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BORDER EFFECTS AND EFFECTIVE TRANSPORT COST

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Abstract [*]

In the agglomeration and growth process, the transport cost is the major factor affecting repartition, location and the spatial equilibrium of the economic activities, to which the economy converges, and consequently the growth process.

In this study, we make a first effort to estimate the effective transport cost on the Portuguese economy, using regional data on trade. The explanatory variables of the model are employment, wages, productivity and intra-regional and inter-regional distances.

We also try to estimate the effect similar to the border effect of McCallum (1995), which is fundamental to explain the inter-regional trade. This inter-regional border effects is the non-explained part of the influence of distance on trade. Our task is to estimate the border effect and effective transport costs of the tradable goods, since this determines the spatial dynamics involved and is more important than the average transport cost.

The obtained empirical results, if relevant and statistically significant, would thus be used in the estimation of a model of the new economic geography involving endogenous growth dynamics.

Introduction

The transport cost is a determining variable in the models of economic geography. In fact the centripetal and centrifugal forces, which are crucial in the choice of localisation for consumers, workers and firms, are dependent on the degree of flows, and the circulation of products between regions, and these, in turn, depend on the transport cost which are involved in this process. Consequently, the transport cost is a major determining variable in the formation of spatial balances and the possible processes of agglomeration or dispersion of economic activities and regional growth.

In order to provide an empirical analysis of the economic geography, it is thus necessary to estimate the effective transport cost, which such commercial transactions incur.

A bias arises in the estimation of the transport cost, which is caused by the heterogeneous nature of the traded products, and the distance they cover. In fact, due to the high transport cost of some products, these are traded specially in relatively short distances[1]. As we intend to estimate the average transport cost, the referred products may introduce a bias in the final results. In other words, if the trade of these products is mainly intra-regional, the average transport cost will be underestimated giving rise to a positive difference between the potential inter-regional trade estimated by gravitational models and the actual trade volumes. This "missing trade"[2] appears in the estimation in the form of a domestic bias, similar to the border effect of McCallum (1995).

The border effect may be defined as the additional reduction in the trade between different regions or countries, over and above that which can be explained simply by the size and the distance between the regions or the considered countries. This effect should not be present in inter-regional trade, as in theory, there are no barrier of any type. However, the empirical studies normally agree that the border effect exists and is significant. The border effect may have its origin in an underestimation of the influence of distance on the flow of trade, given that there are products that are specially traded over short distances.

In order to determine the importance of transport costs in the definition of the spatial equilibrium, Crozet (2000) put forward a method that combines these domestic biases in the estimation of the impact of distance on trade flows. We will subsequently use this method to isolate the border effect and to determine the transport cost in mainland Portugal.

Thus, in the first part we explain the importance of the border effect and the main theoretical and empirical contributions. In the second part, we present the theoretical model and the specification of the function that we will use to estimate the border effect and the effective transport cost. In the third, we introduce some facts related to the regional transport of goods in mainland Portugal and, in the fourth, we introduce

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[1] Consider, for example, products that have a very low ratio of the value to its respective weight, such as minerals, cement and fossil fuels. See Crozet (2000: 59).
[2] As defined by Trefler (1995).

the statistical data that are used in the empirical analysis. Finally, we present the first results obtained and the conclusions, which can be derived from the empirical analysis.

1. The Border Effect

Despite the processes of regional integration and the reduction of commercial barriers, the regional administrative borders and national political borders continue to be important obstacles in commercial transactions. This has been verified in the trade between countries of the OECD where the level of commercial integration is very heterogeneous: e.g. Wei (1996). However, it has also been shown in the trade between countries having a high level of integration: e.g. Head and Mayer (2000) and Nitsch (2000), who analysed the European Union, and McCallum (1995) and Helliwell (1996), who covered the United States and Canada. McCallum (1995: 622) summarizes the conclusions drawn from these studies by considering that "national borders in general continue to matter".

These studies use gravitational models in which the trade between two geographical areas is assumed to be an increasing function of the size of the regions and a decreasing function of the distance between them. Through these models, the potential transactions between two geographical areas can be estimated. It is usually concluded that the potential trade is higher than the actual trade.

