TRADE MARGINS, TRANSPORT COST THRESHOLDS AND MARKET AREAS: MUNICIPAL FREIGHT FLOWS AND URBAN HIERARCHY

Jorge Díaz-Lanchas
Carlos Llano
José Luis Zofío

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Trade margins, transport cost thresholds and market areas: Municipal freight flows and urban hierarchy*

Jorge Díaz-Lanchas[1] Carlos Llano[2] José Luis Zofío[3]

Abstract

Recent research has proposed theoretical foundations on why trade flows tend to agglomerate in some specific cities meanwhile there is no clear empirical evidence on this fact. Using a micro-database on road freight shipments within Spain for the period 2003-2007, we consistently decompose the total value of municipal freight flows into the extensive and intensive margins at the European Nuts-5 (municipal), 3 (provincial) and 2 (regional) levels to study the impeding effect of an actual generalized transport costs on trade flows. We confirm the accumulation of trade flows up to a transport cost value of 330 euros and conclude that this high density is not explained by the existence of administrative limits (home bias effects) but to significant changes in the trade flows-transport costs relationship. To support this hypothesis, we identify significant thresholds in the trade flows-transport costs relationship that are calculated by way of the Endogenous Chow Test of structural change. These breakpoints allow us to split the sample and control for successive administrative borders in both the extensive and intensive margins. Relying on these thresholds we define relevant market areas corresponding to specific transport costs values that portrait a consistent urban hierarchy system, thereby providing clear evidence of the predictions made by the Central Place Theory.

Keywords: Breakpoints, Municipal Freight Flows, Transport Costs, Market Areas, Urban Hierarchy, Central Place Theory

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[1]Díaz-Lanchas: Corresponding author. Department of Economic Analysis: Economic Theory. Universidad Autónoma de Madrid and Lawrence R. Klein Institute/CEPREDE. 28049 Cantoblanco. Madrid. Email: jorge.diaz@uam.es

[2]Llano: Department of Economic Analysis: Economic Theory. Universidad Autónoma de Madrid and Lawrence R. Klein Institute/CEPREDE. 28049 Cantoblanco. Madrid. Email: carlos.llano@uam.es

[3]Zofío: Department of Economic Analysis: Economic Theory. Universidad Autónoma de Madrid and Lawrence R. Klein Institute/CEPREDE. 28049 Cantoblanco. Madrid. Email: jose.zofio@uam.es

1 Introduction

Why and to what extent trade flows tend to agglomerate in some specific places within a country are usually topics left out of the analysis due to the absence of very detailed micro-data on interregional trade flows.[4] There are some studies in which trade flows agglomerate as a result either of intermediate inputs flows (Hillberry and Hummels, 2003; Hillberry, 2002a) or because of the location of firms close to a real border as to reduce transport costs when trading with other countries—Chen (2004); Llano-Verduras et al.(2011). Conversely, there is not a systematic analysis on why trade flows concentrate in cities within a country, specially using very detailed trade flows. In this sense, the study by Hillberry and Hummels (2008) sheds light on the appearance of an internal "home bias" at the municipal level once accurate interregional trade flows and very precise measures of internal distance are used, although they concluded that this (local) "internal home bias" is a reductio ad absurdum of the home bias effect observed at the international level.

In this paper, we extend the analysis by these last authors incorporating new econometric techniques related to trade and urban economics, explaining why trade flows concentrate in some specific places resulting in a hierarchical pattern of cities. In the process, we bear in mind that most of the trade literature focuses on international trade flows, even if the largest share of the trade activity is performed within a country, and specifically, between cities, showing how pertinent the present study is.

Going beyond the study by Hillberry and Hummels (2008), we argue that this "internal home bias effect" is an illusion created by the existence of transport costs thresholds which shape a series of trade or market areas driven by the biggest trading-cities within a country. Indeed, in a further step, we present empirical evidence by which this concentration of trade flows around bigger cities responds to the existence of a hierarchical urban system as it is predicted by the Central Place Theory—McCann (2001); Mulligan et al. (2012); Parr (2002).

