trade volume. Note that these results should be interpreted as correlational rather than causal, as the empirical framework does not fully address potential endogeneity issues such as reverse causality or omitted variables".

These findings contribute to existing work emphasizing the importance as well as the complexity of measuring trade frictions. Recent contributions show that the distance elasticity of trade is potentially mismeasured when internal geography is ignored (Yilmazkuday, 2014). Moreover, variations in distance elasticities have been linked to meaningful welfare effects (Yilmazkuday, 2021). My results complement this literature by showing that the quality of institutions matter for scale elasticities, which are defined and estimated employing distances between countries. Similarly, my finding that EU membership alone does not eliminate fixed frictions is consistent with earlier evidence on persistent border effects within the EU (Chen, 2004 and Nitsch, 2000).

The results provided in this paper highlight a strong association between institutional quality and scale elasticities, for which different possible alternative interpretations should be discussed. First, the direction of causality may run from trade to institutions rather than the opposite. A large literature shows that trade openness can contribute to institutional improvements. For example, Acemoglu and Robinson (2006) argue that trade-induced changes in income distribution can strengthen the political power of groups that demand better institutions, while Rodrik (2000) and Bhattacharyya (2012) emphasize that trade liberalization often entails the adoption of institutional frameworks associated with international integration. Empirical evidence also suggests that trade openness is negatively associated with corruption (Ades and Di Tella, 1999; Treisman, 2000), and may act as a catalyst for institutional reform (Dang, 2010). More recent work highlights that trade policies and institutional quality are jointly determined, with trade liberalization often associated with improvements in governance, while protectionist policies may foster corruption (Dutt and Traca, 2010; Majeed, 2014). Second, the observed relationship may reflect endogenous firm behavior: firms may choose to enter institutionally weak or riskier markets only when expected trade volumes are sufficiently large to offset fixed costs, generating a correlation between trade intensity and measured scale effects. Third, measurement issues may also contribute to the observed patterns. Institutional indicators are perception-based and may capture broader country characteristics correlated with trade costs. Taken together, these considerations suggest that the results should be interpreted as descriptive of empirical regularities rather than causal effects. While consistent with the presence of a fixed component of trade costs related to institutional quality, the analysis does not disentangle the underlying mechanisms, leaving room for multiple interpretations.

My results suggest that institutional convergence, rather than formal EU membership alone, is likely to be an important factor associated with lower fixed trade costs. Anti-corruption reforms, improvements in contract enforcement, and harmonization of regulatory procedures would benefit countries in which institutional frictions remain high. Given that sectors with low tradability tend to exhibit total trade costs that are predominantly driven by their variable component, reducing fixed costs generates only a limited impact on overall trade frictions in these industries. Conversely, in sectors with low variable costs, total

[23] $Z^*_{\text{corr, EU}} \approx 18.1, \quad Z^*_{\text{corr, nonEU}} \approx 200, \quad Z^*_{\text{rule, EU}} \approx 14.4, \quad Z^*_{\text{rule, nonEU}} \approx 347.$

trade costs are more heavily influenced by the fixed component F/v. As a result, reductions in fixed costs will translate into proportionally larger declines in total trade costs for these latter sectors.

7. Conclusion

In this paper, I showed the existence of scale economies in European international trade for all the manufacturing sectors considered over a 40-year long period (1980–2020). At the beginning of this period, the members of what would have become the European Union were only nine, whereas they reached the number of 28 in the last year considered. I explored the possibility that the EU expansion could have changed such economies of scale. The data show an increase in scale elasticities compatible with a decline in fixed trade costs, but the economic magnitude of this change is negligible. The inclusion of extra-European countries as a robustness check, however, confirms the validity of my approach: extra-European elasticities are on average higher than European ones.

Scale economies in trade costs are not linked to sector-specific informational frictions, at least as they are measured by the degree of product homogeneity. Institutional characteristics of the destination country, however, play a role: the higher the level of corruption and the lower the quality of property rights in the importing country, the higher the gain from a trade volume increase. These findings reinforce the view that institutional convergence is essential for reducing fixed trade costs and strengthening market integration within the EU. For policymakers, this means that improving institutional quality may deliver reductions in the fixed costs that limit the extent of market integration.

The analysis suggests several directions for future research. While I focus on manufacturing sectors, it would be interesting to extend the analysis to services trade, focusing on the impact of fixed costs, institutional factors and regulatory barriers. It would also be informative to expand the geographical scope of the analysis to assess whether the mechanisms identified in this paper hold in other regional settings. Moreover, investigating the relationship between scale elasticities and non-tariff barriers would help open the "black box" of the iceberg trade costs.

Ethical compliance

The research presented in this manuscript complies with all ethical guidelines for academic research. No human or animal subjects were involved in this study, and there are no conflicts of interest related to this work.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

See Tables 7–11 and Figs. 3 and 4.

Data availability

Data will be made available on request.

Scale Economies in European Trade (Original data) (Mendeley Data)

Table 7
List of sectors.