Therefore, the studies mentioned above show that both inter-regional and international trade are influenced by a factor which reduces the traded volumes more than would be expected, factor that is known as the border effect. This effect matters whenever a regional or national border is crossed. Border effect measure the degree to which certain economic areas trade more between themselves in comparison to the trade between other equidistant areas of the same size. Recognizing its importance, Obstfeld and Rogoff (2000) consider that border effect is one of the "six major puzzles in international economics" and many studies have been carried out to measure it, and attempt to explain it[3].

In regional trade, the border effect also gives a measure of the degree of fragmentation or integration of the economy, given that it will be observed if the

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[3] See, for example, Anderson and Wincoop (2001).

access to the market in a specific region is different whether we consider local producers or producers of others regions.

McCallum (1995) provided the first empirical contribution to the study of this effect by estimating the determinants of commercial transactions between the Canadian provinces and the American States. He estimated the impact of the political border between the USA and Canada on the trade flows and concluded that a Canadian province imports approximately twenty-two times more from another Canadian province than it does from an American state of a similar size and distance away. He thus showed a considerable border effect. However, the identification of this fragmentation of the Canadian and the United States markets contradicts the common idea of a strong level of commercial integration between these two countries. Head and Mayer (2000) also pointed out that, because of the economic geography of Canada, with 85% of its population living within 100 miles of the American border, exactly the opposite results would be expected to those of McCallum's study (1995).

Hoover (1951) had already observed that political borders could settle very significant obstacles to commercial transactions. In fact, while analysing the rail networks of the United States and Canada he concluded that the majority of south-bound railway lines do not cross the border, which makes the transport between the two countries more difficult and onerous, thus giving rise to the border effect.

The bias observed in trade between regions separated by political borders can, according to Hoover (1951), be explained by the existence of national barriers to trade i.e. the imposition of tariffs and quotas; custom regulations; different tastes and traditions; language and physical obstacles between the countries, whether natural or of another type such as the absence of transport infrastructures. The bias on consumer preference, the costs and risks of exchange markets, the spatial concentration of the demand and the imperfection of the distribution networks can also be included to the above obstacles. However, these explanations are not sufficient to understand completely McCallum's (1995) results. In fact, the effect he observed at the time seems to be excessive, even though the eventual commercial barriers are taken into consideration. If the referred barriers explain those biases, then either there must be a large number of hidden barriers or the elasticity of substitution between the domestic products and the imported goods is very high. However, these hypotheses don't seem very reasonable to explain the trade between the countries.

McCallum's results (1995) are supported by Wolf (1997), who also showed the existence of border effects between American States. Using a gravitational equation, he compared the trade flows between the American States with internal flows. After taking into account the effects of size and distance, the commercial flows were found to be between 1.3 and 4 times more important within a state than between two equidistant states. Despite these domestic effects being clearly less important than those referred earlier, they are still significant and high enough to influence market access, and consequently the regional dynamics of agglomeration and growth.

Crozet (2000) estimated the domestic bias and the elasticity of distance transport cost in four European countries i.e. Germany, Spain, France and the United Kingdom, and also found significant border effects. In fact, after taking into consideration the distance between and the relative sizes of the regions involved, inter-regional trade is, on average, four times greater than the potential trade predicted by the model. It can thus be concluded that the transport costs are extremely important and increase rapidly with distance. Hence, to reduce their transport costs, firms would try to establish themselves near to their markets, reducing the probability of there being a significant process of spatial agglomeration. However, this probability will rise with the increasing importance of the economies of scale.

While studying international trade, Wei (1996) found that trade between countries within the OECD is nine times higher than the trade with countries that do not belong to OECD (but are nonetheless situated at the same relative distance away from each other). Head and Mayer (2000) have shown a domestic bias between countries of the European Union, which decreased from twenty-five to five between 1975 and 1995, certainly due do the reduction of trade obstacles and higher integration.

2. The Border Effect in a Model of Monopolistic Competition

We have already presented some of the studies related to the border effect and will now present and use Crozet's methodology to explain some theoretical issues and the way to estimate this effect. We will later use this methodology to estimate the border effects and the effective transport cost in mainland Portugal.

2.1. Theoretical Considerations

The use of a monopolistic competing market structure in models of economic geography allows to obtain demand equations which are relatively simple and close to the gravitational equations. These are used frequently in the estimation of potential trade flows.[4] This proximity is useful in order to study the impact of distance on trade flows and, consequently, in the study of the decision of firm location.

