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Structural gravity equations with intensive and extensive margins

Matthieu Crozet
Pamina Koenig

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STRUCTURAL GRAVITY EQUATIONS WITH INTENSIVE AND EXTENSIVE MARGINS

NON-TECHNICAL SUMMARY

Since the 1960s, gravity equations have been intensively used in empirical analyses of international trade. This relationship relates econometric bilateral trade flows to the economic size of partner countries and the geographical distance between them. Gravity equations, even in their simplest form, do very good job: they capture a very large part of the variations of trade flows between countries, and provide detailed studies of globalization. Giving an estimate of the "normal" volume of trade between countries, they offer the possibility of identifying countries that report a relatively low level of trade intensity, and thus assess the importance of the barriers to trade. For instance, gravity equations allows to evaluate the "border effects", the impact of monetary integration and exchange-rate stabilization on trade flows, the importance of cultural proximity and of institutions on trade relations, etc.

Despite their obvious usefulness, gravity equations have long been criticized for lacking theoretical background. However, much progress has been made in this area in recent years. Trade models with monopolistic competition show that the effect of distance, which is the key variable in gravity equation, is directly related to price elasticity. Thus, in industries producing relatively homogeneous goods, trade should decay drastically with distance. More recently, models with imperfect competition and heterogeneous firms deeply changed the interpretation of gravity equations (Chaney, *American Economic Review*, 2008). In these models, lower transport costs (i.e. lower distance) increases bilateral trade through an increase of both trade margins: the number of exporting firms (the extensive margin) and the mean value of individual shipments (the the intensive margin).

In these models, the influence of distance on bilateral trade results from a combination of three parameters, which affect both margins: the distance elasticity of transportation costs, the price elasticity and the degree of firm heterogeneity. Our paper presents a complete decomposition of a structural gravity equation derived from Chaney's (2008) model. Using individual export data for a large number of French firms between 1986 and 1992, we estimate the impact of distance on both trade margins. This leaves us with estimates of the three key parameters of the model, at the industry level. The empirical method controls for unobservable importing countries characteristics. To do this, we introduce importing country fixed effects, so that our measure of distance is specific to each exporting firm. Consequently, the identification of the model relies on distances within the French territory, between exporters' location and the border.

This work leads to two sets of conclusions. First, it provides empirical evidence in favor of recent models of international trade. Indeed, our estimated parameters are consistent, for 27 out of 34 industries, with the theoretical model. Second, this exercise shows the

importance of considering trade margins and the degree of firm heterogeneity to analyze the consequences of trade barriers. Some industries, producing hardly transportable goods, are very sensitive to changes in transportation costs; but tariffs may have very marginal impact on them. Above all, our results reveal that the impact of trade barriers depends greatly on sectors' industrial organization. Depending on the degree of firm heterogeneity, the adjustments of production to a change in trade barriers will be mainly channeled rather by entry / exit of firms or by changes in individual exports. Hence, trade policies may affect market structures very differently according to industries. For instance, we show that the effect of trade barriers on aggregate trade is very comparable for steel processing and chemicals. However, for chemicals the increase in trade comes mostly from the entry of new exporters (the intensive margin accounts only for 18.6% of the increase in total trade), while over 42% of the increase in trade results from an increase in incumbents' market share for steel processing. Thus, our structural exploration of Chaney's model reveals that taking firm heterogeneity into account is of crucial importance to assess the real impact of trade liberalization measures on industry dynamics.

Abstract

Recent trade models with heterogenous firms have considerable consequences on the interpretation of gravity equations. Chaney (2008) shows that the effect of distance on trade margins incorporates three parameters: the elasticity of substitution between goods, the elasticity of trade costs with respect to distance, and the degree of firm heterogeneity. We structurally estimate the parameters of trade flows in Chaney's model using French firm-level export data for 1986-1992, and controlling for the fixed costs of exporting. Our estimated parameters are consistent, for 27 out of 34 industries, with the theoretical model. They also allow us to evaluate the effects of transport cost separately from the effects of tarifs, without having to resort to detailed data on trade frictions.

JEL classification: F12.
Key words: Gravity equations, International trade, Firm heterogeneity.

MARGES EXTENSIVES ET INTENSIVES DU COMMERCE: UNE ESTIMATION STRUCTURELLE D'UNE ÉQUATION DE GRAVITÉ

RÉSUMÉ NON-TECHNIQUE

Depuis les années 1960, les analyses empiriques du commerce international font une utilisation intense des équations de gravité. Cette relation économétrique associe les flux bilatéraux de commerce à la taille économique des deux pays partenaires et à la distance géographique qui les sépare. Les équations de gravité, même dans leur forme la plus simple, fonctionnent étonnamment bien : elles capturent l'essentiel des différences d'intensité des échanges commerciaux entre les pays du monde. Elles permettent ainsi de conduire des analyses détaillées de la mondialisation. En donnant une estimation du volume "normal" de commerce entre les Etats, elles offrent la possibilité d'identifier les pays qui commercent relativement beaucoup ou relativement peu, et d'évaluer ainsi l'importance des différentes barrières aux échanges. Ainsi, on utilise par exemple des équations de gravité pour mesurer l'importance des "effets frontières", l'impact de l'intégration monétaire ou de la stabilisation des taux de change sur les flux de commerce, l'importance de la proximité culturelle et des institutions sur les relations commerciales, etc.
En dépit de leur utilité manifeste, les équations de gravité ont longtemps été critiquées, faute de reposer sur des fondements théoriques bien définis. Toutefois, ces dernières années ont été marquées par de nombreux progrès dans ce domaine. Les modèles de commerce en concurrence monopolistique montrent que l'effet de la distance - qui est bien la variable essentielle des équations de gravité - reflète l'impact des coûts de transport sur la demande exprimée par les consommateurs étrangers. Plus les biens sont coûteux à transporter, et plus la demande réagit à une variation du prix, plus la distance entre les pays réduit les flux de commerce bilatéraux. Ainsi, dans les secteurs produisant des biens relativement homogènes, l'effet de la distance serait très fort et le commerce sur longue distance relativement limité. Plus récemment, les modèles en concurrence imparfaite, qui introduisent l'hypothèse de firmes hétérogènes modifient profondément l'interprétation à donner à ces équations de gravité (Chaney, *American Economic Review*, 2008). En effet, dans ces modèles, une réduction des coûts de transport (approximés par la distance géographique) augmente les échanges entre les pays via une progression des deux marges du commerce : le nombre d'entreprises exportatrices (i.e. la marge extensive) et les montants exportés par chacune (i.e. la marge intensive). Cette progression résulte d'une combinaison entre trois paramètres qui affectent simultanément les deux marges : l'élasticité distance du coût de transport, l'élasticité-prix de la demande et le degré d'hétérogénéité des firmes.
Notre article propose une décomposition complète d'une équation de gravité tirée directement du modèle de Chaney (2008). Nous utilisons pour cela des données individuelles

d'exportations pour un grand nombre de firmes françaises, entre 1986 et 1992. Nous estimons l'effet de la distance sur chacune des marges du commerce et nous en tirons des estimations sectorielles des trois paramètres clés de l'équation de gravité. Une originalité de ce travail empirique tient au fait que l'on contrôle parfaitement les spécificités de chaque pays d'importation. Pour ce faire, nous introduisons des effets fixes pays qui nous contraignent à avoir une mesure de la distance spécifique à chaque entreprise. Ainsi, le modèle est identifié à partir des distances, à l'intérieur du territoire français, entre chaque exportateur et la frontière du pays partenaire.