To perform this analysis, we make use of micro-data at the highest possible level of spatial disaggregation corresponding to individual shipments at the Nuts-5 municipal level, for the period 2003-2007. This particular database allows us to determine the existence of a concentration of trade flows in small areas (in this case cities) defin-

[4]Recently, there have appeared studies such as Borraz et al. (2012); Llano et al. (2010); Yi (2010); Yilmazkuday (2012) from an empirical perspective; meanwhile from a theoretical approach Behrens et al. (2013) provide a promising attempt to model how trade frictions affect goods shipped between cities.

ing natural trade areas in the spirit of the central place and location theory—Tabuchi and Thisse (2011), and whose geographical reach is directly related to these transport costs thresholds, which may even exceed alternative levels of administrative aggregation of spatial units; particularly, Nuts-5 and Nuts-3 territorial units. This allows us to maintain that it is precisely the existence of these transport-related breakpoints (thresholds)—not always coinciding with relevant administrative geographical limits—what really explains the appearance of an “internal home bias effect”.

This paper presents several empirical novelties that link and extend different literatures: 1) the study of the internal home bias effect (internal border effect) within a country: Hillberry and Hummels (2003, 2008); Hillberry (2002a) against which we argue that administrative borders do not play an effective role in halting trade as administrative impediments to trade have been removed since long within countries as a result of “single-market” agreements; 2) the trading-cities theoretical literature whose empirical contrast is still pending: Anas and Xiong (2003); Behrens (2005); Cavailhes et al. (2007), and to which we provide relevant illustrations and complementary insights; 3) the study of market areas as regional boundaries depending on the geographical reach of trade: Löffler (1998), and, finally, 4), the re-emergence of the Central Place Theory literature—McCann (2001); Mulligan et al. (2012); Parr (2002); Tabuchi and Thisse (2011).

To accomplish these goals we rely on: 1) the compilation of a very detailed panel dataset (2003-2007) on individual freight trade flows; 2) the definition and calculation of a precise and realistic economic measure of transport costs associated to these flows: the Generalized Transport Cost (GTC) performs better that its usual distance and travel time counterparts in panel data contexts; 3) the adoption of a new methodological approach within the trade literature based on structural econometric tests (endogenous Chow Test) to determine transport cost thresholds, which in turn 4) allows us to define natural market trade areas at different spatial levels of aggregation for the overall value of trade, and its extensive and intensive margins; 5) the interpretation of results in terms of the central place and location theory and their discussion by way of suitable Geographic Information Systems (Arc/GIS) illustrations; and, finally, 6) the study of all these issues using panel data econometrics that enable us to capture the dynamics of the relationship between trade flows, transport costs and internal border (home bias) effects.

To perform this study we adopt a sequential strategy. The first step requires the compilation of a novel database on road freight shipments consisting of micro-data for individual deliveries between Spanish municipalities.[5] The statistical information reported in the RFTS allows us to decompose the value of trade flows into the extensive and the intensive margins following the trade flows definition proposed by Hillberry and Hummels (2008).

The next step is based on RFTS data reporting the origin and destination of a shipment. For each bilateral freight service we calculate the actual monetary measure of transport costs, i.e., generalized transport cost, GTC. This GTC corresponds to the minimum cost of joining any origin and destination, defined as the sum of the cost related to distance (e.g., fuel, toll, tires) and time (e.g., salaries, insurance, taxes). To make these calculations we have resorted to programming techniques using Geographic Information Systems (Arc/GIS) that allow the optimization of the least cost routes through the existing road network in the years 2003-2007. In contrast to all previous studies using the standard and non-monetary transport cost proxies of distance and time, we introduce a real euro measure of the spatial related frictions affecting trade.