Consider a market structure of monopolistic competition in an area made up of R regions. Whatever the region is, all the consumers' have the same utility CES function, given by:

$$U_j = \left(\int_1^n x_k^{1-\frac{1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where n is the total number of varieties available in region j, x_k the quantity consumed of variety k within this region and σ is the elasticity of substitution between any two varieties.

Assuming that n_i is the number of varieties produced in the region; p_i the f.o.b. price of these products; τ_{ij} the iceberg transport cost between regions i and j, where $\tau_{ij} > 1$; ϕ the income share spent in consumption; E_j the income of region j; and q_j the price index of region j, then the value of the demand of the consumers of region j for products of the region i, m_{ij}, is defined as:

$$m_{ij} = \frac{n_i \left(p_i \tau_{ij} \right)^{1-\sigma}}{q_j^{1-\sigma}} \phi E_j \tag{2}$$

where, q_j is given by:

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[4] See Anderson (1979), Bergstrand (1985, 1989), along with Helpman and Krugman (1985, chap. 8).

$$q_j = \left[\sum_{r=1}^{R} n_r \left(p_r \tau_{rj} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{3}$$

The iceberg transport cost is fully supported by the consumers of region j, through prices, which means that:

$$p_j = p_i \tau_{ij} \tag{4}$$

where, p_j is the price paid by the consumers in region j. The value of the imports of the region j coming from region i is equal to:

$$m_{ij} = x_{ij} p_i \tau_{ij} \tag{5}$$

with x_{ij} being the traded volumes, but actually consumed in j. In fact, due to the iceberg transport cost, the quantity exported by i is given by $x_{ij}\tau_{ij}$, while the consumed quantity in j is given by x_{ij}, because a part of the total exports, equal to $x_{ij}(\tau_{ij}-1)$, melts down during the transport.

The transport cost is an increasing function of the distance between the two regions, d_{ij}. To compare the obtained results with the results form previous works, Crozet (2000) considers the specification proposed by Hummels (1999) for the transport cost. Therefore, the iceberg transport cost is given by[5]:

$$\tau_{ij} = B d_{ij}^{\delta} \tag{6}$$

where δ is the elasticity of distance transport cost, with B>0 and τ_{ij}>1.

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[5] Hummels (1999) considers that the transport cost increases with distance and can decrease when a common language exists in both regions, with the proximity and the non-existence of a national border between them. The B parameter measures these effects. See Hummels (1999: 8) and also Head and Mayer (2000: 7).

Substituting m_{ij}, τ_{ij} and q_j, in equation (2) we obtain:

$$x_{ij}p_i Bd_{ij}^{\delta} = \frac{n_i \left(p_i Bd_{ij}^{\delta}\right)^{1-\sigma}}{\left\{\left[\sum_{r=1}^{R} n_r \left(p_r Bd_{rj}^{\delta}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}\right\}^{1-\sigma}} \phi E_j \tag{7}$$

Thus:

$$x_{ij} = \frac{\left(p_i Bd_{ij}^{\delta}\right)^{1-\sigma}}{p_i Bd_{ij}^{\delta}} \cdot \frac{n_i}{B^{1-\sigma}\sum_{r=1}^{R} n_r \left(p_r d_{rj}^{\delta}\right)^{1-\sigma}} \phi E_j \tag{8}$$

Simplifying further, we obtain:

$$x_{ij} = \frac{n_i \left(p_i Bd_{ij}^{\delta}\right)^{-\sigma}}{B^{1-\sigma}\sum_{r=1}^{R} n_r \left(p_r d_{rj}^{\delta}\right)^{1-\sigma}} \phi E_j \tag{9}$$

Finally, the equation for the traded volumes is given by:

$$x_{ij} = \frac{n_i \left(p_i d_{ij}^{\delta}\right)^{-\sigma}}{\sum_{r=1}^{R} n_r \left(p_r d_{rj}^{\delta}\right)^{1-\sigma}} \phi E_j B^{-1} \tag{10}$$

Admitting that the transport cost depends only on the distance and the elasticity of distance transport cost, B equals one, the equation for the traded volumes becomes:

$$x_{ij} = \frac{n_i \left(p_i d_{ij}^{\delta}\right)^{-\sigma}}{\sum\limits_{r=1}^{R} n_r \left(p_r d_{rj}^{\delta}\right)^{1-\sigma}} \phi E_j \tag{11}$$

It can be seen from the equation (11) that the trade flows from i to j are negatively related with the price of the varieties produced in i and with distance between i and j, and positively related with the size of the two regions, as in a gravitational equation. Note that the size of the exporting region is determined by its supply capacity, that is, by the number of produced varieties, n_i, while the size of the importing region is determined by its income, ϕ, on which demand depends upon.