Ce travail conduit à deux types de conclusions. Tout d'abord, il vient confirmer la pertinence empirique des modèles récents de commerce international. En effet, sur 34 secteurs étudiés, 27 produisent des coefficients conformes aux attentes théoriques. Par ailleurs, cet exercice empirique permet de montrer l'importance de la prise en compte du degré d'hétérogénéité des firmes, et de distinguer l'effet sur le commerce total des coûts de transport et des protections commerciales. Certains secteurs, produisant des biens difficiles à transporter, sont très sensibles aux variations des coûts de transport et peuvent être relativement peu affectés par l'imposition de droits de douanes. Surtout, nos résultats révèlent que l'impact des barrières aux échanges dépend très largement de la structure de marché du secteur. Selon le degré d'hétérogénéité des firmes au sein d'un secteur, les ajustements de la production à une variation de la protection commerciale se feront plutôt par des entrées/sorties de firmes ou par une évolution des exportations de chaque entreprise. Les caractéristiques sectorielles conditionnent donc grandement les conséquences à attendre d'une même politique commerciale. Sur ce point, l'exemple de la sidérurgie et de la chimie est particulièrement éclairant. L'impact des barrières aux échanges sur les exportations agrégées est très similaire dans ces deux secteurs ; mais nos estimations montrent que l'évolution des exportations dans le secteur de la chimie passe essentiellement par l'entrée de nouveaux exportateurs (la marge intensive ne compte que pour 18.6% de la variation des exportations totales), alors que dans le secteur sidérurgique, 42% de la variation des exportations résulte de l'évolution des ventes des exportateurs en place. Ce type de résultat vient souligner à quel point il est nécessaire de bien prendre en considération les différentes formes d'organisation des marchés pour analyser l'impact véritable de la libéralisation commerciale sur les dynamiques industrielles.

RÉSUMÉ COURT

Les modèles de commerce international avec firmes hétérogènes ont modifié l'interprétation des équations de gravité (Chaney, 2008). L'effet de la distance sur les marges du commerce dépend de trois paramètres : l'élasticité-distance du coût de transport, l'élasticité-prix et le degré d'hétérogénéité. Cet article mobilise des données individuelles sur les exportateurs français pour conduire une estimation structurelle de ces trois paramètres. Il confirme la pertinence du cadre théorique ; pour 27 secteurs sur 34, les paramètres estimés sont conformes aux attentes théoriques. Il montre aussi que les coûts de transport ont un impact très différent de celui des droits de douane.

JEL classification : F12.
Mots Clefs : Equation de gravité, Commerce international, Firmes hétérogènes.

STRUCTURAL GRAVITY EQUATIONS WITH INTENSIVE AND EXTENSIVE MARGINS[1]

Matthieu CROZET[2]
Pamina KOENIG[3]

1. Introduction

Estimating the effects of trade barriers on trade flows is a central research question in international trade. These estimations serve to improve our understanding of the structure of world trade and produce economically-important information such as the impact of regional trade agreements, borders, non-tarif barriers and other trade frictions on trade flows. Since its first application to international trade issues by Tinbergen (1962), the gravity equation has been a leading tool for the estimation of bilateral trade flows. The basic form relates bilateral trade flows to the economic size of the trading countries and the geographic distance between them, and over time its specification has been amended and improved both theoretically and empirically.

Current estimations of trade barriers based on gravity equations face two key issues. First, while it is easy to measure the distance elasticity of trade, it is much harder to evaluate the trade-cost elasticity of trade, due to the lack of direct measures and detailed data on trade frictions. Second, recent trade models with heterogenous firms (Melitz, 2003; Chaney, 2008) have major consequences on the interpretation of these empirical estimations. When firms are heterogenous, only a subset of firms will export for a given level of trade costs. As trade costs fall, two mechanisms are at work: incumbent exporters increase their volume of sales (the intensive margin), and new firms enter the export market (the extensive margin).

From the point of view of empirical research, heterogenous-firm models introduce a new parameter, which alters the interpretation of the estimated coefficients of distance on trade. The key parameters governing the intensive margin are the same as those in traditional models with homogenous firms: the elasticity of substitution between goods, and the elasticity of trade costs with respect to distance. The extensive margin, on the other hand, depends not

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[2]CEPII & Université de Reims (matthieu.crozet@cepii.fr).

[3]Université Paris X & Paris School of Economics (pkoenig@u-paris10.fr).

only on these two parameters, but also on a parameter reflecting the distribution of productivity across firms. At the aggregate level, the impact of trade costs on bilateral trade flows is the sum of the trade-cost effect on the intensive and extensive margins. Chaney (2008) and Melitz and Ottaviano (2005) show that the elasticity of aggregate trade flows with respect to distance can therefore not be interpreted as the elasticity of substitution between goods, but rather as the degree of heterogeneity between firms.

In this paper, we show that new trade models with heterogenous firms represent an additional contribution to the empirical trade literature by allowing the estimation of the three structural parameters determining trade flows, and thus avoid the trade-barrier measurement problem. Using the characteristics of heterogenous firms and individual export flows, we estimate the structural parameters of Chaney's trade model. We thus consider three equations on French firm-level export data: a gravity equation at the firm level (providing a combination of the demand elasticity and the distance elasticity); an export-selection equation (yielding a combination of the three unknown parameters); and a rank-size distribution of productivity across firms (providing a combination of the demand elasticity and heterogeneity parameters). The estimated parameters underline the importance of the intensive and extensive margins of international trade, and are consistent, for 27 out of 34 industries, with the theoretical model of trade with heterogeneous firms à la Chaney (2008) and Melitz-Ottaviano (2005).

The paper is structured as follows. Section 2 sketches the theoretical model, and Section 3 explains the empirical strategy. Section 4 presents the data and regression estimates revealing the existence of the intensive and extensive margins. Looking at the raw data, we highlight the importance of distance on firm-level and aggregate trade flows, and show that the extensive margin accounts for a major part of the difference in aggregate trade flows across countries. Section 5 presents the structural estimates of the three parameters: the elasticity of substitution, the distance elasticity of trade costs, and the degree of firm heterogeneity. Section 6 concludes.

2. The model

This section succinctly presents a simple model of international trade with heterogenous firms, bringing out the main features of Chaney (2008). We highlight the expressions for the trade-cost elasticity of the extensive and the intensive margins.

2.1. Production and consumption

We consider a Home country facing R foreign markets. The Home country produces H differentiated goods and a homogenous numéraire good. In the H manufacturing industries, firms engage in monopolistic competition à la Dixit-Stiglitz. All consumers have the same CES utility function:

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

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 will consider each industry separately, we drop the subscript k for notational convenience in the Model section.

There are N firms in the Home country. To produce and sell on a foreign market, each firm incurs a firm-specific marginal cost, and a destination-country specific fixed cost. As our empirical analysis estimates the parameters on French firm exports, all firms are located in the same exporting country. Therefore, in the following the subscript i denotes a firm and the subscript j a foreign country. We consider the export fixed cost as identical for all firms exporting to the same destination country. For a firm i with marginal cost a_i, the total cost of supplying consumers in country j with $q(a_i)$ units of good is: $TC_{ij}(a_i) = q(a_i)a_i + C_j$. Moreover, we assume the existence of "iceberg" transportation costs: $\tau_j > 1$ units of good have to be shipped in order to ensure that one unit arrives in country j.

