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Structural gravity equation with extensive and intensive margins*

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Abstract

New trade models with heterogeneous firms have had a consequent influence on gravity equations. According to Chaney (2007) and Melitz and Ottaviano (2005), the theoretical relationship between trade costs and trade flows is the sum of the effect of trade costs on the number of exporting firms (the extensive margin) and the value of individual exports (the intensive margin). The distinctive effect of distance on the two margins deeply modifies predictions of the trade literature, among which the sectoral effect of trade policies. Using French firms-level export data to 61 countries, on the period 1989-1992, we provide unbiased structural estimates of the three parameters governing trade elasticities with respect to distance. This dissection of the gravity equation provides consistent evidence in favor of heterogeneous firms models of trade.

Keywords: Gravity equation, International trade, Firm heterogeneity.
JEL Classification: F12.

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1 Introduction

Gravity equations are probably one of the most salient successes in empirical economics. These equations associate bilateral trade flows to the economic size of the trading countries and the geographic distance between them. They have received a growing interest during the last decade, and the numerous empirical studies based on these simple models confirm the strong influence of distance on international trade patterns. The empirical trade literature extended the analysis of the impact of distance on trade. Using historical data, Irwin and Terviö (2002) and Disdier and Head (2007) highlight the evolution of the distance effect in time; Rauch (1999) and Rauch and Trindade (2002) study the importance of cultural distance through the measure of the influence of social networks on international trade, and a number of papers analyse the role of transport time and infrastructures in shaping trade flows (Hummels 2001; Evans and Harrigan, 2005; Limao and Venables 2002; Brun et al, 2005).

While theoretical trade models now incorporate the role of geographical and cultural distances, recent academic research has paid more attention to the channels through which a decrease in trade costs increases aggregate bilateral trade. Anderson and van Wincoop (2004) point to the theoretical components of the gravity coefficient. In a Dixit-Stiglitz-Krugman monopolistic competition model, distance affects trade flows through a price effect: distance increase trade costs, which decrease the volume of exports. The impact of distance on trade flows thus depends on two parameters: the distance elasticity of trade costs and the elasticity of substitution.

The new trade models emphasizing the heterogeneity of firms (Melitz, 2003)[1] considerably change the theoretical relationship between trade costs and trade flows. Indeed, when firms are heterogeneous, for given trade costs only a subset of firms export. When trade costs decrease, incumbent exporters increase their volume of sales (the *intensive margin*, and new firms enter the export market (the *extensive margin*). The effect of distance on the aggregate volume of trade is the sum of the distance effect on the intensive and the extensive margins. Chaney (2006), modifying Krugman's (1980) model, and Melitz and Ottaviano (2005), still with a monopolistic competition model but with a different utility function, show that the impact of trade costs on aggregate bilateral trade flows depends on the degree of firms heterogeneity and not on the elasticity of substitution.

The prevalence of both intensive and extensive margins of trade has been documented in

[1] See also Jean (2002)

recent papers. Eaton, Kortum and Kramarz (2004) analyse how the variation of French market share abroad affects the nature of bilateral trade. Hillberry and Hummels (2007) provide a decomposition of the distance effect on intranational US shipments, and Bernard, Jensen, Redding and Scott use US export data at the firm-level to estimate the impact of distance on the intensive and extensive margins. However, while these studies provide important empirical evidence, they are not governed by specific theoretical models. Helpman, Melitz, Rubinstein (2007) estimate a structural model on bilateral export data for 158 countries, and obtain trade margins elasticities based on aggregate trade flows.

In this paper, we estimate Chaney's model of trade with heterogeneous firms, and provide a structural estimation of the influence of distance on international trade using French firm-level export data. Indeed, empirical analyses inferring from a gravity equation unbiased estimates of the distance effect on trade flows must consider the distinctive effect of trade on the two margins. Obtaining rigourously estimated sectoral parameters contributes to the plentiful empirical literature that focuses on the estimation of trade price elasticities (see for instance Erkel-Rousse and Mirza, 2002), and may be as important as ameliorating predictions concerning the impact of economic integration on industrial location and agglomeration.

We use the distinctive influence of trade costs on the two trade margins to estimate, from a panel of firm level data, the three structural parameters that contribute to the global distance effect on trade: the elasticity of substitution, the distance elasticity on transport costs, and the level of firm heterogeneity. The estimated parameters confirm the prevalence of extensive and intensive margins of international trade, and are consistent, for 28 out of 34 industries, with the theoretical models of trade with heterogeneous firms à la Chaney (2007) and Melitz-Ottaviano (2005).

The paper is structured as follows. Section 2 sketches the theoretical model. Section 3 presents the data and explains the empirical strategy. In section 4, we propose an overlook at trade elasticities computed using the decomposition of the distance effect on trade into intensive and extensive margins. While this method provides important stylized facts, it bears several shortcomings that lead us to present in section 5 an alternative methodology. Structural parameters of the gravity equation are computed using individual export flows. Section 6 concludes.

2 The model

This section succinctly presents a simple model of international trade with heterogenous firms, synthesizing the main features of Chaney (2006). We highlight the expressions for the trade costs elasticity of the extensive and the intensive margins.

2.1 Production and consumption

The world consists of R national markets. Each country produces H differentiated goods and a homogenous numéraire. In the H manufacturing industries, firms engage in monopolistic competition à la Dixit-Stiglitz. All consumers have the same CES utility function:

$$U = q_0^{\mu_0} \Pi_{k=1...K} \left(\int_{j=1}^{R} q_{kj}^{\sigma_k - 1} \right)^{\mu_k \frac{\sigma_k}{\sigma_k - 1}}, \tag{1}$$

where q_{kj} is the quantity of good k demanded by a representative consumer in country j, σ_k is the elasticity of substitution between varieties of good k, q_0 is the consumption of the numéraire good, and μ_0 and μ_k are positive parameters such that ($\mu_0 + \sum_k \mu_k = 1$). Since the empirical analysis has to consider each industry separately, we drop the subscript k for notational convenience.

To produce and sell on a market, each manufacturing firm incurs a firm-specific marginal cost, and a country-specific fixed cost. For a firm from country i, with a marginal cost a, the total cost of supplying consumers in country j with $q(a)$ units of good is: $TC_{ij}(a) = q(a)a + C_{ij}$. More, we assume the existence of an "iceberg" transport cost; $\tau_{ij} > 1$ units of good have to be shipped from i to ensure that one unit arrives in country j.

As usual in the Dixit-Stiglitz monopolistic competition framework, the profit-maximizing price is a constant mark-up over marginal cost. Hence, the delivering price on market j of a good produced in country i by firm with a marginal cost a is:

$$p_{ij}(a) = \frac{\sigma}{\sigma - 1} a \tau_{ij}. \tag{2}$$

We note E_j the total expenditure in country j in the relevant industry, and P_j the price index in country j. Then, one can show from (1) and (2) that the demand emanating from country j for a given variety in i is:

$$m_{ij}(a) = p_{ij}(a) q_{ij}(a) = \left(\frac{p_{ij}(a)}{P_j} \right)^{1-\sigma} E_j. \tag{3}$$

2.2 Trade costs and the extensive and intensive margins of trade

As in Baldwin and Okubo (2006), we consider that firms in country i differ in terms of their marginal cost; a is supposed to follows a Pareto distribution, bounded between 0 and 1, with a scaling parameter $\gamma \geq 1$.[2] Hence, marginal costs is distributed according to $P(\tilde{a} < a) = F(a) = a^{\gamma}$ and $dF(a) = f(a) = \gamma a^{\gamma-1}$. The parameter γ is an inverted measure of the degree of firms' heterogeneity. With a γ close to one, the distribution of marginal costs is almost uniform between 0 and 1; as γ goes to infinity, the distribution becomes more concentrated since the share of firms with a relatively high marginal cost ($a \simeq 1$) increases.

For a marginal cost a, the profits earned from sales on market j are: $\pi_{ij}(a) = m_{ij}(a) - TC_{ij}(a)$. Using profit maximizing prices (equation 2), we obtain:

$$\pi_{ij}(a) = m_{ij}(a)\frac{1}{\sigma} - C_{ij} = \left(\frac{\sigma}{\sigma-1}\frac{a\tau_{ij}}{P_j}\right)^{1-\sigma} E_j - C_{ij}. \tag{4}$$

Individual profit governs the decision to export to country j. It increases with destination market size (E_j), and decreases with impediments to trade (τ_{ij} and C_{ij}). As usual in monopolistic competition models, the importing country price index (P_j) enters positively in both trade flows and exports profit expressions. This price index can be interpreted as a measure of remoteness from the rest of the world, which captures the influence of the greater competition that occurs in more central markets.[3]

We note $\overline{a}$ the value of marginal costs that ensures that the revenues of sales in country j just equal the total cost of exporting. From (4), this threshold value is:

$$\overline{a}_{ij} = \lambda_j \left(\frac{1}{C_{ij}}\right)^{1/(\sigma-1)} \frac{1}{\tau_{ij}}, \tag{5}$$

with $\lambda_j = \frac{\sigma-1}{\sigma}\left(E_j\right)^{1/(\sigma-1)} P_j$.

Finally, all the firms from i which have a marginal cost smaller or just equal to $\overline{a}_{ij}$ decide to export to j. The total number of exporting firms is thus:

$$N_{ij} = \int_0^{\overline{a}_{ij}} N_i f(a)da = \left[N_i \frac{\gamma}{\gamma-1}\lambda_j^{\gamma}\right]\left(\frac{1}{C_{ij}}\right)^{\gamma/(\sigma-1)} \tau_{ij}^{-\gamma}, \tag{6}$$

[2] We assume $\gamma > \sigma - 1$.