The price index of region j deflates the income of that region, and reflects the impact of competition in the market of region j on the companies of region i. The less the competition in region j, that is to say, the further away from market j the competitors of i are and/or the higher the production costs may be, the lower is the possibility of the activities of competitors having a negative effect on the companies of region i in the market of region j.

Therefore, the imports of region j coming from region i decrease with the number of competitors of other regions and increase with prices. Both the number of competitors and prices are weighted by the distance that separates them from j.

In order to transform equation (11) into an estimable one, some authors change the price index into a specific fixed effect of the importing country. Others[6] have introduced a measure of remoteness for the regions, which allows the effect of distance to vary according to the increased or decreased proximity of other commercial partners. Controlling remoteness allows two regions near to each other, but far away from any others, to trade more between themselves than two other regions, which are separated by the same distance but are closer to their commercial partners. According to Wolf (1997), the remoteness of a given pair of regions is measured by the ratio of distances between them and the average of their production

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[6] Including among others: Deardorff (1995), Wei (1996) and Wolf (1997). Each of these uses different specifications for the remoteness variable, using distance and the GDP. See Wolf (1997: 6) for a summary.

weighted by the average distance to all regions[7]. Wei (1996) uses a different measure by summing, for each region, the income of other regions weighted by the distance that separates them from the region under consideration.[8] The introduction of a measure of remoteness is still a matter of discussion. On the one hand, because the GDP does not reflect correctly the number of firms or prices of traded products, while on the other hand, because the parameters that are used are arbitrary values.[9]

To overcome this problem Crozet (2000), in line with Head and Mayer (2000), relates the trade flows towards region j with the internal flows of that region, i.e. he estimates the ratio of the two product flows, x_{ij} and x_{jj}. Using this method the price index disappears from the equation without being necessary to pass through a reduced form. It makes possible to estimate the price elasticity and the elasticity of distance transport cost, δ, while relating the distance coefficient with the price coefficient.

2.2 The Under-estimation of Transport Costs

Using the method proposed by Head and Mayer (2000), Crozet (2000) also considers that, with a demand bias in favour of varieties produced in the region, the ratio between flows from region i to region j and flows within region is given by:

$$\frac{x_{ij}}{x_{jj}} = \frac{1}{b} \frac{n_i \left(p_i d_{ij}^{\delta}\right)^{-\sigma}}{n_j \left(p_j d_{jj}^{\delta}\right)^{-\sigma}}, \text{ where b>1} \tag{12}$$

Estimating this equation, in its linear and logarithmic form, the impediments to trade, or the border effects, are measured by the constant, which will be negative and have an absolute value equal to log b.

The effect of distance on the estimation of average transport costs will now be considered. To do this, we admit only two types of tradable products, 1 and 2, where product 1 supports a relatively reduced transport cost and product 2 a relatively higher

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[7] See Wolf (1997: 6-7).
[8] See also Helliwell (1997).
[9] As Head and Ries (1999) point out, some authors do not perfectly understand the exact meaning of this variable in the gravitational equation, as they add not only a variable of remoteness specific to the importing region but also a variable specific to the exporter, which has no theoretical justification.

value. The ratio between flows from region i to j to flows within the region j are given by:

$$\frac{x_{ij}}{x_{jj}} = \frac{n_{1i}\left(p_{1i}d_{ij}^{\delta 1}\right)^{-\sigma} + n_{2i}\left(p_{2i}d_{ij}^{\delta 2}\right)^{-\sigma}}{n_{1j}\left(p_{1j}d_{jj}^{\delta 1}\right)^{-\sigma} + n_{2j}\left(p_{2j}d_{jj}^{\delta 2}\right)^{-\sigma}} \qquad (13)$$

where $\delta 1 < \delta 2$

As the elasticity of distance transport cost of product 2, $\delta 2$, is relatively high, the trade of this product between the two regions will be relatively low, so that:

$$n_{2i}\left(p_{2i}d_{ij}^{\delta 2}\right)^{-\sigma} < n_{2j}\left(p_{2j}d_{jj}^{\delta 2}\right)^{-\sigma} \qquad (14)$$

This gives rise to the risk of, during the economic estimation process, over weighting the product 1, as the commercial transactions of product 2 between the two regions may be relatively low. Consequently the average transport cost has clearly been underestimated by taking into account the transport cost of product 1, $\delta 1$.