Subsequently, to study the dependence of trade flows on transport costs and the magnitude (either real or illusory) and significance of the “internal home bias effect” we rely on the pseudo-poisson maximum likelihood (PPML) estimator proposed by Santos Silva and Tenreyro (2006, 2010, 2011), as the most efficient way to control for pervasive zero value trade flows and heteroskedasticity problems within the gravity model. The results obtained using the PPML estimation including time-varying origin and destination fixed effects, show that “municipal boundaries” have a stronger impact on trade flows and the extensive and intensive trade margins than the results reported by Hillberry and Hummels (2008); i.e., trade inside municipalities or between contiguous municipalities is much more important than trade between non-contiguous or long distant municipalities, especially in the extensive margin. This is explained by the changing pattern (elasticity) of the effect of transport costs on trade, which is particularly intense for short distances (euros) rather than any other border effect impediment. In this sense, considering administrative boundaries not as borders haltering trade, but as likely distances where the trade flow-transport cost relationship changes, they do reflect different effects on trade. Indeed the borders between provinces (Nuts-3) have

[5] The Road Freight Transportation Survey, RFTS, differs in several ways from the American Commodity Flow Survey undertaken through a partnership between the Census Bureau and the Bureau of Transportation Statistics (DOT). Relevant for this study is that in the latter case, the surveyed statistical units are production establishments (wholesalers and retailers), while the RTFS surveys road freight companies producing the transportation service.

a seizable effect on all the trade decomposition variables, but lower than the municipal level (Nuts-5), while regional borders (Nuts-2) have no significant or even an inverse effect on trade flows.

These findings corroborate the idea that the impact of bigger administrative boundaries (Nuts-2) on trade flows is not as important as the trade literature has emphasized: Chen (2004); Hillberry and Hummels (2008); Requena and Llano (2010); Wolf (2000). Indeed, this result suggests that the trade-concentration effect at the municipal level is highly related to agglomeration economies (Chen, 2004; Hillberry, 2002a; Puga, 2010).

Going in a further step as to understand this localized trade pattern, we argue that these agglomeration economies only take place around large cities because of the existence of an urban hierarchy system that emanates from the Central Place Theory (Mulligan et al., 2012; Parr, 2002; Tabuchi and Thisse, 2011). Hence, the so called "home bias effect" arises at the municipal level because high-order cities act as supply centers either for theirs metropolitan areas or for the lower rank surrounding cities. A relationship not explored thoroughly in the trade and urban empirical literature.

To study this hypothesis we determine to what extend the extensive margin of trade (number of shipments) is geographically located at very short distances, while the intensive margin (average value per shipment) remain basically constant, reflecting that the effect of transport costs on each component is quite different. To achieve this goal, we introduce a new methodology in the trade literature proposed by Berthelemy and Varoudakis (1996) for endogenous economic growth models. These authors conjecture the existence of different structural models between specific breakpoints, and propose an endogenous Chow Test that we adopt to divide the sample in sub-samples in order to determine the existence of differences in the trade flows-transport costs relationship.

In the current framework, as trade flows are geographically localized in terms of low transport costs (short distances), we perform this test to determine if GTCs (transport costs) are conditioning this particular trade pattern. Our hypothesis is based on the idea that transport costs and GDPs in the gravity equations cannot have the same effect on trade as the geographical distance of trade associated to transport cost increases. We conjecture that this localized trade pattern in short distances is due to the extensive margin, but once trade flows achieve a relevant breakpoint (a GTC threshold), the extensive margin and the intensive margin present two diverging and even opposite patterns; i.e., the intensive margin begins to gain relevance while the extensive margin becomes flat at rather low values. That is why we cannot estimate the effect of administrative boundaries over trade flows as a mean effect for the whole spectrum of distances mainly because not all the administrative boundaries appear in every shipment and are not equally important,[6] i.e., neither the extensive and intensive margins always dominate at the same GTCs ranges.