[3] Indeed, noting $\overline{a}_{hj}$ the marginal cost of the less efficient firm in country h that exports to country j, and N_h the total mass of firms in country h, this price index is: $P_j = \sum_{h=1}^{R}\left(\int_0^{\overline{a}_{hj}} N_h \left(\frac{\sigma}{\sigma-1}x\tau_{hj}\right)^{1-\sigma}\gamma x^{\gamma-1}dx\right)^{1/(1-\sigma)}$. As in the Dixit-Stiglitz-Krugman framework, it is the sum of all bilateral trade costs, weighted by the number of firms that export to country j (see Anderson and van Wincoop, 2003, for detailed analysis of the role of this index in gravity equations).

And the value of bilateral trade from i to j is:

$$\begin{aligned} M_{ij} &= \int_0^{\bar{a}_{ij}} N_i m_{ij}(a) f(a) da \\ &= \Theta \frac{E_j}{P_j^{1-\sigma}} N_i \left(C_{ij}\right)^{-\frac{[\gamma-(\sigma-1)]}{\sigma-1}} \left(\tau_{ij}\right)^{-\gamma} \end{aligned} \tag{7}$$

with $\Theta = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\frac{\gamma}{\gamma-(\sigma-1)}\right) \lambda_j^{\gamma-(\sigma-1)}$.

This bilateral trade equation is very similar to the traditional gravity equation derived from the Dixit-Stiglitz-Krugman (DSK) framework. The bilateral trade flow increases with the demand in destination country (E_j) and the supply capacities in exporting country (N_i). Trade is also a decreasing function of bilateral trade costs τ_{ij}. There are nevertheless two main differences with the standard DSK gravity equation. First, the fixed cost required to enter the foreign market appears logically as an additional determinant of bilateral trade. Second, the trade costs elasticity of trade differs significantly from the homogenous firms case. Indeed, it is straightforward from (7) that:

$$\frac{\partial M_{ij}}{\partial \tau_{ij}} \frac{\tau_{ij}}{M_{ij}} = -\gamma.$$

Here, the trade costs elasticity of trade does not depend on the price elasticity, whereas it is equal to $(1-\sigma)$ in the DSK model.[4] This is one of the most striking result of the model, since it imposes to reconsider the plentiful empirical and theoretical literature that associates the industrial product differentiation parameter to central features of international trade, such as the magnitude of the impact of trade costs (Anderson and van Wincoop, 2004), border effects, home market effects (Davis and Weinstein, 2003; Head and Mayer, 2004) and the consequences of trade liberalization on industrial agglomeration (Baldwin and Okubo, 2006).

To understand why the introduction of firms' heterogeneity perturbs the trade costs elasticity, let us consider trade margins. Indeed, the influence of trade costs on aggregated bilateral flows results from the combined effect of both the intensive and the extensive margins. A decrease in τ_{ij} expands both the number of firms in i that choose to export to country j (see

[4]Note that the model presented in this section makes a simplifying assumption. Indeed, following Chaney (2006), we consider that τ_{ij} does not impact E_j and P_j, i.e. we assume implicitly that country i is a "small" country which has a negligible influence on the world economy. In the case of a "large" country, a change in τ_{ij} has a direct impact on P_j, but also an indirect influence on both P_j and E_j through the level of aggregated profits in all countries (See Chaney, 2006 for a discussion of these issues).

equation 6) and the volume exported by each firm (see equation 3). We refer respectively to these changes as the extensive and the intensive margins of trade. Hence, noting $\varepsilon_{\tau_{ij}}^{M_{ij}}$ the trade costs elasticity of total trade, $\varepsilon_{\tau_{ij}}^{INT_{ij}}$ and $\varepsilon_{\tau_{ij}}^{EXT_{ij}}$ the trade costs elasticities of the intensive and extensive margins, we have necessarily:

$$\varepsilon_{\tau_{ij}}^{M_{ij}} = \varepsilon_{\tau_{ij}}^{INT_{ij}} + \varepsilon_{\tau_{ij}}^{EXT_{ij}} = -\gamma \tag{8}$$

To compute the trade costs elasticity of the extensive margin ($\varepsilon_{\tau_{ij}}^{EXT_{ij}}$), one cannot just consider equation (6). Indeed, economic integration expands the number of exporting firms, as suggested by equation (6), but as τ_{ij} decreases further the firms which enter into the export market are less efficient and export smaller quantities (see result 4 in Baldwin, 2005). Thus, the impact of a marginal reduction in trade costs on the extensive margin is equal to the increase in the number of exporting firms multiplied by the quantity exported by the threshold firm (i.e. the firm which marginal cost is $\overline{a}_{ij}$):[5] $\varepsilon_{\tau_{ij}}^{EXT_{ij}} = \left[N_i m_{ij}(\overline{a}_{ij}) f(\overline{a}_{ij}) \frac{\partial \overline{a}_{ij}}{\partial \tau_{ij}}\right] \frac{\tau_{ij}}{M_{ij}}$. Using (3), (5) and (6), we obtain after some manipulations:

$$\varepsilon_{\tau_{ij}}^{EXT_{ij}} = -\left[\gamma - (\sigma - 1)\right]. \tag{9}$$

Finally, we can use equation (8) to obtain the trade costs elasticity of the intensive margin:

$$\varepsilon_{\tau_{ij}}^{INT_{ij}} = -(\sigma - 1). \tag{10}$$

Note that $\varepsilon_{\tau_{ij}}^{INT_{ij}}$ is exactly the trade costs elasticity of total trade one can derive from a Krugman (1980) type model of trade with homogenous firms. In the following sections, we confront the above expressions for the intensive and extensive margins elasticity to the data in order to obtain estimations for the structural gravity parameters.

3 Empirical strategy and data

We explain how we proceed to obtain estimations of the gravity parameters and present the data.

[5] See Chaney (2006) for a more explicit decomposition of total trade into extensive and intensive margins.

3.1 Empirical strategy

Chaney's model emphasizes how much considering firms' heterogeneity matters for international trade analysis. It shows that the consequence of economic integration should differ among industries. First, a similar reduction in trade costs will have a larger influence on bilateral trade in less heterogenous industries (i.e. those for which γ is large). Second, the decomposition of the effect of trade integration will not be the same depending on the degree of goods differentiation in the sector. In industries producing highly differentiated products (i.e. where σ is relatively low), trade integration allows the entry of a large number of firms, each of them with a relatively small market share. In these industries trade expands mainly through the extensive margin. On the contrary, in industries producing homogenous goods, a reduction in trade costs expands trade principally through the intensive margin. When trade costs decrease, less efficient firms encounter stronger difficulties to enter export markets: only a small number of firms become new exporters.

Using trade data for a large set of exporting firms, it is possible to estimate the parameters shaping the influence of distance on total trade and on each trade margin, dissecting the gravity equation. Let us assume a very simple fonction of trade costs: $\tau_{ij} = D_{ij}^{\delta}$, where D_{ij} is the bilateral distance between i and j, and δ a strictly positive coefficient.[6] The distance elasticities of trade are:

$$
\begin{aligned}
\varepsilon_{d_{ij}}^{M_{ij}} &= -\delta\gamma \\
\varepsilon_{d_{ij}}^{INT_{ij}} &= -\delta(\sigma - 1) \\
\varepsilon_{d_{ij}}^{EXT_{ij}} &= -\delta\left[\gamma - (\sigma - 1)\right]
\end{aligned}
\qquad (11)
$$

In section 4, we estimate the above elasticities of trade margins using aggregate French exports. These elasticities provide interesting stylized facts in line with the patterns of trade highlighted by the current literature. However, they do not allow to compute the exact gravity parameters of equation (11). We explain why in section 4.3, and present a complementary methodology in section 5 based on individual export data.

Then, using an estimated measure of γ, it is possible to compute for different industries,

[6] See for instance Hummels (2001b) and Anderson and Van Wincoop (2004).

Table 1: Summary statistics

Year	Nb firms	% of Exporters	% of mono-region firms	% of exporters among mono-region firms
1989	22910	67.60	84.05	65.08
1990	22940	67.26	83.54	64.56
1991	23921	66.93	83.40	64.17
1992	23342	67.53	83.27	64.95

each structural parameter governing the relation between distance and trade: i.e. the distance elasticity of transport cost (δ), the elasticity of substitution (σ) and the heterogeneity parameter (γ).

3.2 The trade data

Our database contains firm-level exports from France to 61 foreign countries, between 1989 and 1992. Data come from two different sources. Firm-level exports are collected by the French Customs and are available at INSEE. The original database comprises the amount of exports by firm and country, for each firm located on the French metropolitan territory. We merge firm-level exports with other information on firms issued from the Enquêtes Annuelles d'Entreprises (EAE) also available at INSEE. Firms are identified with a 9-digits numerical called the Siren identifier. For each Siren, the EAE provides several variables, among which the industrial sector and the address of the firm. These firm-level informations being only available for firms with more than 20 employees, the export database used in the empirical analysis is restricted to this subset of firms.

The remaining variables are foreign GDPs and distances. We restrict the original Customs database to 61 countries, among which the OECD members and 31 other countries from all continents (see table 8 in the appendix).