Hence, re-writing equation (13) gives:

$$\frac{x_{ij}}{x_{jj}} = \frac{n_i\left(p_i d_{ij}^{\delta 1}\right)^{-\sigma}}{n_j\left(p_j d_{jj}^{\delta 1}\right)^{-\sigma}} \left[\frac{\dfrac{n_{1i}}{n_i} + \dfrac{n_{2i}}{n_i}\left(d_{ij}^{\delta 2-\delta 1}\right)^{-\sigma}}{\dfrac{n_{1j}}{n_j} + \dfrac{n_{2j}}{n_j}\left(d_{jj}^{\delta 2-\delta 1}\right)^{-\sigma}}\right] \qquad (15)$$

Considering that the structures of production are identical in the two regions, i.e. $\left(\dfrac{n_{1i}}{n_i} = \dfrac{n_{1j}}{n_j}\right)$ and $\left(\dfrac{n_{2i}}{n_i} = \dfrac{n_{2j}}{n_j}\right)$, and if $d_{jj} < d_{ij}$, then:

$$\left[\frac{\dfrac{n_{1i}}{n_i} + \dfrac{n_{2i}}{n_i}\left(d_{ij}^{\delta 2 - \delta 1}\right)^{-\sigma}}{\dfrac{n_{1j}}{n_j} + \dfrac{n_{2j}}{n_j}\left(d_{jj}^{\delta 2 - \delta 1}\right)^{-\sigma}} \right] < 1 \tag{16}$$

We can conclude that the transport cost may be underestimated in equation (12) since part of this effect is included in the constant and may therefore be considered as a border effect. However this only can be explained by the fact that certain products are specially traded over relatively short distances.

2.3. The Model

Our task is to estimate the domestic biases and subsequently estimate a value for the elasticity of distance transport cost and hence create a gravitational equation based on equation (12).

We have to notice that the model has a monopolistic competition market structure, in which all the traded products are differentiated, with employment being used as the only factor of production. This model similarly assumes proportionality between the number of varieties and the production due to the behaviour of the manufacturers. A form that can be estimated is obtained by applying the condition of profit maximization, which assures that the price is proportional to the nominal salary, and by establishing that the number of firms is proportional to the employment.

Taking the log of equation (12), we get a relative demand function, which can be estimated by using panel data settings, where i is the exporting region, j the importing region and t the respective year:

$$\log\left(\frac{x_{ijt}}{x_{jjt}}\right) = -\log(b) + \log\left(\frac{L_{it}}{L_{jt}}\right) - \sigma\log\left(\frac{w_{it}}{w_{jt}}\right) - (\delta\sigma)\log\left(\frac{d_{ijt}}{d_{jjt}}\right) + \mu_{ijt} \tag{17}$$

where L_{kt} represents the employment in region k and is a proxy of the number of varieties produced n, w_{kt} represents the average remuneration of region k, which constitutes a proxy for the prices in this region, and u_{ijt} is the error term. We also

have used as a proxy for prices the productivity. The border effect is measured by the exponential of the absolute value of the constant in this equation. To determine the elasticity of distance transport cost, δ, we simply have to calculate the ratio between the distance and salaries coefficients.

Having presented the theoretical model, we will now analyse some facts regarding regional trade in mainland Portugal, and estimate the parameters.