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

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

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

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

2.2. Trade costs and the intensive and extensive margins of trade

Marginal cost a is assumed to follow a Pareto distribution, bounded between 0 and 1, with a scaling parameter $\gamma \geq 1$.[4] Hence, marginal cost is distributed according to $P(\tilde{a} < a) =$

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

$F(a) = a^\gamma$ and $dF(a) = f(a) = \gamma a^{\gamma-1}$. The parameter γ is an inverted measure of the degree of firm heterogeneity. With a value of 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.

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

$$\pi_{ij}(a_i) = m_{ij}(a_i)\frac{1}{\sigma} - C_j = \left(\frac{\sigma}{\sigma-1}\frac{a_i\tau_j}{P_j}\right)^{1-\sigma} E_j - C_j. \tag{4}$$

Individual profit drives the decision to export to country j. This increases with destination market size (E_j), and falls with impediments to trade (τ_{ij} and C_j). As is standard in monopolistic-competition models, the importing-country price index (P_j) enters positively in the expressions for both trade flows and export profits. This price index captures the influence of the greater competition that occurs in more central markets.[5]

We denote by $\overline{a_j}$ the marginal-cost level ensuring that the revenue from sales in country j just equals the total cost of exporting. From (4), this threshold value is:

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

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

Finally, all firms with marginal cost below or equal to $\overline{a}_j$ will export to j. The total number of exporting firms is thus:

$$N_j = \int_0^{\overline{a}_j} N f(a) da = \left[N \frac{\gamma}{\gamma-1}\lambda_j^\gamma\right] \left(\frac{1}{C_j}\right)^{\gamma/(\sigma-1)} \tau_j^{-\gamma}, \tag{6}$$

Hence the value of bilateral trade from country H to market j is given by:

[5] Let $\overline{a}_{hj}$ denote the marginal cost of the least-efficient firm in country h that exports to country j, and N_h the total mass of firms in country h, then the 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, this 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 a detailed description of the role of this index in gravity equations). The presence of heterogenous firms influences this price index because trade costs also affect the number of foreign exporters to market j.

$$
\begin{aligned}
M_j &= \int_0^{\overline{a}_j} N m_{ij}(a_i) f(a) da \\
&= \Theta \frac{E_j}{P_j^{1-\sigma}} N \left(C_j\right)^{-\frac{[\gamma-(\sigma-1)]}{\sigma-1}} \left(\tau_j\right)^{-\gamma} \qquad (7)
\end{aligned}
$$

where $\Theta = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\frac{\gamma}{\gamma-(\sigma-1)}\right) \lambda_j^{\gamma-(\sigma-1)}$.
This export equation is very similar to the traditional gravity equation derived from the Dixit-Stiglitz-Krugman (DSK) framework. Bilateral trade flows increase with the demand in destination country (E_j) and supply capacity in the exporting country (N). Trade is also a decreasing function of trade costs, τ_j. There are nonetheless two main differences from 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-cost elasticity of trade differs significantly from the homogenous-firm case. Indeed, it is straightforward from (7) that:

$$\frac{\partial M_j}{\partial \tau_j} \frac{\tau_j}{M_j} = -\gamma.$$

Here, the trade-cost elasticity of trade does not depend on the price elasticity, whereas it is equal to $(1-\sigma)$ in the DSK model.[6] This is one of the most striking results of the model, since it requires us to reconsider the plentiful empirical and theoretical literature relating the industrial-product differentiation parameter to central features of international trade, such as the size of the impact of trade costs or border effects.
To understand why the introduction of firm heterogeneity affects the trade-cost elasticity, we consider trade margins. It is important to note that our definition of trade margins differs from that used in most empirical studies (see Hillberry and Hummels 2008; Mayer and Ottaviano 2008), where aggregate trade is decomposed into the number of exporters and the average shipment by exporter. This implicitly attributes the average export value to each individual shipment. Here, as in Chaney (2008), the extensive margin is defined as the value shipped by the marginal exporter, which is less than the average shipment.
The influence of trade costs on aggregate bilateral flows results from the combined effect of both the intensive and extensive margins. A fall in τ_j expands both the number of firms exporting to country j (see equation 6) and the volume exported by each firm (see equation

[6] Note that the model presented in this section makes a simplifying assumption. Following Chaney (2008), we imagine that τ_j does not affect E_j and P_j, i.e. we assume implicitly that the exporting country is "small" with negligible influence on the world economy.

3). We refer to these as the extensive and intensive margins of trade respectively. Letting $\varepsilon_{\tau_j}^{M_j}$ denote the trade-cost elasticity of total trade, and $\varepsilon_{\tau_j}^{INT_j}$ and $\varepsilon_{\tau_j}^{EXT_j}$ the trade-cost elasticities of the intensive and extensive margins, we have necessarily:

$$\varepsilon_{\tau_j}^{M_j} = \varepsilon_{\tau_j}^{INT_j} + \varepsilon_{\tau_j}^{EXT_j} = -\gamma \tag{8}$$

To compute the trade-cost elasticity of the extensive margin ($\varepsilon_{\tau_j}^{EXT_j}$), we cannot just consider equation (6). Economic integration does increase the number of exporting firms, as suggested by equation (6), but as τ_j falls further the firms which enter 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 with marginal cost of $\overline{a}_j$):[7] $\varepsilon_{\tau_j}^{EXT_j} = \left[N m_{ij}(\overline{a}_j) f(\overline{a}_j) \frac{\partial \overline{a}_j}{\partial \tau_j} \right] \frac{\tau_j}{M_j}$. Using (3), (5) and (6), we obtain, after some manipulation:

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

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

$$\varepsilon_{\tau_j}^{INT_j} = -(\sigma - 1). \tag{10}$$

Note that $\varepsilon_{\tau_j}^{INT_j}$ is exactly the trade-cost elasticity of total trade which can be derived from a Krugman-type (1980) model of trade with homogenous firms.

3. Empirical strategy

We now explain how we proceed for the structural estimations. Chaney's model emphasizes how firm heterogeneity will matter for international trade analysis. He shows that the consequence of economic integration will differ across industries. First, a similar reduction in trade costs will have a greater influence on bilateral trade in less heterogenous industries (i.e. those in which γ is larger). Second, the decomposition of the effect of trade integration will differ according to the degree of differentiation of goods in the sector. In industries with highly-differentiated products (i.e. where σ is relatively low), trade integration allows the entry of a large number of firms, each of which with a relatively small market share. In these industries trade expands mainly via the extensive margin. On the contrary, in industries with

[7] See Chaney (2008) for a more explicit decomposition of total trade into intensive and extensive margins.

homogenous goods, a reduction in trade costs expands trade principally through the intensive margin. This is because lower trade costs mean that less-efficient firms will experience greater difficulties in entering export markets: only a small number of firms will become new exporters.

Using trade data for a large set of exporting firms, we estimate the parameters determining the influence of distance on total trade and on each trade margin. Dissecting the gravity equation, we obtain all of the parameters necessary for the evaluation of the trade-cost elasticity of trade. We assume a very simple trade-cost function: $\tau_j = \theta D_j^{\delta}$, where θ is a positive constant, D_j is the distance between the Home country and j, and δ is a strictly positive coefficient.[8] The distance elasticities of trade margins are:

$$\begin{aligned} \varepsilon_{d_j}^{INT_j} &= -\delta(\sigma - 1) \\ \varepsilon_{d_j}^{EXT_j} &= -\delta\left[\gamma - (\sigma - 1)\right] \end{aligned} \tag{11}$$

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

The first step consists in obtaining $-\delta\gamma$, by estimating the influence of distance to foreign countries on the export decision of each firm. Equation (5) shows the maximum marginal cost at which a firm will export. Using the definition of the Pareto distribution, and reintroducing the k subscript, we derive the probability that a firm located in i with marginal cost a exports to country j:

$$\text{Prob}[Exp_{kjt}(a_i)] = P(a_i < \overline{a}_j) = \left[\lambda_j \left(\frac{1}{C_j}\right)^{1/(\sigma-1)} \frac{1}{\tau_j}\right]^{\gamma},$$

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

We estimate this equation by taking logs for trade costs and by using firm fixed effects as well as fixed effects for industries, import countries and time.[9] For the country fixed effects not to eliminate the distance variable, our measure of distance has to exhibit variation within

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

[9] Note that this expression does not depend on firms' characteristics, a_i. It is however very likely that trade costs τ_j contain some unobserved idiosyncratic individual characteristics (for example, firm networks, or former experience on export markets). These will be captured by firm fixed effects.