4 A first glance at trade margins

In this section we estimate the magnitude of trade elasticities, hence the respective elasticity of aggregate trade flows, of the number of exporters, and of the individual volume of trade with respect to distance. Estimations are done on aggregated French exports. Eaton et al. (2004) already performed such estimations on French exports, however focusing on the effect of a change in French market share abroad and not on the variation in trade flows due to distance. We are interested in the *distance* elasticity of trade flows (and in the decomposition of this elasticity), and hence follow the methodology proposed by Hillberry and Hummels (2007) in their decomposition of the variation of intranational US shipments. The first-subsection develops the estimated equations on total trade and the second presents the results by industry.

4.1 The influence of distance on trade margins

Following Hillberry and Hummels (2007), we decompose, for each industry k, the aggregate volume of trade from France to a given country j ($M_{k,j}$) into the number of shipments ($N_{k,j}$, the extensive margin) and the average value per shipment ($\overline{m}_{k,j}$, the intensive margin), as follows:

$$M_{k,j} = N_{k,j}\overline{m}_{k,j}.$$

Taking logs, we get:

$$\ln M_{k,j} = \ln N_{k,j} + \ln \overline{m}_{k,j}. \tag{12}$$

We analyze how each component varies with distance. We regress separately each of the three terms of equation (12) on distance, controlling for the size of importing countries by using the current GDP. We introduce two variables capturing cultural proximity between France and the importing country: a dummy indicating countries where French is spoken by at least 9% of the population ($French_j$), and a dummy taking the value one if the destination country is a former French colony($Colony_j$).[7] These variables aim to capture a part of the fixed cost of exporting, C_{kij} which is a determinant of total bilateral trade flows (equation 7). We control for years and industries specificities using full sets of fixed-effets. We estimate the following equation:

$$\ln Margin_{jkt} = \alpha_1 \ln Dist_j + \alpha_2 \ln GDP_{jkt} + French_j + Colony_j + e_k + e_t + v_{jkt}, \tag{13}$$

where e_k and e_t are industry and year fixed effets, v_{ktj} is an error term and $\ln Margin_{ktj}$ is subsequently the log of total bilateral trade, the log of the average value per shipment, and the log of the number of shipments.

[7] These two variables are made available by the CEPII (see: *www.cepii.fr*).

We are interested in distance coefficients for total trade and for the extensive and intensive margins. Because OLS is a linear operator, the former coefficient (i.e. on total trade) is equal to the sum of the two latter coefficients (i.e. on the two margins). We can therefore see which part of the distance effect on aggregate shipments is due to the variation in the average shipment per firm and which part is due to the number of shipments.

Table 2: Decomposition of industrial French Exports (pooled regressions)

Dependant Variable :	(1) Total $\ln(M_{jkt})$	(2) Intensive $\ln(M_{jkt}/N_{jkt})$	(3) Extensive $\ln(N_{jkt})$	(4) Total $\ln(M_{jkt})$	(5) Intensive $\ln(M_{jkt}/N_{jkt})$	(6) Extensive $\ln(N_{jkt})$
$\ln(Dist_j)$	-0.983[a]	-0.382[a]	-0.602[a]	-0.981[a]	-0.396[a]	-0.585[a]
	(0.017)	(0.012)	(0.010)	(0.017)	(0.012)	(0.009)
$\ln(GDP_{k,j})$	0.682[a]	0.423[a]	0.259[a]	0.838[a]	0.455[a]	0.384[a]
	(0.008)	(0.006)	(0.004)	(0.009)	(0.007)	(0.005)
French$_j$				0.866[a]	0.005	0.861[a]
				(0.048)	(0.053)	(0.025)
Colony$_j$				0.576[a]	0.253[a]	0.323[a]
				(0.052)	(0.042)	(0.026)
	Year and industry fixed effects					
Nb. Obs.	7762	7762	7762	7762	7762	7762
R^2	0.712	0.647	0.682	0.745	0.65	0.757

Note: OLS - year and industry fixed effects. Robust standard errors in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% level.

Table 2 displays the results of the estimation of equation (13). As expected, GDP has a significant positive effect on total trade and on both the intensive and extensive margins. Distance has always a negative influence. The decomposition of the influence of distance on trade gives a slight advantage to the extensive margin. When distance decreases by 1%, trade increases by 0,983% (0,981% with controls for cultural proximity). About 60% of this effect goes through the extensive margin (i.e. $(0.602/0.983).100 \simeq 61.2$). Only 40% of the increase in the aggregate trade flow originates in the increase of the average shipment per firm. When controlling for cultural proximity (i.e. column 3 to 6), the coefficients on distance increase slightly in absolute value. However, the balance between intensive and extensive margins remains almost unchanged; about 60% of the trade-reducing effect of distance is attributed to the reduction of the average export per firm.

Interestingly, we observe in table 2 that while both variables of cultural proximity have a strong impact on total trade, the language dummy has no significant influence on the intensive

Table 3: Decomposition of aggregate regional (*zones d'emploi*) trade flows

Dependant Variable :	(1) Total $\ln(M_{ijk})$	(2) Intensive $\ln(M_{ijk}/N_{ijk})$	(3) Extensive $\ln(N_{ijk})$	(4) Total $\ln(M_{ijk})$	(5) Intensive $\ln(M_{ijk}/N_{ijk})$	(6) Extensive $\ln(N_{ijk})$
ln(Dist)	-1.399[a]	-0.687[a]	-0.712[a]	-1.399[a]	-0.687[a]	-0.712[a]
	(0.052)	(0.036)	(0.027)	(0.052)	(0.036)	(0.027)
ln(GDP)				0.498[a]	0.335[a]	0.163[a]
				(0.087)	(0.070)	(0.036)
	Years and import countries fixed effects					
Nb. Obs.	53935	53935	53935	53935	53935	53935
R^2	0.383	0.301	0.338	0.383	0.302	0.338

Note: Robust standard errors in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels.

margin. This result is precisely one of the main prediction of Chaney's model. Indeed, it can be shown from equations (6) and (7) that the fixed cost of exporting only influences the number of exporting firms and has no bearing on the extensive margin. The result in table (2) is thus an empirical validation of the theoretical framework exposes in previous section and shows that linguistic difference acts as an additional fixed cost for all potential exporting firms. On the contrary, the dummy for colonial link is always significantly positive. Therefore, this historical and cultural variable proxies also a variable trade cost (it is indeed correlated with preferential trade agreements, for instance).

One of the limitation of equation (13) is that we cannot control for all unobserved characteristics of importing countries, and notably for price indices (P_j). The omission of such a determinant of bilateral trade may alter greatly the estimates of gravity equation (Anderson and Van Wincoop, 2003). Hence, as a robustness check, we also considered bilateral exports from the 341 areas composing the French metropolitan territory (Corse excluded). Unfortunately, for a given industry, the number of exporting firm in each of these areas, called *zone d'emploi*, is generally too low to perform such regressions at the industry level. Hence, for each *zone d'emploi* we compute the total value of manufacturing exports, the average value per shipment, the number of shipments and the distance to the importing country. We now have several exporting areas for each importing country, thus we can perform an estimation of the model with fixed effect for importing countries. Table 3 reports these estimates. All the estimated coefficients on distance are greater in absolute value than those displayed in table 2. Nevertheless, the balance between the extensive and the intensive margin remains roughly unchanged; the extensive margin contributes for about 51% (i.e. $(712/1.399).100 \simeq 51$) to the total effect of distance on trade.

4.2 Trade margins' elasticities by industry

We now estimate the trade margins elasticities (equation 13) for each industry separately. Results are synthesized in figure 1. The figure reports, for each industry, the absolute value of the coefficients of distance on the intensive margin, the extensive margins and the total trade.[8] The dark part of each bar is proportional to the coefficient on the intensive margin, the light part of the bar represents the coefficient on the extensive margin. The length of each bar is the sum of the two coefficients and is proportional to the distance effect on total trade. The upper part of the figure presents the both estimates obtained without common language controls. The lower part shows the coefficients estimated with these cultural variables. Despite the presence of slight differences between the sets of estimates for some industries, the introduction of the two additional variables does not change greatly the balance between the two margins of trade neither the ranking of the different industries. Hence we focus on the estimates obtained controlling for linguistic proximity, which are reported on table 4 (columns 1 to 3).

The coefficients on distance differ greatly between industries. They are ranking from 0.24 for aeronautical building and 1.52 for garment industry, with a mean deviation of 0.24. As expected, the industries exhibiting relatively large coefficients on distance are mainly those producing hardly transportable goods, such as woodwork. However some of these high coefficients are associated to industries producing more easily transportable goods such as textile. In this case the importance of the distance effect on trade may result from a lower degree of firms' heterogeneity (i.e. a larger γ). The balance between the two margins of trade varies a lot from an industry to another. The share of the impact of distance on total trade attributed to the extensive margin varies from 41.8% for office equipment up to 91.7% for aeronautical building. There are only 9 industries out of 34 for which the part of the intensive margin is larger or equal to 50%.

4.3 The shortcomings of the elasticity decomposition

The decomposition of trade elasticities presented in this section should allow us to compute the exact parameters governing the gravity equation in the presence of heterogeneous firms. As

[8] All the estimated coefficients on distance are negative.