3. Commercial Flows in Portuguese Regions: What the Facts Show

In figure 1 we can see the average distance travelled for types of product during the period 1996 and 1999. This average distance is a weighted mean obtained by considering the total number of kilometres travelled and the total number of journeys made.
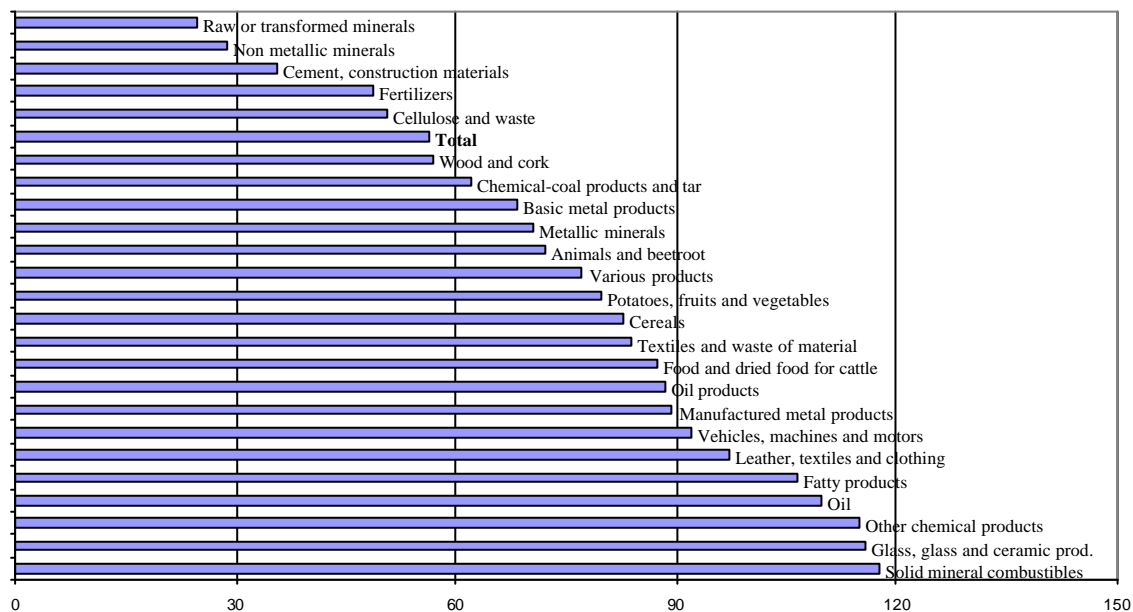

Figure 1: Average distance, in km, travelled by types of products, between 1996 and 1999.

We can see that the average distance travelled by products between 1996 and 1999 was 56km. Among the products that on average travelled a relatively short distance were minerals, cement, and construction materials. These products have, in majority, a very low ratio of the value of the products to its respective weight, and therefore are specially traded over short distances. Those that travelled on average longer distances

included solid minerals combustibles, glass and glass-based products, ceramics, other chemicals, crude oil, fatty products, leather, textiles and clothing, vehicles, machines and motors. These products are essentially final consumption products, such as fatty products, leather, textiles and clothes along with products of relatively high value such as vehicles, machines and motors. The presence of oil and oil-based products is due to these sectors' own characteristics with very specific sources of supply. It can also be seen that no products travelled, on average, more than 120km, which is a relatively short distance especially considering the shape and geography of Portugal.

We can thus conclude that distance does seem to influence product flows. On the other hand, some of these commercial flows are between economic agents that are not located very far away from each other meaning that a large proportion of these flows are especially intra-regional in nature.

4. Period of analysis and data used

Our study only covers the period 1996 to 1999, as part of the necessary data is not available for earlier periods. We have only used data from the Road Transport of Goods Enquiry, which includes the freight transported among 99 groups of products according to the NST/R[10]. We have grouped these data into 24 large categories, in accordance with the tables given by INE[11]. The enquiry supplies data on the transport of goods between and within the five regions NUTS II into which mainland Portugal is divided. The exclusive use of the statistics based only on road transport does not place any serious limitations on the empirical study since transport by rail, sea, and air is not particularly significant in the majority of groups considered.

In fact, sea transport is only relevant in the transport of oil and oil-based products.[12] Rail transport is more important, however in 1998 and 1999 (the only years for which we have data relating to the transport of goods by rail) only represented about 3% of the road transport of goods. In fact, in 1998, were transported 8 966 thousands of tonnes by rail and 262 752 thousands of tonnes by road; in 1999,

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[10] Standard Good Classification for Transport Statistics/Revised.
[11] INE is the Portuguese National Statistical Office.
[12] During 1998, the transport of these products by sea represented only 40% of the average road transport for the period 1996 to 1998. See Ramos (2001).

were transported 9 265 and 269 754 thousands of tonnes by rail and road, respectively.