France. Our distance variable is thus computed between the city where the firm is located and the foreign country. We are left with the intra-national distance, which is firm-specific. We estimate the following probit equation, as the first step of our estimation strategy:

$$\text{Prob}[Exp_{kjt}(a_i)] = -\delta\gamma \ln D_{ij} + e_i + e_{kjt} + \nu_{ikjt}, \tag{12}$$

where D_{ij} is the distance between firm i and country j, e_i is a firm fixed effect and e_{kjt} is an industry-import country-year fixed effect which controls for foreign market size, prices and export fixed cost.

The second step consists in estimating the determinants of the individual export value from equation (3). Log-linearizing equation (3) gives the following estimable gravity equation for individual firms:

$$\ln[m_{kjt}(a_i)] = -\delta(\sigma - 1)\ln(D_{ij}) + e_i + e_{kjt}, \tag{13}$$

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

We use the preceding estimates to compute the three trade-elasticity parameters, δ, σ and γ. To determin these, we turn to step 3, which consists in estimating the Pareto distribution. It can be shown from equations (2) and (3) that for each firm with productivity $1/a_i$, the cumulative production of all firms with a higher productivity, is: $X = \lambda(1/a_i)^{-[\gamma-(\sigma-1)]}$. 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 and, for each year and industry, sort the firms from the most productive to the least productive. For each firm, we then compute the sum of the turnovers generated by all firms of lower rank. Regressing the log of this cumulative production on the log of individual TFP,[11] we obtain the estimated value of $-[\gamma - (\sigma - 1)]$ for each industry. We use the three estimated expressions $-\delta\gamma$, $-\delta(\sigma-1)$ and $-[\gamma-(\sigma-1)]$ to compute the values of γ, σ and δ. In the following section, we explain the data we need to carry out these estimations.

4. The trade data

We here describe the construction of the export database, highlighting that the variability of distance is intra-national. We then use our data to compute trade margins and show that distance affects individual-level export flows and the decision to export.

[10] The proxy for individual TFP is based on the Olley-Pakes procedure.

[11] All regressions include year fixed effects.

4.1. Individual export data and intra-national distance

Our estimation procedure reveals the trade-data requirements for the regressions. For equations (12) and (13) we need firm-level export data, with controls for both the country-specific fixed cost and price index, so that distance only represents the variable trade cost. Individual export data from France are collected by French Customs and are available from INSEE. Our export database contains the value of exports by firm and country, for each firm located in the French metropolitan area, from 1989 to 1992.

The structural estimation procedure concentrates on the impact of variable trade costs on trade. Fixed costs reflect procedures such as looking for potential costumers, barriers such as translation between languages, and so on. We assume that the fixed cost is specific to each importing country. We therefore have the possibility of using country fixed effects in the estimation to control for fixed costs and importing-country price indices. As mentioned above, these country fixed effects doe not soak up all of the variation in distance, as our distance variable is specific to each exporting firm. The variation in distance arises from the particular location of the exporting firm within France, which then only captures movements in variable trade costs. In order for this variable cost to play a significant role in export decisions, we carry out the estimations on adjacent countries only: Belgium-Luxembourg, Germany, Switzerland, Italy and Spain.

Our measure of intranational distance between each exporting firm and each export market is computed as follows. 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. We are able to calculate this intranational distance as we have very detailed data from INSEE on 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 for intranational trade costs between the exporting plant and the French border. However, while the location of every plant of each firm is available, we do not know from which plant 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 which case we use the address of the headquarters), but it can be a problem in the case of larger firms, which may have several production plants located in different parts of the country.

The Continental French territory is divided up into 21 administrative regions (these *régions* have an average size of 25 500 km^2).[12] In the following, we restrict the sample to mono-region firms, whose plants are all located in one of the 21 *régions*. This allows us to minimize measurement error in the calculation of intranational distance, while not restricting the database to single-plant firms.

Figures 4.1. and 4.1. show that there is substantial variation in intranational distance variable.

[12]These *régions* are the NUTS2 level in the Eurostat nomenclature.

These represent, for each *employment area*,[13] the share of exporters in the total population of manufacturing firms and the mean value of their shipments. Darker shading denotes greater values of mean individual trade flows (Figure 1) and the share of exporting firms (Figure 2). The negative effect of distance on trade stands out, as most of the darker 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. It appears clearly that distance influences firm exports even within the French territory.

Finally, to add further information on firms' characteristics, we merge firm-level exports with the Annual French Business Surveys, (Enquêtes Annuelles d'Entreprises, EAE), which are also available from INSEE. Individual firms are identified via a 9-digit code, called the Siren identifier. For each Siren, the Business Surveys provide information on industrial sector, total employment, and the address of the firm. Merging with the Business Surveys does however raise an additional issue regarding selection, as firm-level information is only available for firms with more than 20 employees. As the address of the firm is central for distance, we have restricted the trade data to firms with more than 20 employees. Table 1 presents some descriptive statistics on the sample of exporting firms. In each year, single-region firms represent over 83% of the total number of firms in the sample. Among those firms, the share of exporters is lower than in the whole sample, but the difference remains small (about 65% against 68% for the whole sample). Single-region firms account for about 78% of total exports.

By restricting our sample, we tend to retain medium-size firms. The exporters in the final database are upper-bounded by the exclusion of multi-region firms, and lower-bounded by being restricted to firms with over 20 employees. The potential estimation bias generated by these restrictions needs to be recognised. We cannot explicitly evaluate the size of this bias, as no information is available on the within-France location of smaller firms, and we do not know from which region exports originate for multi-region firms. However the resulting sample of firms fits the theoretical models well. The assumption that firm size is Pareto distributed plays an important role in our framework, and our restricted sample performs slightly better in this respect than does the overall sample. The distribution of manufacturing firms in developed countries appears to better correspond to a Pareto law in the case of medium-size firms (see for instance Axtell, 2001 and Cabral and Mata, 2003). Further, the Pareto distribution is a power law, predicting a linear relationship between the log of the rank and the log of firm size. Rank size regressions on our sample of medium-size firms, produce satisfactory results: the R-squared statistics by industry are relatively high, ranging

[13] *Employment areas* (of which there are 348) are an additional level used by INSEE, and are defined by workers' commuting patterns.