Figure 1: Distance elasticities of intensive margin, extensive margin and total trade (absolute values)

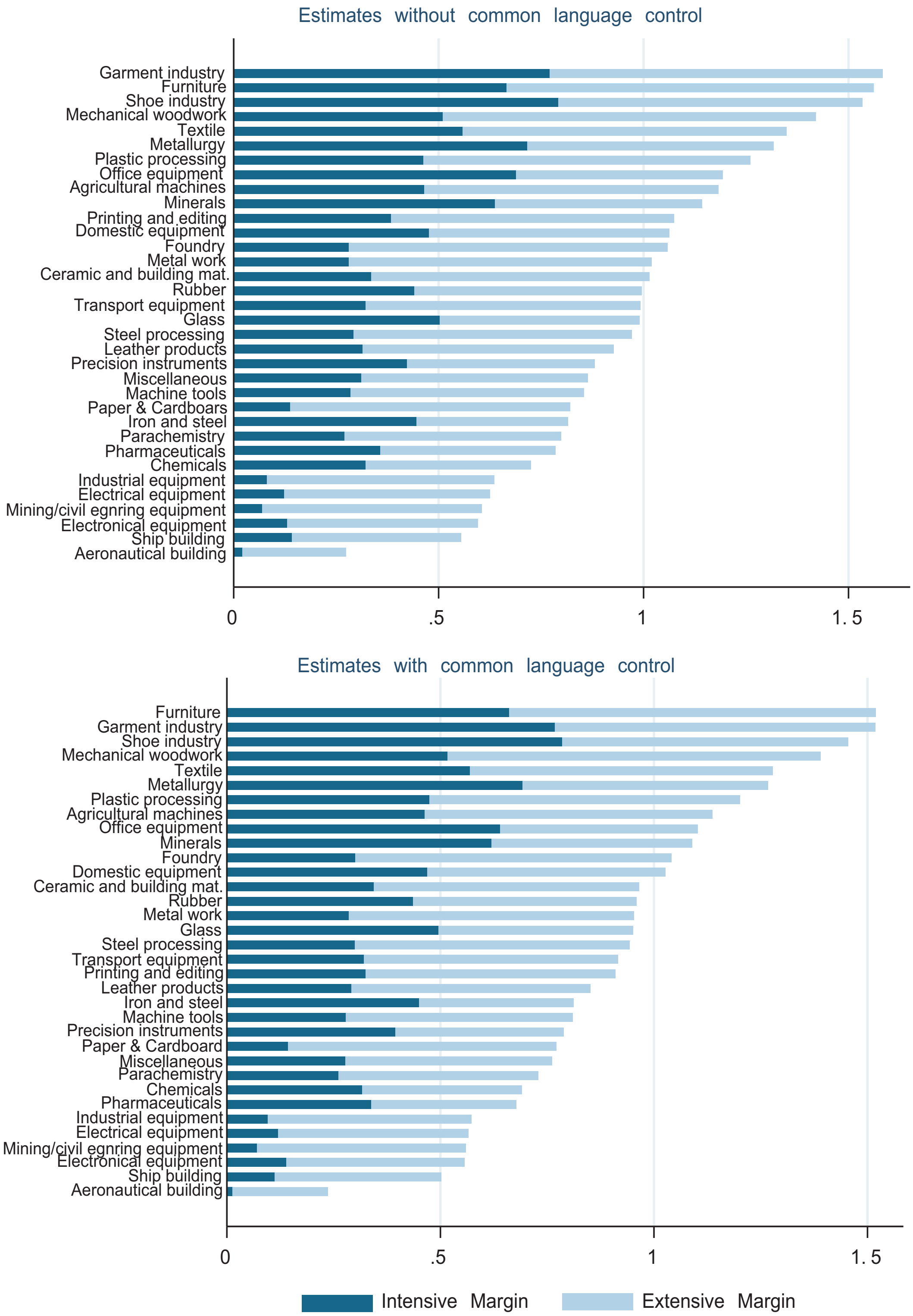


Table 4: Decomposition of industrial French Exports

industry	Total	Mean Ship.	Nb. Ship.
Iron and steel	-0.81	-0.45	-0.36
Steel processing	-0.94	-0.3	-0.64
Metallurgy	-1.27	-0.69	-0.58
Minerals	-1.09	-0.62	-0.47
Ceramic and building mat.	-0.96	-0.34	-0.62
Glass	-0.95	-0.49	-0.46
Chemicals	-0.69	-0.32	-0.37
Parachemistry	-0.73	-0.26	-0.47
Pharmaceuticals	-0.68	-0.34	-0.34
Foundry	-1.04	-0.3	-0.74
Metal work	-0.95	-0.29	-0.67
Agricultural machines	-1.14	-0.46	-0.67
Machine tools	-0.81	-0.28	-0.53
Industrial equipment	-0.57	-0.1	-0.48
Mining/civil egnring eqpmt	-0.56	$-0.07^{\sharp}$	-0.49
Office equipment	-1.1	-0.64	-0.46
Electrical equipment	-0.57	-0.12	-0.45
Electronical equipment	-0.56	-0.14	-0.42
Domestic equipment	-1.03	-0.47	-0.56
Transport equipment	-0.92	-0.32	-0.6
Ship building	-0.5	$-0.11^{\sharp}$	-0.39
Aeronautical building	-0.24	$-0.01^{\sharp}$	-0.22
Precision instruments	-0.79	-0.39	-0.39
Textile	-1.28	-0.57	-0.71
Leather products	-0.85	-0.29	-0.56
Shoe industry	-1.45	-0.78	-0.67
Garment industry	-1.52	-0.77	-0.75
Mechanical woodwork	-1.39	-0.52	-0.87
Furniture	-1.52	-0.66	-0.86
Paper & Cardboard	-0.77	-0.14	-0.63
Printing and editing	-0.91	-0.32	-0.59
Rubber	-0.96	-0.44	-0.52
Plastic processing	-1.2	-0.47	-0.73
Miscellaneous	-0.76	-0.28	-0.48

$^{\sharp}$: coefficient not significant at the 10% level.

shown in equation (11), the reaction of respectively total trade, individual trade, and of the number of exporters to distance are directly related to the structural parameters of the model. However, we now explain why some characteristics of the data may bias the estimations of the gravity parameters.

The first shortcoming arises from the restriction of our database to firms of more than 20 employees. Because we lack all the small-size exporting firms, the magnitude of the extensive margin elasticity will be under-estimated compared to the existing estimates in the literature using exhaustive sets of exporting firms (Hillberry and Hummels, 2007; Bernard et al., 2007; Eaton et a., 2004). Because the smallest exporters are not visible when using the large firms database, most of the observed adjustment is the increase in foreign sales by existing and larger exporters.

The second issue relates to the use of an OLS decomposition of the elasticity of trade flows. Indeed, it does not fully reflect the theoretical definition of trade margins. In Chaney's model (see equation 11), the extensive margin is defined as the quantity exported by the marginal exporting firms. Firms that can take advantage of a marginal reduction in trade costs to start exporting are smaller than the incumbent exporters. This definition does not match the one we implicitly used in equation (13), which assumes that all firms have the same volume of exports.

The last difficulty is that the only exporting country in our data is France. We thus can not include importing market fixed effects and distance. Hence, two consequences that may bias the estimations. First, the estimations do not control for the price index in the destination country (Anderson and van Wincoop, 2003; Baldwin and Taglioni, 2006). Second, we cannot control for the fixed cost of exporting. If the fixed cost is specific to the importing country, we might expect that it is correlated with distance to France: distant countries are likely to exhibit customs, languages and legal systems that are more different from French ones than European and occidental countries. The distance variable can then also capture a change in the fixed cost of exporting, in which case our estimated coefficients cannot be associated confidently to their theoretical values in (11).

The overall effect of these three shortcomings is undetermined. On the one hand, it is intuitive that the restriction of the database to large firms should result in an underestimation of the extensive margin (and of the distance elasticity of the extensive margin). On the other hand, the two other items point to an overestimation of the extensive elasticity. The use of the OLS decomposition instead of taking into account the amount exported by the marginal firm clearly inflates the extensive margin. The same consequence car be expected when not controlling for the fixed cost of exporting, according to the theoretical model. Chaney (2007) shows that the elasticity of the extensive margin with respect to the fixed cost is $([[\gamma/(\sigma-1)]-1)$, whereas the elasticity of the intensive margin with respect to the fixed cost is equal to zero. Hence, the impossibility to distinguish between the fixed cost and the variable trade cost should not influence the estimation of the intensive margin while it should bias upward the estimation of the distance elasticity of the extensive margin.

The following section proposes an alternative way of estimating unbiased parameters of the gravity equation.

5 The structural gravity parameters

We explain how we proceed to circumvent the above difficulties and then present results for the three gravity parameters by industry.

5.1 The influence of distance on individual trade

Two features characterize our procedure to estimate unbiased gravity parameters. First, because the restriction of our bilateral trade data does not allow to compute precisely the extensive margin of trade, we use micro-level data and estimate the decision to export and the individual volume of trade of individual firms.

Second, in order to control for the import-country specific fixed cost and price index, we use a distance variable that is specific to each French firm. The variation in distance now arises from the location of exporting firms inside France. This allows to use importing country fixed effects. With these, distance is only expected to capture changes in the variable trade cost. Inter-firm variations of distance to a given export market matter a lot when considering neighboring countries, however we can expect that they have a negligible impact in the case of remote countries. Therefore, we run estimations on border countries only: Belgium-Luxembourg, Germany, Switzerland, Italy and Spain.