For this reason we decided to consider only the road transport of goods, which enable us to use a longer period of analysis. However, even the information available from the "Road Transport of Goods Enquiry" has its limitations[13], two of which are described below.

Firstly, the information related to the transport of goods by road is obtained by sampling methodology, which could make its use ill advised for the regional desegregation at the level of NUTS II in respect to some less-traded products. On the other hand it is not possible to isolate totally the intra- and inter-regional trade from the international trade of goods. Certainly, some of these products were imported from, and others exported to, the rest of the world, but they would have been transported by road.

Secondly, the source of information regarding the transport of goods by road, the INE "Road Transport of Goods Enquiry", only covers transport by heavy goods vehicles with a gross weight of more than 3 500kg (lorries and tractors). Lighter vehicles are excluded even though they could be responsible for a significant amount of both intra- and inter-regional trade. The available data could thus favour products with a lower degree of transformation.

The data source regarding employment and average wages was the yearly survey, published by the Ministry of Employment for all existing firms[14]".

For the gross value added and employment, which are necessary to calculate productivity, we have used the "regional accounts", of the INE.

The inter-regional distances travelled were calculated using the distance by road between the two main cities of each region. Intra-regional distances were obtained in the usual way i.e. by considering that S_j represents the area of the region j in square km, so that the distance within the region j, d_{jj}, is given by $d_{jj} = \frac{2}{3}\sqrt{\frac{S_j}{\pi}}$. With the latter distance measure, we are assuming that production is located at centre of the region and consumers are uniformly distributed across the region[15].

The database was constructed taking each sector in turn.

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[13] See Ramos (2001).
[14] Database SISED, Ministry of Employment, Lisboa.
[15] See Head and Mayer (2000, 2002).

5. Some results obtained from the estimation process

To estimate equation (17), we have used the feasible generalized least squares method with panel data settings. We have started to use the average remuneration as a proxy for regional prices. Some of the results obtained are presented in table 1. In columns (2) and (4) the results were obtained after correcting for heteroscedasticity.

Table 1. Remuneration as a proxy for prices.

	(1)	(2)	(3)	(4)
Dependent Variable	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$
Constant	0,129*** (0.79)	0.029*** (0.49)	-0.344** (-2.27)	-0.473* (-8.96)
Relative employment	1	1	0.567* (20.98)	0.571* (40.69)
Relative remuneration	0.807* (3.05)	0.725* (7.19)	1.575* (6.44)	1.515* (15.73)
Relative distance	-1.669* (-18.03)	-1.578* (-40.18)	-1.338* (-15.47)	-1.230* (-34.38)
Number of observations	1192			
Number of Groups	359			
Wald test	333.77	1654.32	670.54	4059.36
Log likelihood	-2495.558	-1992.198	-2379.352	-1888.27

Note: The t-stat is given in brackets.
* Coefficients are statistically significant at the 1% level.
** Coefficients are statistically significant at the 5% level.
*** Coefficients not statistically significant.

The results obtained deserve some comment. The Wald test is a test of the coefficients based on the estimated variance. Due to the value of the test we reject H_0 and therefore accept the coefficients. In columns (1) and (2) we imposed the restriction that the coefficient of the relative employment be equal to one as suggested by the theoretical model, a restriction that was not used in columns (3) and (4). With the referred restriction, the constant is not statistically significant and the sign for relative remuneration is positive, that is, contrary, to what was expected from equation (17). If we do not impose this restriction on the estimation, as in columns (3) and (4), the coefficient for the relative employment becomes positive and different from one. It has a value of 0.567 and 0.571, respectively in columns (3) and (4). The

estimated constant and coefficient for relative distance both have the expected negative signs.

In all these estimations, the sign obtained for the average relative remuneration was always opposite to that predicted by theory. There could be two explanations for this. The first is related to the nature of the data. The relative remunerations were, in fact, calculated from the average remunerations of workers employed at establishment level. Hence there are figures related to self-employed work that were not considered. This could have biased the calculation of average remuneration. The second is related to the use of the remuneration average as a proxy for product prices. This could mean that the variable considered might not reflect correctly the differences in productivity between the regional sectors and therefore is not a good proxy for product prices.