Figure 1: Mean value of individual-firm exports (single-region firms, 1992)

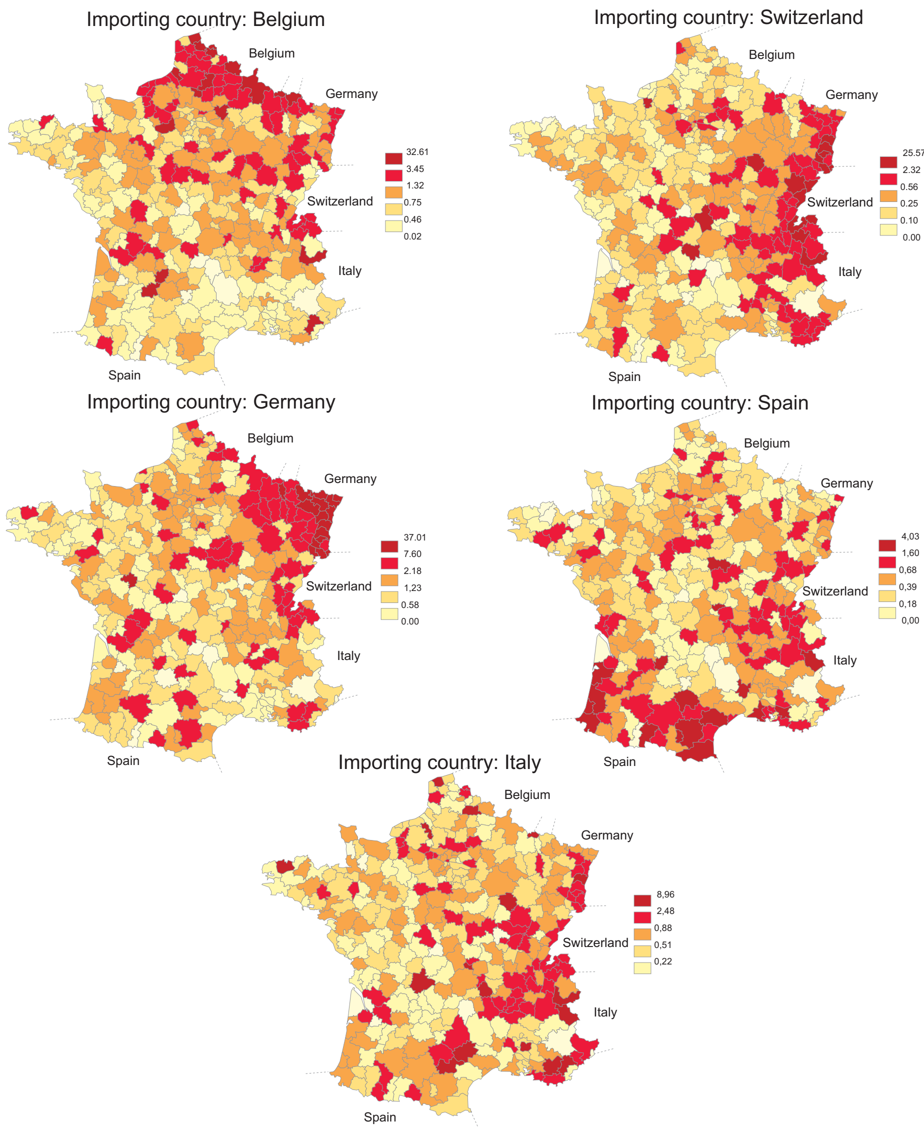


Figure 2: Percentage of firms which export (single-region firms, 1992)

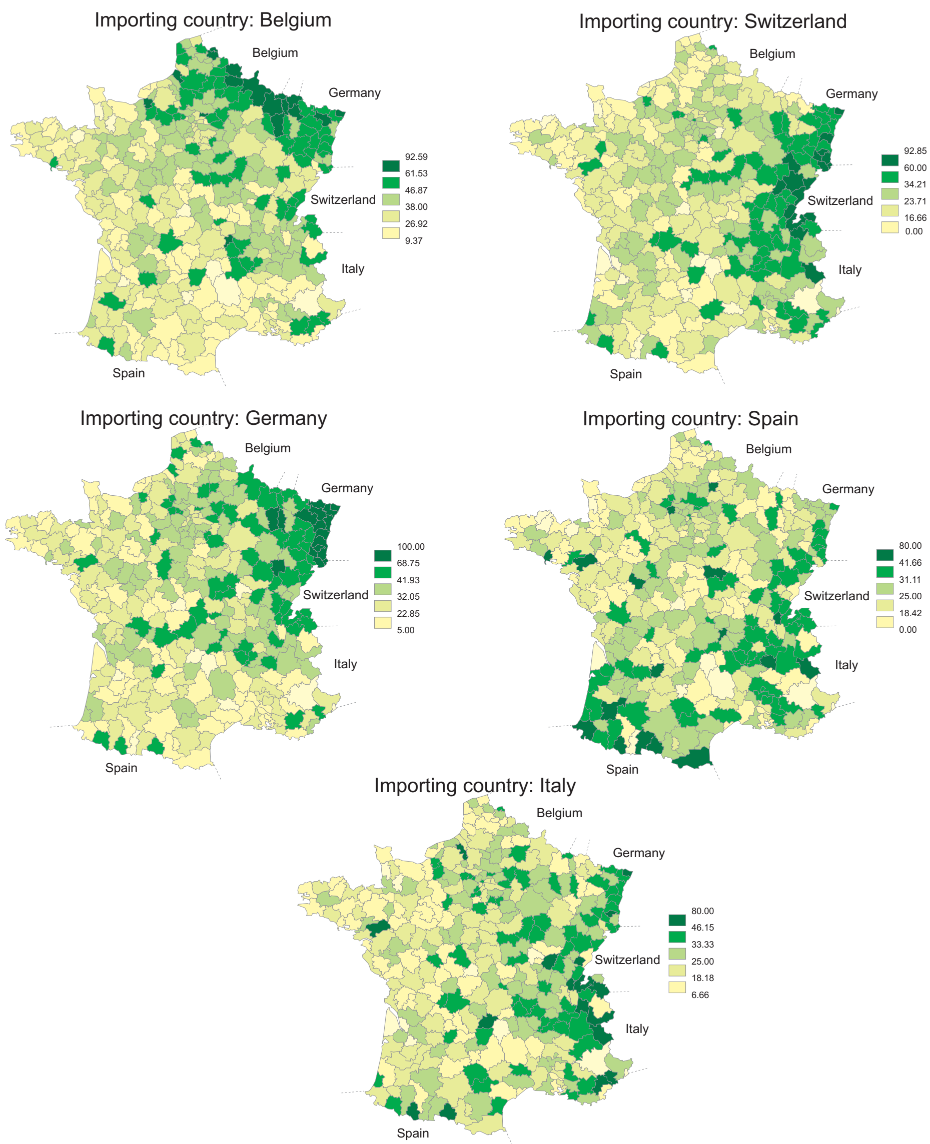


Table 1: Summary statistics

Year	No. firms	% of exporters	% of single-region firms	% of exporters among single-region firms
1986	22553	68.9	81.1	64.9
1987	22859	69.3	81.2	65.4
1988	23604	69.5	81.1	65.6
1989	23066	69.3	79.5	66.1
1990	23089	68.4	83.4	65.1
1991	24080	67.8	83.3	64.5
1992	23494	68.6	83.2	65.5

from 0.47 to 0.92, with a mean value of 0.706. The same regressions carried out on all firms with over 20 employees yield less satisfactory results, with smaller R-squareds in all but two industries.

4.2. A first look at trade margins

Before turning to the structural estimations, we highlight some interesting features of the data, which are consistent with both intensive and extensive trade margins. Trade models with heterogenous firms have been estimated in a parallel strand of the literature documenting intensive and extensive trade margins. Eaton, Kortum and Kramarz (2004) analyse how the French market share abroad affects the nature of bilateral trade. Hillberry and Hummels (2008) provide a decomposition of the distance effect on intranational US shipments, and Bernard, Jensen, Redding and Schott (2007) use US export data at the firm level to estimate the impact of distance on the intensive and extensive (decomposed into the number of firms and the number of products) margins. Helpman, Melitz, and Rubinstein (2007) is the only existing estimation of a structural trade model. Using bilateral export data for 158 countries, they obtain trade-margin elasticities based on aggregate trade flows.