For the following estimations we need a measure of the intranational distance between each exporting firm and each export market. We assign to each importing country an exit-city located at the border, and we compute intranational distance as the distance between the firm and the exit-city. Then, we compute international distance as the distance between the French border city and the destination country. Computing intranational distance is made possible by the

Figure 2: Mean value of individual firms exports

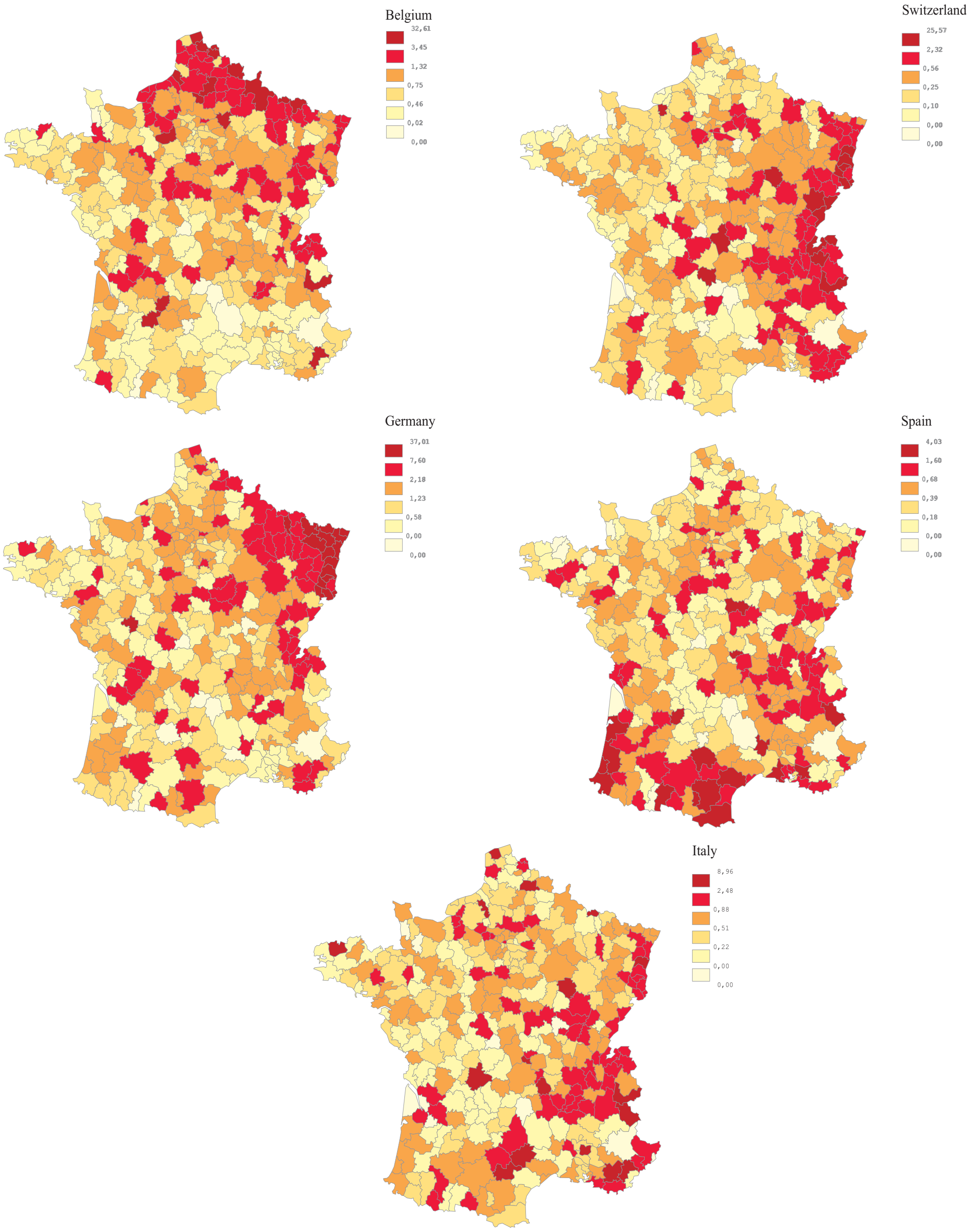
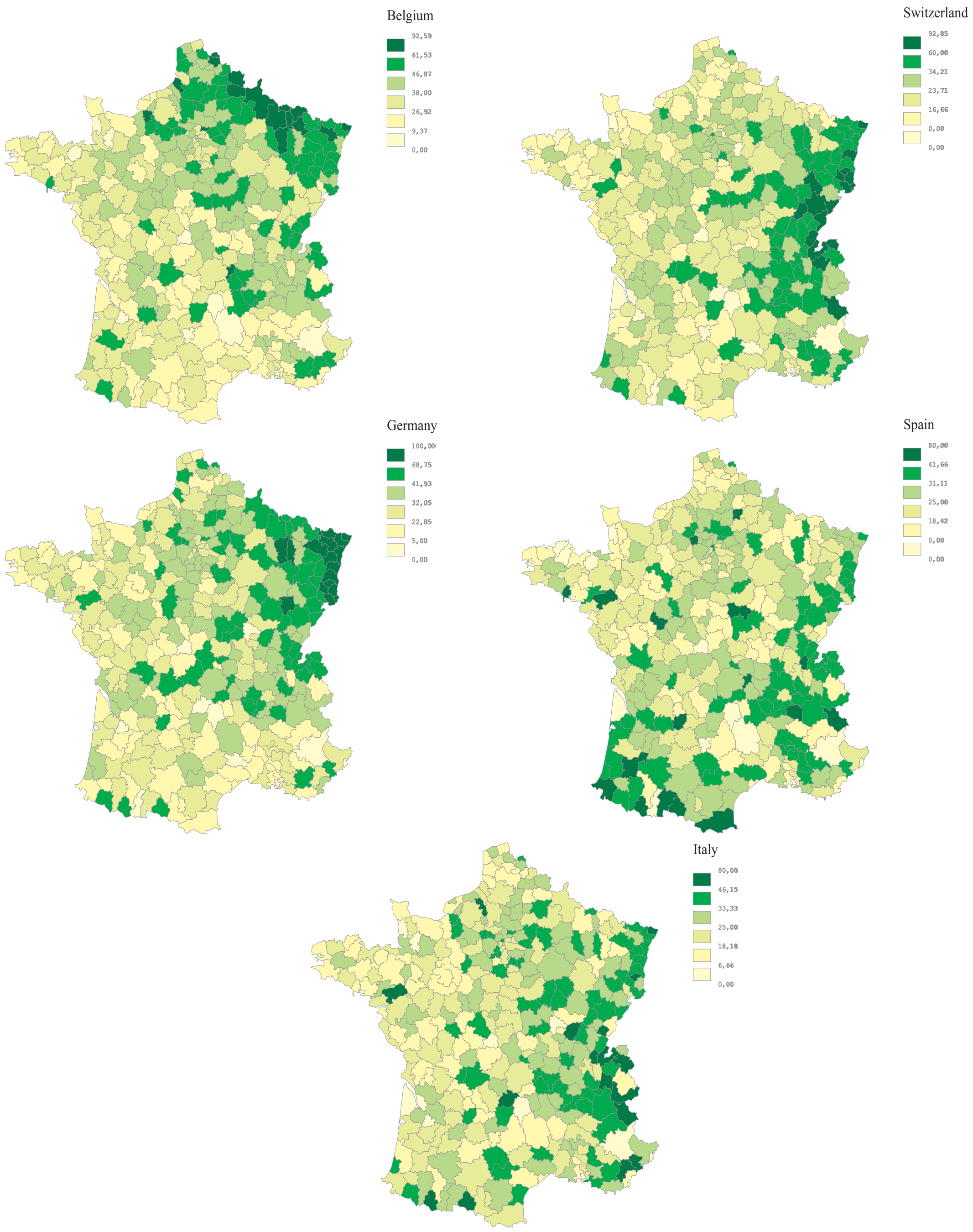


Figure 3: Share of exporting firms



highly detailed data provided by INSEE concerning the location of firms. Each firm has one or more establishments or plants, which can be production plants or headquarters. Ideally, the intranational distance measure should be a proxy of intranational trade costs between the producing plant and the French border, for the goods sold by firms to foreign countries. However, while the location of every plant of each firm is available, we have no information on the plant from which exports originate. This is not a problem in the case of relatively small firms for which all establishments are located in the same region (in this case we use the address of the headquarters), but it can be a problem in the case of larger firms, which have several producing plants located in different parts of the country. We therefore restrict the sample to firms for which all plants are located in one of the 22 *regions*, which are the highest French administrative divisions.[9] This allows to minimize measurement error in the computation of intranational distance, while not restricting the database to single-plant firms. Single-regions firms represent more than 83% of the total number of firms in the sample.

Figures 2 and 3 show how internal distances shape individual exports. They represent, for each *zone d'emploi*, the share of exporters in the total population of manufacturing firms and the mean value of their shipments. Dark colors denote high values of the number of exporting firms and of individual trade flows. Most of the dark regions are located close to the relevant border: The Pyrenees (South West) for Spain, Rhône-Alpes, Provence-Côte d'Azur and Franche-Comté (South East) for Italy and Switzerland, Alsace, Lorraine and Champagne-Ardennes (East) for Germany, and Nord-Pas de Calais, Picardie and Ardennes (North-East) for Belgium.