Vehicles
Machines
Textiles
Chemicals
Minerals
Metals
Other
Food
Wood and Paper

Table 8
Estimated scale elasticities — Sector specific σ.

Sector	ϕ	S.E.
Aggregate	−0.107***	0.001
Chemicals	−0.141***	0.002
Food	−0.105***	0.001
Machines	−0.091***	0.002
Metals	−0.141***	0.002
Minerals	−0.141***	0.002
Textiles	−0.139***	0.004
Vehicles	−0.181***	0.007
Wood–Paper	−0.147***	0.003

Table 9
Estimated scale elasticities — Big VS large destinations.

Variable:	Population	GDP
ϕ_{LARGE}	−0.139***	−0.137***
	(0.002)	(0.002)
ϕ_{SMALL}	−0.130***	−0.131***
	(0.003)	(0.003)
N	24536	24536
R2	0.99	0.99

Table 10
EU expansion.

Name	Accession	Name	Accession
Belgium	Founder	Sweden	1-Jan-95
France	Founder	Cyprus	1-May-04
Germany	Founder	Czech Rep.	1-May-04
Italy	Founder	Estonia	1-May-04
Luxembourg	Founder	Hungary	1-May-04
Netherlands	Founder	Latvia	1-May-04
Denmark	1-Jan-73	Lithuania	1-May-04
Ireland	1-Jan-73	Malta	1-May-04
UK	1-Jan-73	Poland	1-May-04
Greece	1-Jan-81	Slovakia	1-May-04
Portugal	1-Jan-86	Slovenia	1-May-04
Spain	1-Jan-86	Bulgaria	1-Jan-07
Austria	1-Jan-95	Romania	1-Jan-07
Finland	1-Jan-95	Croatia	1-Jul-13

Table 11
Estimated scale elasticities — Rauch classification.

Coefficient	Estimate
$\phi_{differentiated}$	−0.052***
	(0.001)
$\phi_{ref.priced}$	−0.059***
	(0.001)
$\phi_{organized}$	−0.065***
	(0.001)
N	1371016
R2	0.96

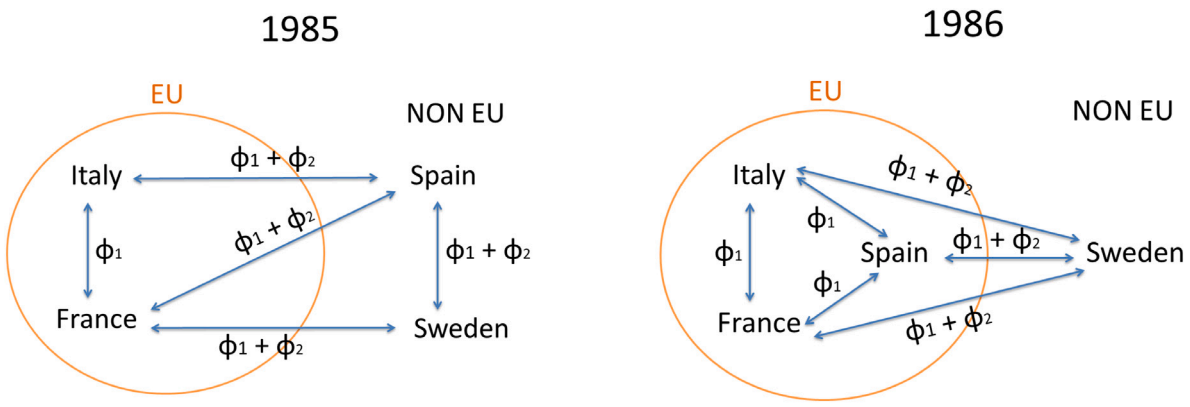

Fig. 3. EU elasticities: An example.

Fig. 4. Institutional variables by country group.

Table 12
Institutional variables & EU membership — Pre 2004.

	(1)	(2)
Internal_Dist	−0.3159***	−0.3081***
	(−10.93)	(−10.76)
International_Dist	−1.1481***	−1.2221***
	(−34.14)	(−36.41)
Corruption_Imp x International_Dist	0.0859***	
	(17.32)	
Rule of Law_Imp x International_Dist		0.1295***
		(17.53)
N	3645	3645
R2	1.00	1.00

t statistics in parentheses.
* < 0.10, ** < 0.05, *** < 0.01.

Table 13
Institutional variables & EU membership — Post 2004.

	(1)	(2)
Internal_Dist	−0.3060***	−0.3147***
	(−20.39)	(−20.59)
International_Dist	−1.0833***	−1.1104***
	(−54.03)	(−55.03)
Corruption_Imp x International_Dist	0.0624***	
	(24.78)	
Rule of Law_Imp x International_Dist		0.0801***
		(24.46)
N	12 393	12 393
R2	0.99	0.99

t statistics in parentheses.
* < 0.10, ** < 0.05, *** < 0.01.

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