We now show how the patterns in our data fit the existing results in the literature. We estimate the size of two different trade elasticities with respect to distance: those of the number of exporters and the average individual-firm volume of trade. In this section, we do not restrict the database to neighboring countries. Estimations are carried out on aggregate French exports to 159 countries, by industry, over all exporters and on single-region exporters only. We differ from the estimations of French exports in Eaton et al. (2004), as they focus 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 (2008) in their decomposition of the variation of intranational US shipments. We thus decompose, for each industry k, the aggregate volume of trade from France to a given country j into the number of shipments (N_{kjt}) and the average value per shipment ($\overline{m}_{kjt}$), as follows:

$$M_{kjt} = N_{kjt}\overline{m}_{kjt}.$$

Taking logs, we have:

$$\ln M_{kjt} = \ln N_{kjt} + \ln \overline{m}_{kjt}. \tag{14}$$

We analyze how each component varies with distance. We regress separately each of the three terms of equation (14) on distance, controlling for the size of importing countries via their current GDP.

We introduce three variables reflecting cultural proximity between France and the importing country: a dummy for French being spoken by at least 9% of the population ($French_j$), a dummy controlling for contiguity, and a dummy taking the value one if the destination country is a former French colony($Colony_j$).[14] These variables aim to capture part of the fixed cost of exporting, C_j which is a determinant of total bilateral trade flows (equation 7). We include a full set of industry and year dummies. We estimate the following equation:

$$\ln(Margin_{kjt}) = \alpha_1 \ln D_j + \alpha_2 \ln GDP_{kjt} + French_j + Contig_j + Colony_j + e_k + e_t + v_{kjt}, \tag{15}$$

where e_k and e_t are industry and year fixed effects, v_{jkt} is an error term and $\ln(Margin_{kjt})$ is in turn the log of average value per shipment, and the log of the number of shipments. As OLS is linear, the coefficient on total trade will be equal to the sum of the coefficients on the two margins. We can therefore see which part of the distance effect on aggregate shipments is due to changes in the average shipment per firm and in the number of shipments.

Table 2 shows the results of the estimation of equation (15) over all firms (columns 1 and 2) and only on single-region firms (columns 3 and 4). We first note that the coefficients in the two sets of regressions are very similar, except for those on the contiguity variable. Our sample of single-region firms thus exhibits the same trade patterns as the full set of firms with respect to the decomposition of trade margins. Being close to a border country matters more for a single-region firm than for a multi-region firm, as reflected in the significant coefficient in column (4), compared to the insignificant estimate in column (2). Second, the estimated

[14]These three variables were obtained from the CEPII (see: *www.cepii.fr*).

Table 2: Decomposition of French aggregate industrial exports (34 industries - 159 countries - 1986/1992)

	All firms		Single-region firms	
	(1)	(2)	(3)	(4)
	Average Shipment	Number of Shipments	Average Shipment	Number of Shipments
	ln (M_{kjt}/N_{kjt})	ln (N_{kjt})	ln (M_{kjt}/N_{kjt})	ln (N_{kjt})
ln (GDP_{kj})	0.461^a	0.417^a	0.421^a	0.417^a
	(0.007)	(0.007)	(0.007)	(0.008)
ln ($Dist_j$)	-0.325^a	-0.446^a	-0.363^a	-0.475^a
	(0.013)	(0.009)	(0.012)	(0.009)
$Contig_j$	-0.064^c	-0.007	0.002	0.190^a
	(0.035)	(0.032)	(0.038)	(0.036)
$Colony_j$	0.100^a	0.466^a	0.141^a	0.442^a
	(0.032)	(0.025)	(0.035)	(0.027)
$French_j$	0.213^a	0.991^a	0.188^a	1.015^a
	(0.029)	(0.028)	(0.032)	(0.028)
N	23553	23553	23553	23553
R^2	0.480	0.591	0.396	0.569

Note: These are OLS estimates with year and industry dummies. Robust standard errors in parentheses with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% level respectively.

coefficients of the gravity equation have the expected sign. GDP has a significant positive effect on both the volume exported by firms and the number of exporters. Distance always attracts a negative estimate. A common colonial history and sharing the same language increase both the intensive and extensive margins. Third, the decomposition of the influence of distance on trade shows a somewhat greater effect on the extensive margin, for all firms and for our sample. About 57% of the distance effect on trade works through the extensive margin (i.e. $(0.475/(0.363 + 0.475)) * 100 \simeq 56.7$); 43% of the increase in aggregate trade flows comes from larger average shipments per firm. Previous work (Eaton et al., 2004; Bernard, Jensen, Redding and Schott, 2007) finds qualitatively similar results, with the extensive margin being more important than the intensive margin. However it is difficult to compare our results exactly, as the methodologies are different. The most comparable results are found in Hillberry and Hummels (2008), who analyze trade flows within the United States, and Mayer and Ottaviano (2008), who study French and Belgian individual export flows. These two studies show respectively that 96% and 75% of the distance effect on trade comes from the extensive margin. Our results are thus consistent with theirs, although we find a somewhat lower figure, as we do not consider firms with less than 20 employees, and thus lose part of the extensive margin. Without these small firms, we also lose part of the intensive margin, however not as much as the extensive margin because they are expected to export less than the average export flow. Structural estimation of the three gravity parameters should produce a figure for the extensive margin similar to the the higher estimate in Mayer and Ottaviano (2008). This is what our estimations in the following section obtain: reconstructing the share of the extensive trade margin from the estimated parameters γ, δ and σ, produces a figure close to 74%.

The elasticity decompositions shown in Table 2 inform us about the existence of the two trade margins; however, the estimates cannot be directly linked to the structural parameters of the model. In Chaney's model (see equation 11), the extensive margin is defined as the quantity exported by the marginal exporting firm. Firms which take advantage of a marginal reduction in trade costs to start exporting are smaller than the incumbent exporters. This definition does not match that which we implicitly use in equation (15), which assumes that all firms have the same volume of exports. Moreover, as explained above, we would like to control for the price index in the destination country and for the fixed costs of exporting.

5. Structural gravity parameters

We now consider firm-level estimations which control for destination-country fixed effects. We discuss the results for the industry gravity parameters and then use the estimates to illustrate the sectoral elasticities of trade flows to trade barriers and distance.

5.1. Results by industry

We estimate the influence of distance on individual export probability and individual exports for each industry separately. All these regressions are carried out with the contiguity dummy, country-year fixed effects and firm fixed effects. We obtain sectoral estimations for $\delta\gamma$ and $\delta(\sigma-1)$ respectively. The estimated coefficients are shown in columns (1) and (2) of Table 3.[15] Distance has a significant negative impact on export probability for all but one industry (the shoe industry), and a significant negative impact on individual export volume for all but five industries (pharmaceuticals, electronical equipment, aeronautical building, precision instruments and the shoe industry). The average value of the coefficients for the export probability by industry ($-\delta\gamma$) is -1.29. As expected, the estimations of distance elasticities of bilateral trade carried out on aggregate trade flows produce very similar results. The meta-analysis of Disdier and Head (2007) surveys 1466 gravity estimations and obtains a mean coefficient value of -0.91 with a median value of -0.87. This similarity conforms to theory, which predicts the same coefficient on distance for equations (7) and (12).