We now turn to the econometric estimations. The estimation method consists in three steps. First we estimate the probability that a firm exports, through which we obtain the set $\delta\gamma$. Second, we derive $-\delta(\sigma-1)$ from the estimation of gravity equations on individual exports. Finally, to distinguish all three parameters δ, σ and γ, we estimate the Pareto distribution, i.e. the relation between individual productivity and production, to obtain an estimate of $-[\gamma-(\sigma-1)]$.

The first step consists in obtaining an estimation of $-\delta\gamma$. We estimate the influence of distance to foreign countries on the export decision for each firm. Equation (5) gives the maximum marginal cost at which a firm decides to export. Using the definition of the Pareto distribution, we get the probability that a firm located in i with a marginal cost a exports to country j:

[9] These regions are the Nuts2 in the Eurostat nomenclature.

$$[Prob[Export_{ij}(a)]] = P(a < \bar{a}_{ij}) = \left[\lambda_j \left(\frac{1}{C_{ij}}\right)^{1/(\sigma-1)} \frac{1}{\tau_{ij}}\right]^{\gamma}, \quad \lambda_j = \frac{\sigma-1}{\sigma} (E_j)^{1/(\sigma-1)} P_j.$$

Taking logs, we obtain:

$$\ln\left[Prob[Export_{ij}(a)]\right] = -\delta\gamma \ln(Dist_{i,j}) + e_{jt} + e_k, \tag{14}$$

where e_{jt} is an import country-year fixed effect which controls for foreign market size and price index, and e_k is an industry fixed effect. To estimate equation (14) we need, for each firm, the probability to export to country j. This probability is directly related to the profits earned from sales on market j, i.e. equation (4). The decision to export depends on firms characteristics, importing country characteristics and trade costs. We estimate the following equation:

$$Exp_{ij} = \alpha \ln(Dist_{aj}) + e_a + e_{jt} + e_k, \tag{15}$$

where Exp_{ij} is a dummy that takes the value 1 if the firm a exports to country j and zero otherwise. e_a is a firm fixed effect and $Dist_{aj}$ is the distance between the city where firm a is located and the border to the importing country; α is a negative coefficient. We perform a logit estimation of this equation and use the log of the predicted value as a dependent variable in equation (14).

The second step of our procedure consists in estimating the determinants of the individual export value from equation (3). A simple log-linearization of equation (3) gives the following estimable gravity equation for individual firms:

$$\ln(m_{akjt}) = -\delta(\sigma-1)\ln(Dist_{aj}) + e_a + e_{jt} + e_k, \tag{16}$$

where m_{akjt} is the value shipped by a given French firm a to the neighboring market j. The theoretical framework gives a clear-cut prediction for the coefficient on distance in this equation; it is the distance elasticity of the intensive margin, $-\delta(\sigma-1)$.

Regression results for the two steps are displayed in table 5. Columns (1) to (4) report results of the estimation of equations (15), and columns (5) to (8) for equation (14). Columns (9) to (12) refer to individual exports. Besides distance, we also introduced in columns (2), (4), (6), (8), (10) and (12) a dummy variable that takes the value one when the firm is located

Table 5: Individual export values toward 5 neighboring countries

	Equation 15 - Logit Dep. Var.: Export Decision				*Equation 16* - OLS Dep. Var.: ln(Export value)			
	(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)
ln(Dist)	-0.879[a]	-0.700[a]	-1.248[a]	-0.971[a]	-0.483[a]	-0.250[a]	-0.570[a]	-0.345[a]
	(0.011)	(0.012)	(0.017)	(0.019)	(0.017)	(0.019)	(0.015)	(0.017)
Contiguity		0.622[a]		0.808[a]		0.517[a]		0.541[a]
		(0.016)		(0.025)		(0.024)		(0.021)
Firms FE	no	no	yes	yes	no	no	yes	yes
Pseudo-R^2	0.067	0.070	-	-	0.062	0.066	-	-
Nb. Obs.	376905	376905	243545	243545	120112	119970	120112	120112
	Equation 14 - OLS Dep. Var.: ln(Export Probability)							
	(5)	(6)	(7)	(8)				
ln(Dist)	-0.550[a]	-0.414[a]	-1.029[a]	-0.844[a]				
	(0.000)	(0.000)	(0.002)	(0.003)				
Contiguity		0.324[a]		0.486[a]				
		(0.000)		(0.004)				
R^2	0.987	0.985	0.653	0.618				
Nb. Obs.	376905	376905	243545	243545				

Note: Robust standard errors in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels.

in a département sharing a common border with the destination country. All the variables are highly significant and of the expected sign. When we control for individual characteristics and contiguity, the coefficient on distance is -0.844 for the export decision. This coefficient is close to the usual gravity estimations on aggregate trade data (Disdier and Head, 2007, survey 1466 estimations and obtain a mean coefficient value of 0.91 and a median value of 0.87). The coefficient on distance obtained from equation (16) is much smaller (-0.345). These two results are consistent with the theoretical predictions. Indeed, when using aggregated trade data, the coefficient on distance should be equal to $-\delta\gamma$, which is precisely the coefficient given by equation (14). With individual firms data, the coefficient of the gravity equation (16) is only the distance elasticity of the intensive margin of trade: $-\delta(\sigma-1)$.

5.2 Results by industry

We estimate the influence of distance on the individual export probability and on individual exports for each industry separately. All these regressions are performed with country-year fixed effects and firm fixed effects. They give us sectoral estimations for $\delta\gamma$ and $\delta(\sigma-1)$. Coefficients are shown in columns (1) and (2) of table (6) and (7). The first table does not include the

Table 6: The structural parameters of the gravity equation

Industry	(1) $-\delta\gamma$	(2) $-\delta(1-\sigma)$	(3) $-[\gamma-(\sigma-1)]$	(4) σ	(5) δ	(6) γ
Iron and steel	-2.44	-1.5	-0.74	3.88	0.52	4.68
Steel processing	-1.96	-1.15	-2.48	5.75	0.24	8.12
Metallurgy	-1.75	-0.75	-2.63	3.66	0.28	6.2
Minerals	-1.85	-1.5	-2.51	17.81	0.09	20.72
Ceramic and building mat.	-2.22	-1.43	-2.38	6.78	0.25	8.97
Glass	-1.86	-0.62	-3.03	2.83	0.34	5.51
Chemicals	-1.37	-0.91	-1.25	5.05	0.22	6.11
Parachemistry	-1.14	-0.3	-2.16	2.08	0.28	4.11
Pharmaceuticals	-0.99	-0.13*	-2.15			
Foundry	-1.69	-1.35	-3.97	18.72	0.08	22.17
Metal work	-1.29	-0.54	-3.56	4.21	0.17	7.65
Agricultural machines	-1.38	-0.87	-3.64	8.59	0.12	12.01
Machine tools	-1.18	-1.03	-3.47	30.71	0.03	34.01
Industrial equipment	-1.17	-0.75	-3.04	8.06	0.11	10.95
Mining/civil egnring eqpmt	-1.36	-0.77	-2.71	5.69	0.16	8.32
Office equipment	-0.28	-1.05	-1.71			
Electrical equipment	-0.89	-0.33	-3.46	3.52	0.13	6.88
Electronical equipment	-0.73	-0.34	-2.44	3.82	0.12	6.03
Domestic equipment	-0.85	-0.66	-5.22	16.79	0.04	20.35
Transport equipment	-1.23	-0.86	-3.4	10.19	0.09	13.13
Ship building	-2.29	-3.34	-3.53			
Aeronautical building	-0.54	-0.28*	-5.36			
Precision instruments	-1.03	-0.54	-2.5	4.7	0.15	7.05
Textile	-1.06	-0.58	-2.16	4.82	0.15	6.94
Leather products	-0.79	-0.36	-2.39	3.66	0.14	5.75
Shoe industry	-0.59	-0.83	-3.71			
Garment industry	-0.17	0.15*	-1.29			
Mechanical woodwork	-1.68	-0.46	-2.5	2.27	0.36	4.63
Furniture	-1.05	-0.61	-3.22	6.81	0.11	9.96
Paper & Cardboard	-1.29	-1.01	-2.84	14.26	0.08	16.95
Printing and editing	-1.1	-0.89	-1.55	11.61	0.08	13.12
Rubber	-1.4	-0.89	-3.9	9.17	0.11	12.87
Plastic processing	-1.13	-0.76	-2.66	7.69	0.11	9.99
Miscellaneous	-0.71	-0.48	-2.21	6.49	0.09	8.1
Mean	**-1.25**	**-0.89**	**-2.82**	**8.20**	**0.17**	**10.76**

*: coefficient not significant at the 10% level.