Consequently, it makes no sense to calculate the elasticity of distance transport cost from the results obtained. It is thus necessary to consider other proxies, which reflect more accurately the prices in the various sectors and regions.

To estimate the domestic bias, bearing in mind the latter limitation, we calculate the exponential of the value of the constant in absolute terms. As the coefficients are not statistically significant in columns (1) and (2), we can only calculate the bias obtained using the estimations represented in columns (3) and (4). The respective results obtained are 1.41 and 1.60. We can thus conclude that short-distance, intra-regional trade is, on average, 1.41 to 1.60 times more important than expected by the model, which supports the idea of a border effect. With the limitation previously noted in this study, we estimate the domestic bias of mainland Portugal to be less than in Spain or France, where the corresponding values were estimated by Crozet (2000) to be 7 and 3 respectively.

As these results are not satisfactory, we have considered another proxy for the prices i.e. the productivity. The results obtained from the estimation of equation (17), using the productivity as a proxy for prices, are presented in table 2. In columns (2) and (4) the results were obtained after making a correction for heteroscedasticity.

As in table 1, in columns (1) and (2) we imposed the restriction that the coefficient of the relative employment be equal to one.

Table 2. Productivity as a proxy for prices.

	(1)	(2)	(3)	(4)
Dependent Variable	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$	$\log\left(\dfrac{m_{ij}}{m_{jj}}\right)$
δ	6.14	4.96	-	-
Constant	0.139***	0.006***	-0.323*	-0.477*
	(0.85)	(0.09)	(-2.10)	(-9.24)
Relative employment	1	1	0.578*	0.587*
			(20.17)	(37.59)
Relative productivity	-0.271*	-0.313*	0.232**	0.224*
	(-2.68)	(-8.78)	(2.34)	(4.74)
Relative distance	-1.663*	-1.552*	-1.347*	-1.217*
	(-17.95)	(-37.75)	(-15.33)	(-33.5)
Number of observations	1192			
Number of Groups	359			
Wald test	331.11	1546.58	616.22	2860.54
Log likelihood	-2496.6	-1978.502	-2396.991	-1907.528

Note: The t-stat is given in brackets.
* Coefficients are statistically significant at the 1% level.
** Coefficients are statistically significant at the 5% level.
*** Coefficients not statistically significant.

   With this restriction, the constant is still not statistically significant, but the signs of relative productivity and relative distance are both now negative, as expected. Consequently, we may calculate the elasticity of distance transport costs, which we also show in table 2. This elasticity, calculated as the ratio between the coefficient for relative distance and relative productivity, is equal to 6.14 in the first column and 4.96 in the second. In Crozet (2000), the same elasticity varies from 0.47 in the case of Germany, to 0.90 in the case of Spain. The results that we have obtained are far higher.

   If we do not restrict the coefficient of relative employment to having a value of one, the results are different, as we can see from columns (3) and (4). The constant now has statistical significance. The relative employment has a positive coefficient, but is different from one, and the relative productivity has a positive sign, the opposite to that expected.

   Consequently, we cannot calculate the elasticity of distance transport cost from the obtained results either.

   The domestic bias, using the estimations represented in columns (3) and (4), is 1.38 and 1.61 respectively. These are very similar to the results obtained from table 1.

In this case, we can thus conclude that short-distance, intra-regional trade is, on average, 1.38 to 1.61 times more important than predicted by the model.

Conclusions

Through studying the border effects developed by McCallum (1995), one can measure the domestic biases that affect trade. These are interpreted as the cost in terms of the reduction of trade flows resulting from the crossing of either regional or international borders.

All authors have previously concluded that, whatever the period or geographical area, there is a border effect which considerably reduces trade flow. Applying this model to the case of Portugal we find that the same holds true. In fact, intra-regional trade is 1.38 to 1.61 times more important than predicted by the model, although this is less than in other European countries such as Spain and France. We have noted, however, that the results themselves are biased as we also obtained, in these cases, a negative value for the elasticity of distance transport cost contrary to the expectations of the theory.

When we use as a proxy for prices the productivity, the results have allowed us to calculate an elasticity of distance transport cost to be equal to 6.14 or to 4.96, which is far higher than the results obtained for Germany, Spain, France and Great Britain.

Finally, it should be noted that this is a study still in progress. Further work should either use different types of data, or correct the existing data by using other variables in order to obtain results that are more consistent with theory

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