We use the preceding estimates together with the Pareto estimations (our step 3) to compute the three parameters composing the trade elasticities, δ, σ and γ. We obtain consistent coefficients for a large majority of industries: 27 out of 34 in Table 3. Taken together, these industries account for 79.8% of total French manufacturing exports and 76.2% of manufacturing exporters. For all industries with significant coefficients, the estimates are consistent in sign and size with theory: the values of σ are strictly greater than 1, and those of γ are greater than $\sigma - 1$.

The values of σ reported in Table 3 range between 1.11 and 3.63, with an average value of 1.72. These are smaller than those in the recent literature. Broda and Weinstein (2006) report values of between 4 and 6.8 when estimating the parameters on three-digit data. Eaton and Kortum's (2002) results lie around the average value of 8.3, and Erkel-Rousse and Mirza (2002) obtain a mean value of 3.7. Hummels (2001a) obtains an average value of 5.6 and that in Head and Ries (2001) is 7.9.[16] Nevertheless, the comparison of our sectoral estimates of σ with those of Broda and Weinstein (2006) is satisfactory. Broda and Weinstein (2006) provide import-demand elasticities for SITC Rev.3 3-digit products; we aggregate this data to match our sectoral classification, taking the median value of their estimates. The cross-industry correlation is 0.55 and significant at the 1% level. The Spearman rank correlation is lower at 0.33, but still significant at the 10% level.

Our average value for δ is 0.41. This is close to the estimates in the existing literature based on international transport costs. The mean value of the distance elasticity of trade

[15] Column 1 in Table (3) shows the marginal coefficients of the individual export probability.

[16] 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 a measure of γ for each industry.

Table 3: The structural parameters of the gravity equation (Firm-level estimations)

Industry	(1) $P[Export > 0]$ $-\delta\gamma$	(2) Export value $-\delta(\sigma-1)$	(3) Pareto[#] $-[\gamma-(\sigma-1)]$	(4) γ	(5) σ	(6) δ
Iron and steel	-2.98[a]	-0.96[a]	-1.36	2.01	1.64	1.49
Steel processing	-1.26[a]	-0.54[a]	-1.74	3.02	2.28	0.42
Metallurgy	-1.59[a]	-0.36[a]	-1.85	2.39	1.54	0.67
Minerals	-2.15[a]	-0.51[a]	-2.86	3.76	1.90	0.57
Ceramic and building	-1.70[a]	-0.29[a]	-1.97	2.38	1.41	0.71
Glass	-1.96[a]	-0.32[a]	-2.13	2.55	1.42	0.77
Chemicals	-1.26[a]	-0.23[a]	-1.09	1.34	1.25	0.94
Speciality chemicals	-0.79[a]	-0.19[a]	-1.39	1.83	1.44	0.43
Pharmaceuticals	-0.79[a]	-0.09	-1.40			
Foundry	-1.39[a]	-0.26[a]	-2.37	2.91	1.54	0.48
Metal work	-0.74[a]	-0.16[a]	-2.43	3.08	1.65	0.24
Agricultural machines	-1.60[a]	-0.27[a]	-2.39	2.88	1.49	0.56
Machine tools	-0.81[a]	-0.11[a]	-2.47	2.86	1.39	0.28
Industrial equipment	-0.85[a]	-0.17[a]	-1.97	2.46	1.49	0.34
Mining/civil eqpmt	-1.00[a]	-0.12[a]	-1.90	2.15	1.25	0.47
Office equipment	-0.63[a]	-0.39[a]	-1.57	4.20	3.63	0.15
Electrical equipment	-0.62[a]	-0.02	-2.34			
Electronical equipment	-0.48[a]	-0.08	-1.63			
Domestic equipment	-0.48[b]	-0.25[c]	-2.13	4.43	3.29	0.11
Transport equipment	-1.19[a]	-0.34[a]	-2.23	3.12	1.89	0.38
Ship building	-2.81[a]	-1.55[a]	-1.52	3.39	2.87	0.83
Aeronautical building	-0.29	-0.11	-3.27			
Precision instruments	-0.73[a]	0.04	-1.63			
Textile	-0.85[a]	-0.12[a]	-1.37	1.6	1.23	0.53
Leather products	-0.87[a]	-0.21[a]	-1.63	2.15	1.52	0.4
Shoe industry	0.10	-0.18[a]	-2.30			
Garment industry	-0.33[a]	-0.02	-1.04			
Mechanical woodwork	-1.60[a]	-0.11[a]	-1.50	1.61	1.11	0.99
Furniture	-1.09[a]	-0.20[a]	-2.25	2.74	1.50	0.40
Paper & Cardboard	-1.20[a]	-0.26[a]	-1.76	2.25	1.49	0.54
Printing and editing	-0.87[a]	-0.16[a]	-1.24	1.53	1.28	0.57
Rubber	-1.20[a]	-0.37[a]	-2.52	3.65	2.13	0.33
Plastic processing	-1.07[a]	-0.24[a]	-1.60	2.05	1.45	0.52
Miscellaneous	-0.75[a]	-0.19[a]	-1.22	1.64	1.42	0.46
Mean	**-1.29**	**-0.33**	**-1.87**	**2.59**	**1.72**	**0.54**

[a], [b] and [c] denote significance at the 1%, 5% and 10% level respectively. #: All coefficients in this column are significant at the 1% level. Estimations are carried out with the contiguity variable.

costs in Radelet and Sachs (1998) is 0.13. Glaeser and Kohlhase's (2003) estimate of the same parameter is 0.3, and Hummels' (2007) average estimate is 0.2. Our figure is larger, which is likely due to the fact that we only consider continental shipments. Road transport decays more strongly with distance: for instance, Combes and Lafourcade (2005) obtain an elasticity of 0.8 using road transport costs within France. For a closer comparison, we use freight rates for bilateral trade by road. These data do not exist for Europe, so we use sectoral freight rates between the US and Canada, constructed from two sources: the NBER U.S. import database compiled by Feenstra, Romalis and Schott (2002), and those found in Hummels (2007).[17] The correlation between our δ's and the North-American freight rates is not significant; however the Spearman rank correlation is 0.55 and significant at the 1% level.

5.2. The impact of lower trade barriers

A simple way to illustrate these results is to show the impact of lower values of distance, or trade barriers, on the patterns of trade from France. Our estimation of Chaney's gravity model allows us to compute the differentiated effect of distance on trade from the effect of tariffs on trade, without having to use detailed tariffs or price data. We compute both effects and show the results by industry in Figure 5.1..