Table 7: The structural parameters of the gravity equation (estimate with contiguity variable)

Industry	(1) $-\delta\gamma$	(2) $-\delta(1-\sigma)$	(3) $-[\gamma-(\sigma-1)]$	(4) σ	(5) δ	(6) γ
Iron and steel	-4.15	-1.52	-0.74	1.43	3.54	1.17
Steel processing	-1.75	-1.06	-2.48	4.77	0.28	6.25
Metallurgy	-1.79	-0.68	-2.63	2.59	0.42	4.22
Minerals	-1.8	-1.53	-2.51	15.16	0.11	16.67
Ceramic and building mat.	-1.8	-0.71	-2.38	2.54	0.46	3.92
Glass	-1.69	-0.51	-3.03	2.31	0.39	4.35
Chemicals	-1.16	-0.75	-1.25	3.29	0.33	3.54
Parachemistry	-1.0	-0.21	-2.16	1.58	0.37	2.74
Pharmaceuticals	-0.92	-0.04*	-2.15			
Foundry	-1.65	-1.05	-3.97	7.94	0.15	10.91
Metal work	-0.98	-0.33	-3.56	2.77	0.18	5.32
Agricultural machines	-1.25	-0.67	-3.64	5.15	0.16	7.79
Machine tools	-1.0	-0.47	-3.47	4.05	0.15	6.52
Industrial equipment	-0.98	-0.47	-3.04	3.78	0.17	5.82
Mining/civil egnring eqpmt	-1.34	-0.52	-2.71	2.73	0.3	4.44
Office equipment	-0.1	-1.14	-1.71			
Electrical equipment	-0.71	-0.12	-3.46	1.67	0.17	4.13
Electronical equipment	-0.53	-0.21	-2.44	2.65	0.13	4.09
Domestic equipment	-0.72	-0.00*	-5.22			
Transport equipment	-1.08	-0.51	-3.4	3.99	0.17	6.38
Ship building	-2.35	-2.51	-3.53			
Aeronautical building	-0.28	-0.05*	-5.36			
Precision instruments	-0.76	0.04*	-2.5			
Textile	-1.08	-0.34	-2.16	1.98	0.35	3.14
Leather products	-0.73	-0.29	-2.39	2.56	0.19	3.94
Shoe industry	-0.22	-0.3	-3.71			
Garment industry	-0.08	-0.22*	-1.29			
Mechanical woodwork	-1.56	-0.26	-2.5	1.51	0.52	3.01
Furniture	-0.78	-0.39	-3.22	4.24	0.12	6.46
Paper & Cardboard	-1.2	-0.86	-2.84	8.17	0.12	10.01
Printing and editing	-0.88	-0.68	-1.55	6.38	0.13	6.94
Rubber	-1.39	-0.89	-3.9	7.88	0.13	10.78
Plastic processing	-0.98	-0.53	-2.66	4.18	0.17	5.84
Miscellaneous	-0.54	-0.31	-2.21	4.03	0.1	5.25
Mean	**-1.15**	**-0.68**	**-2.82**	**4.21**	**0.36**	**5.91**

*: coefficient not significant at the 10% level.

contiguity variable. The second table does.

Both tables show consistent estimates. Distance always has a significantly negative impact on export probability, whereas it is significantly negative for most of the industries on individual exports (but the following sectors: pharmaceuticals, aeronautical building, mechanical woodwork, and domestic equipment but only when controlling for contiguity). For office equipment, shipbuilding, shoe industry and precision instruments, the estimated value of $\delta\gamma$ is smaller than $\delta(\sigma - 1)$, which is inconsistent with the theoretical framework. However, we obtain consistent coefficients for a very large majority of industries: 28 out of 34 in table 6 and 26 out of 34 in table 7.

We use the preceding estimates to compute the three parameters composing trade elasticities, δ, σ and γ. To solve for these parameters, we turn to step 3, which consists in estimating the Pareto distribution. It can be shown from equation (3) that for each firm with a productivity $1/a$, the cumulative production of all firms with a higher productivity, is: $X = \lambda(1/a)^{-[\gamma-(\sigma-1)]}$. We estimate the coefficient $-[\gamma - (\sigma - 1)]$ using the same set of French firms as in steps 1 and 2. We generate a proxy for the productivity[10] of each firm a and, for each year and industry, sort the firms from the most productive to the less productive. For each of them, we compute the sum of the value added generated by all firms of lower rank. Regressing the log of this cumulative production on the log of individual TFP[11], we obtain an estimated value of $-[\gamma - (\sigma - 1)]$, for each industry, displayed in table 6 and 7 (columns 4 and 5).

We use the three estimated expressions $-\delta\gamma$, $-\delta(\sigma-1)$ and $-\gamma-(\sigma-1)$ to compute γ, σ and δ. The two sets of parameters are different in magnitude, however they are highly correlated. The coefficient of correlation between the two series is equal to .6 for σ, .75 for δ and .66 for γ. The rank correlations are even larger: .86 for σ, .89 for δ and .89 for γ.

For 28 industries out of 34 (more than 80%) these estimates are significant and consistent in sign and magnitude with the theory; Values of σ are strictly above 1, and γ are greater than $\sigma - 1$. The values of σ reported in table (7) range between 1.43 and 15.16 with an average value equal to 4.21. They are consistent with the results for σ in the recent literature. Broda and Weinstein (2006) report results between 4 and 6.8 when estimating the parameters on 3-digits data. Eaton and Kortum (2002)'s results lie around the average value of 8.3, and Erkel-Rousse

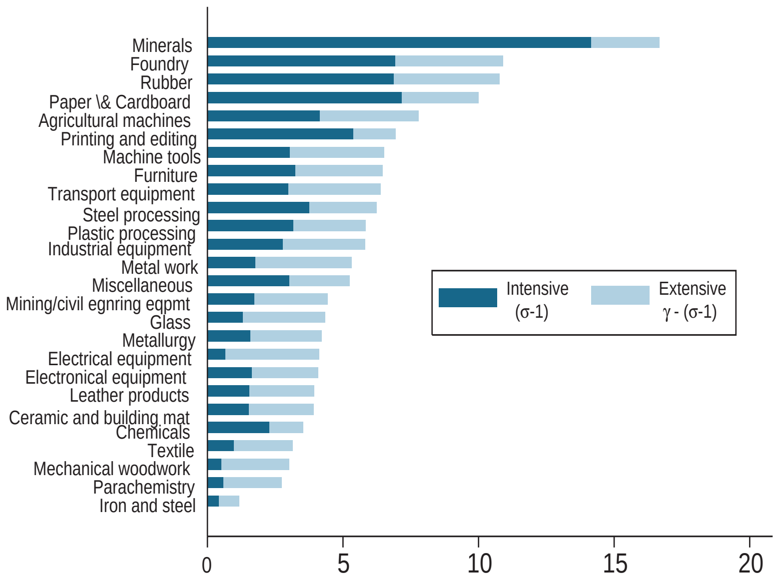
[10] We estimate, for each industry separately, the following equation on individual firms data: $\ln(Value\ added_{a,t}) = \alpha \ln(Employment_{a,t}) + e_t + v$, where e_t is a year fixed effect, and v an error term. We use the exponential of the sum of e_t and the residual of the estimated equation as a proxy for the productivity of firm a.

[11] All regressions include year fixed effects.

and Mirza (2002) obtain a mean value equal to 3.7. The average value in Hummels (2001a) is 5.6. Head and Ries (2001) obtain 7.9. Note that Hummels (2001a) and Head and Ries (2001) estimate the impact of trade barriers on bilateral trade flows, which according to the model should be interpreted as measures of γ for each industry. Therefore, it is not surprising that their estimates are greater than our σ and closer to our mean values of γ.

Controlling for contiguity, our average value for δ is 0.36. This is close to the estimates in the existing literature based on international transport costs. Radelet and Sachs (1998) have a mean value of the distance elasticity of trade costs equal to 0.13. For the same parameter, Glaeser and Kohlhase (2003) report 0.3, and Hummels (2007) 0.2 as their average estimate. Our result is higher, which is surely due to the fact that we only consider continental shipments. Road transport costs have a stronger decay with distance; for instance, Combes and Lafourcade (2005) obtain an elasticity equal to 0.8 using road transport costs within France.

Figure 4: Estimated impact of trade barriers on trade margins, by industry (absolute values)

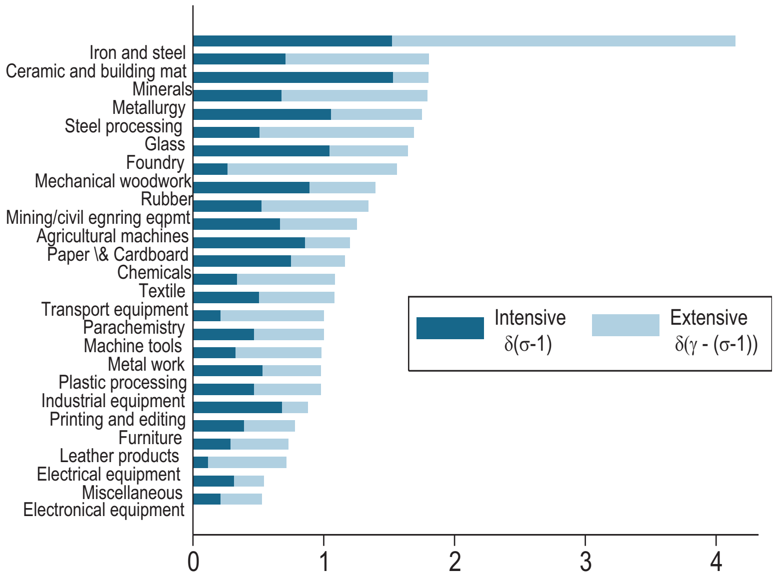


A simple way to analyse these results is to present the overall effect of trade *barriers*.

Figure 4 plots the decomposition of the elasticity of trade margins with respect to the variable trade cost τ, computed for all industries for which we obtained consistent estimates. Industries that are a not very sensitive to trade barriers are mainly those producing highly differentiated products, i.e final goods (such as *textile*[12]) and/or high-tech industries (*Chemistry*, *Electrical*

[12] *Note that our data covers only French firms which produce relatively high quality (and thus relatively differ-*

Figure 5: Estimated impact of distance on trade margins, by industry (absolute values)



and *Electronical equipment*). On the opposite, industries with a large trade elasticity consist mainly in raw products. The relationship between the degree of differentiation (σ) and the trade elasticity (γ) is due to the correlation between the two parameters. Indeed, the share of the extensive margin in the aggregate trade elasticity is a decreasing function of σ, and is therefore larger for industries that have a large trade elasticity. For instance, the share of extensive margin elasticity ranges between 15% for *Minerals* and 84% for *Electrical equipment.* The cases of *Machine tools* and *Transport equipment* are particularly interesting. Whereas they are usually identified as highly differentiated industries, they appear as highly sensible to trade barriers. But these two sectors have a relatively high share of extensive margin, compared to industries with similar trade elasticity (about 53%, which is more than the average, while the mean value of extensive margin is less than 50% for *Furniture*, equal to 39.6% for *Steel processing* and to 22.4% for *Printing and editing*). In other words, these two industries actually produce relatively differentiated goods, but they have a relatively low degree of firm heterogeneity (i.e. a high γ). These two industries confirm the theoretical point emphasized in Chaney (2007): The degree of product differentiation does not govern the overall influence of ad-valorem trade barrier.

Finally, figure 5 shows the estimated values of trade elasticities with respect to *distance.* Compared to Figure 4, the sorting of the industries is very different. The consequence of

entiated) textile.

freight costs is clearly observable. Heavy good industries, such as *Iron and steel* or *Ceramic and building materials*, which are among the less sensitive to tariffs, are the most affected by distance. Inversely, the distance effect is relatively low for goods which can be easily transported such as *Electronical* and *Electric equipment*. Here again, inter-industry comparisons of our estimated results are in line with theoretical predictions.

6 Conclusion

In this paper, we provide structural estimates of the three gravity parameters by industry: the elasticity of substitution (σ), the trade costs elasticity to distance (δ) and the degree of firm heterogeneity (γ). Indeed, new trade models with heterogeneous firms predict that the impact of distance on trade flows is the sum of the intensive margin and the extensive margin's elasticity with respect to distance. For each sector, the effect of a decrease in trade costs depends on the respective magnitude of each margin, which in turn depends on the value of γ and σ.

Two sections illustrate our methodology to estimate these parameters. First, we provide an estimation of the elasticity to distance of the intensive and extensive margins, using the OLS decomposition in Hillberry and Hummels (2007) on aggregate French export flows. The magnitude of each margin is clearly illustrated, with patterns that are in line with the existent results in the literature. However, this estimation does not allow to follow up with unbiased parameters because of the restriction of our database. We thus turn to the second part of our work, in which we use individual export flows. First, we estimate the set $-\delta\gamma$ from the probability that a firm exports. Then we derive $-\delta(\sigma-1)$ from the estimation of individual gravity equations. Finally, to distinguish the three parameters, we estimate the Pareto distribution to obtain an estimate of $-[\gamma-(\sigma-1)]$.

For a large majority of sectors (more than 80%), the estimated gravity parameters are consistent in sign and magnitude with the theory. Values of σ are strictly above 1 and γ are greater than $\sigma-1$. Our average value of σ is 4.21. Among others, Hummels (2001a) and Head and Ries (2001) respectively report 5.6 and 7.9, however according to Chaney (2007), their value estimated as the elasticity of aggregate trade flows to trade costs should be interpreted as measures of γ. Therefore, finding that their estimates are greater than our σ and close to our mean value of γ is in line with the recent theoretical framework. In a more general way, our empirical investigation shows that considering firms' behavior is a prerequisite to understand the impact of trade barriers on international trade flows. We confirm that microfounded trade theories ameliorate predictions derived from gravity equations concerning the evaluation of the impact of trade integration.

7 References

Anderson J. E. and E. Van Wincoop, 2003, “Gravity With Gravitas: A Solution To The Border Puzzle”, *American Economic Review*, 93(1): 170-192.

Anderson J. E. and E. Van Wincoop, 2004, “Trade costs”, *Journal of Economic Literature*, 42(3): 691-751.

Baldwin R., 2005, “Heterogeneous Firms and Trade: Testable and Untestable Properties of the Melitz Model”, *NBER Working Papers*, 11471.

Baldwin R. and T. Okubo, 2006, “Heterogeneous firms, agglomeration and economic geography: spatial selection and sorting”, *Journal of Economic Geography*, 6(3):323-346.

Baldwin R. and D. Taglioni, 2006, “Gravity for dummies and dummies for gravity”, *CEPR-DP*, 5850.

Barba Navaretti G. and A. Venables, 2004, *Multinational Firms in the World Economy*, Princeton University Press.

Broda C. and D. E. Weinstein, 2006, “Globalization and the Gains from Variety”, *Quarterly Journal of Economics*, 121 (2): 541-585.

Brun J.-F., C. Carrère, P. Guillaumont and J. de Melo, “Has Distance Died? Evidence from a Panel Gravity Model”, *World Bank Economic Review*, 19(1): 99-120.

Chaney T., 2007, “Distorted gravity: Heterogeneous Firms, Market Structure and the Geography of International Trade”, University of Chicago, *mimeo*.

Combes PP and M. Lafourcade, 2005, “Transport Costs: Measures, Determinants and Regional Policy Implications for France”, *Journal of Economic Geography*, 5: 319-349.

Eaton J. and S. Kortum, 2002, “Technology, Geography, and Trade”, *Econometrica*, 70(5): 1741-1779.

Eaton J. and S. Kortum and F. Kramarz, 2004, "Dissecting Trade: Firms, Industries, and Export Destinations", *American Economic Review, Papers and Proceedings*, 93: 150-154.

Erkel-Rousse H. and D. Mirza, 2002, "Import Price-Elasticities: Reconsidering the Evidence", *Canadian Journal of Economics*, 35(2): 282-306.

Fujita M., P. Krugman and A. Venables, 1999, *The Spatial Economy. Cities, Regions, and International Trade*, Cambridge: MIT Press.

Davis, D.R., and D.E. Weinstein, 2003, "Market Access, Economic Geography and Comparative Advantage: an Empirical Test", *Journal of International Economics*, 59: 1-23.

Disdier A.-C. and K. Head, 2007, "The Puzzling Persistence of the Distance Effect on Bilateral Trade", *The Review of Economics and Statistics*, forthcoming.

Evans, C. and J. Harrigan, 2005, "Distance, Time, and Specialization: Lean Retailing in General Equilibrium", *American Economic Review*, 95(1), 292-313.

Glaeser, E. and J. Kohlhase, 2003, "Cities, Regions and the Decline in Transport Costs", Discussion Paper 2014, Harvard Institute of Economic Research.

Head, K. and T. Mayer, 2004, "The Empirics of Agglomeration and Trade", in J.V. Henderson and J-F. Thisse (eds), *Handbook of Urban and Regional Economics*, Vol. 4. North Holland.

Hummels D., 2001a, "Toward a Geography of Trade Costs", *mimeo.*

Hummels D., 2001b, "Time as a Trade Barrier" *mimeo.*

Hummels D., 2007, "Transportation Costs and International Trade in the Second Era of Globalization", *Journal of Economic Perspectives*, forthcoming.

Hillberry R. and Hummels D., 2007, "Trade responses to geographic frictions: A decomposition using micro-data", *European Economic Review*, forthcoming.

Irwin D. A. and M. Terviö, 2002, "Does trade raise income? Evidence from the twentieth century", *Journal of International Economics*, 58: 1-18.

Jean S., 2002, "International Trade and Firms' Heterogeneity Under Monopolistic Competition", *Open Economies Review*,13(3): 291-311.

Krugman, P.R., 1980, "Scale Economies, Product Differentiation, and the Pattern of Trade", *American Economic Review*, 70: 950-9.

Limao N. and A. Venables, 2001, "Infrastructure, Geographical Disadvantage, Transport Costs and Trade", *World Bank Economic Review*, 15: 451-479.

Medin H., 2003, "Firms export decisionsfixed trade costs and the size of the export market", *Journal of International Economics*, 61: 225241.

Melitz M., 2003, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica*, 71(6): 1695-1725.

Melitz M. and G.I.P. Ottaviano, 2005, "Market size, trade and productivity", *NBER Working Paper*, 11393.

Radelet S. and J. Sachs, 1998, "Shipping Costs, Manufactured Exports and Economic Growth", Center for the International development, *mimeo.*

Rauch, J., 1999, "Networks versus markets in international trade", *Journal of International Economics*, 48(1): 7-35.

Rauch, J. and V. Trinidade, 2002, "Ethnic Chinese networks in international trade", *Review of Economics and Statistics*, 84(1): 116-130.

8 Appendix

Table 8: List of countries

Algeria	Canada	Finland	Ireland	Mexico	Spain
Argentina	Centrafrique	Gabon	Israel	Netherlands	Sweden
Australia	Chad	Germany	Italy	Niger	Switzerland
Austria	Chile	Greece	Japan	Nigeria	Syria
Belgium/Lux	China	Haiti	Laos	Norway	Togo
Benin	Colombia	Hungary	Lebanon	Pakistan	Tunisia
Brazil	Comores	Ile Maurice	Madagascar	Poland	Turkey
Bulgaria	Cote d'Ivoire	India	Mali	Portugal	United-Kingdom
Cambodge	Danemark	Irak	Marocco	Roumania	United-States
Cameroun	Egypt	Iran	Mauritanie	Senegal	Venezuela
					Vietnam