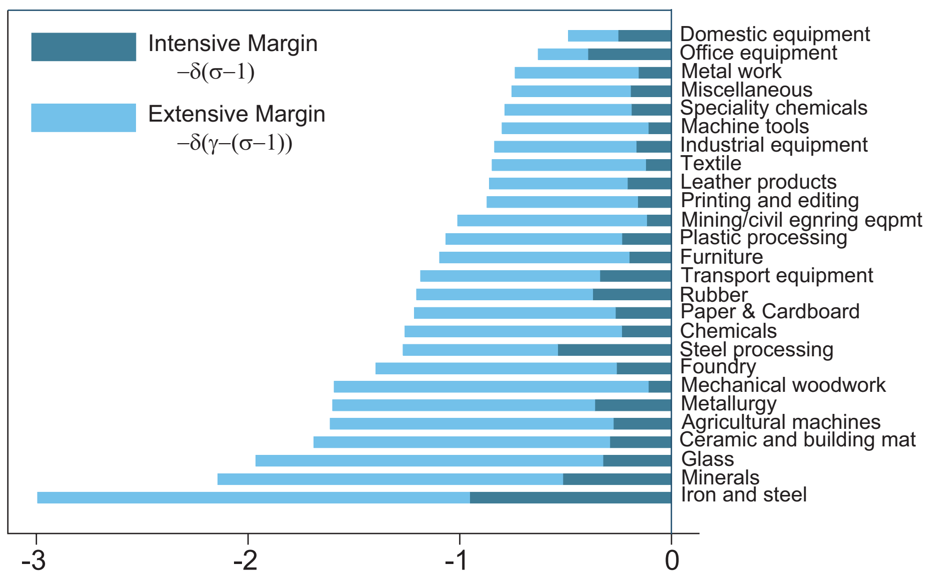
Reducing distance increases the extensive margin by $\delta[\gamma-(\sigma-1)]$ and the intensive margin by $\delta(\sigma-1)$. Panel (a) in Figure 5.1. shows the decomposition of the aggregate trade elasticity to distance across industries. The width of the bar represents the distance elasticity of trade by industry. It is the sum of the distance elasticities of the extensive margin (the grey part of the bar) and the intensive margin (the black part of the bar). The effect of freight costs on the elasticity of aggregate trade stands out clearly. The effect of distance is strongest for Iron and steel, minerals, glass, ceramic and building materials, agricultural machines, and metallurgy. These industries are those producing relatively heavy goods (high δ). On the other hand, the effect of distance on aggregate trade is the smallest for domestic equipment, electrical equipment, office equipment, metal work, and speciality chemicals.

Our results allow us to disentangle the effects of a change in distance on the patterns of trade from the effects of a change in trade costs such as tariffs. Lowering tariffs increases the extensive margin by $[\gamma-(\sigma-1)]$ and the intensive margin by $(\sigma-1)$. Panel (b) in Figure 5.1. displays 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. This shows the different sensitivity of the number of exporters and individual export volume to lower trade barriers by industry. The industry ranking is very different from that in panel (a). The industries displaying the greatest sensitivity to tariffs are office equipment,

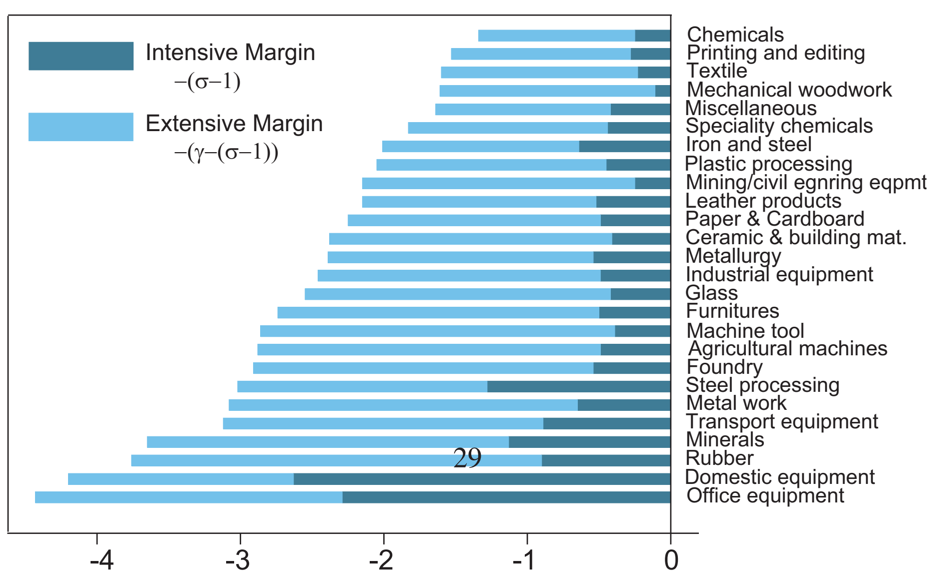
[17] We thank Daniel Mirza and Emmanuel Milet for computing and providing us with the freight data.

Figure 3: The estimated impact of trade barriers and distance on trade margins, by industry

(a) Impact of distance on trade margins



(b) Impact of a tariff on trade margins



domestic equipment, rubber, minerals, and transport equipment. Table 3 shows that these are industries characterized by above-average γ's, and hence for which the overall effect of trade barriers on trade flows is mostly shaped by γ. On the other hand, the least sensitive are chemicals, printing and editing, textile, mechanical woodwork, and speciality chemicals. The considerable differences between the panels (a) and (b) of Figure 5.1. proves that inferring predictions on the consequences of trade liberalization from distance coefficients is potentially very hazardous.

Finally, we use our estimated parameters δ, σ and γ to reconstruct the share of the extensive margin in the overall effect of distance or trade barriers on trade: $1-[(\sigma-1)/\gamma]$, which is the key figure in the literature. The trade-weighted average share across all industries for which coefficients are consistent is 74.2%. This number is much higher than the share of extensive margin obtained through the decomposition in Section 4. Hence, despite the restrictions on our sample of exporters, we obtain a number which closely matches the share of the distance effect from the extensive margin in Mayer and Ottaviano (2008). It is interesting to see how the structural estimations allow us to circumvent the data restriction and obtain the same results as those obtained from exhaustive samples.[18]

Figure 5.1. shows considerable variation in the share of the extensive margin in the global distance elasticity of trade flows. The share of the extensive margin ranges between 37.3% for office equipment to 93% for mechanical woodwork. Steel processing and chemicals are good examples of the importance of considering trade margins. The effect of distance on aggregate trade in these two sectors is almost the same (a 10% fall in distance increases trade by around 12.6%). However, for chemicals the increase in trade comes mostly from the entry of new exporters (the intensive margin accounts only for 18.6% of the increase in total trade), while over 42% of the increase in trade results from an increase in incumbents' market share for steel processing. The figures show that industries are likely to have very different responses to a change in trade barriers, beyond the consequences on aggregate trade. Trade policies may affect market structures very differently according to industries. Taking firm heterogeneity into account is thus very important for the assessment of the impact of trade liberalization measures on industry dynamics.

[18]The trade decomposition proposed by Hillberry and Hummels (2008) and Mayer and Ottaviano (2008) implicitly assumes that all firms are identically performant on export markets. Our definition of the extensive margin should result in a smaller share of extensive margin, which only accounts for the contribution of marginal exporters to total trade. Our results confort this prediction, as we find a slightly smaller share of extensive margin than the one in Mayer and Ottaviano (who find 75%) and Hillberry and Hummels (who estimate a share of 96%).

6. Conclusion

The empirical literature on the effects of trade integration on the structure on trade flows has been considerably affected by new trade models with heterogenous firms. In this paper we use individual export-behavior equations together with firm-level data to estimate the three parameters which determine trade flows in the gravity equations derived from heterogenous-firm models (Chaney, 2008): the elasticity of substitution (σ), the elasticity of trade costs to distance (δ) and the degree of firm heterogeneity (γ).

We here consider French exports to border countries, to control for the destination country's fixed cost and isolate the effect of variable cost on trade. We estimate three equations: a gravity equation at the firm-level, an export-selection equation and a rank-size distribution of productivity across firms, which provide us with a combination of the three parameters, δ, σ, and γ, for each sector. For a very large majority of sectors, the estimated gravity parameters are consistent in sign and size with theory: values of σ are strictly greater than 1 and the γs are greater than $\sigma - 1$. These industries account for 79.8% of total manufacturing French exports.

Obtaining unbiased estimates of the gravity equation parameters contributes to our understanding of the effect of trade integration on the patterns of world trade. It is particularly important to obtain these estimates since recent theoretical models have introduced major changes to the way in which existing empirical estimations should be interpreted.

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