Furthermore, we have performed the structural Chow Test several times in order to determine what are the transport cost thresholds that condition interregional trade flows. Once we have determined the existence of different breakpoints, we split our PPML regressions in terms of these new thresholds—in contrast, for example, to Eaton and Kortum (2002) who divide trades flows considering arbitrary distances. With these new breakpoints, we conclude that the border (home bias) effect is not unique, while it does not have an average nor a linear impact on trade as the trade literature emphasizes. Indeed, as these breakpoints are not affected by arbitrary administrative borders, we argue that it is precisely the use of these breakpoints what really matters when studying the border (home bias) effect on trade flows as they spill out over consecutive administrative boundaries.

Based on the statistical determination of these transport cost thresholds we argue that they define natural market areas within a country. As this methodology on structural breaks has never been considered in the trade literature, we provide the first illustration of its potential in relation to the Central Place Theory (CPT) models and its associated market areas. Different thresholds create concentric iso-GTCs rings representing the geographical reach of trade for a location (city), which is increasing on its size and eventually overlaps with the market area of other locations. These market areas naturally define an urban hierarchy providing an empirical justification of the central place theory.

Moreover, according to Parr (2002), O'sullivan (2003) and Mulligan et al. (2012), although central place theory predicts the existence of market areas and explains how cities supply their surrounding areas by way of trade flows, the existing empirical studies fall short from this reference, since they provide illustrations based on population agglomeration rather than actual trade flows. Related to this goal we propose a new mapping representation based on municipal product diversification, and how these calculated market areas shape the urban hierarchy proposed by the CPT by which larger

[6] For instance, if a shipment is delivered at a cost of 500€ (about 455 km or 5 hours at the legal speed limit of 90 km/h), we must analyse what margins predominate and what are the spatial limits in which each one of them takes place (Nuts 5, 3 or 2).

municipalities (Rank 1 and Rank 2 cities) determine an area of influence which is more extensive than the one obtained for smaller cities (Rank 3 or Rank 4 cities). The empirical regularities that we find are a promising result for future research linking trade and central place theories.

Once the motivation of the study and the review of the literature have been introduced, we lay out the structure of the article. The next section discusses the database on municipal trade flows and the generalized transport costs, justifying why the GTC is the most suitable measure of transport cost in a panel data framework. Section 2.3 presents the decomposition of the value of trade into the extensive and intensive margins, analyzes their values based on nonparametric kernel density distributions, and shows the results obtained with different specifications of the gravity model using the pseudo-poisson distribution. Here we discuss the determinants of the value of trade and its margins in terms of our monetary measure of transport costs. Section 4 discusses the structural breakpoint methodology based on the endogenous Chow Test that allows to determine the transport cost thresholds, and successively replicate the PPML regressions for each range of trade values according to these thresholds. In section 5 we interpret and illustrate our results in terms of the central place theory, mapping a hierarchical system of cities and their overlapping regional boundaries. The last section draws the conclusions.

2 Trade flows and their extensive and intensive margins

2.1 Trade value data: The road freight transportation survey

For this study we rely on a micro-database on shipments by road within Spain during the period 2003-2007 elaborated within the research project C-intereg.[7] This database is based on the annual Road Freight Transportation Survey, RFTS, compiled by the transport division of the Ministerio de Fomento, which randomly surveys a sample of freight companies and independent truckers, with vehicles over 3.5 tons and operating within the national territory. This database surveys almost 85% of all Spanish internal trade flows; the remaining 15% corresponding to rail, maritime and air modes. It

[7]This project estimates, as far as we know, the largest database on interregional trade flows estimated in Spain. It includes bilateral trade flows specifying the region (Nuts-2) and the province (Nuts-3) of origin and destination, both in tones and euros. For further information see Llano et al. (2010)

includes information about the characteristics of the vehicle and shipments, such as the number of tons carried out by the truck,[8] the number of shipments between the origin and the destination , the type of product,[9] the operations performed by the truck in each shipments, as well as the actual travel distance in kilometers between the geographical origin and destination of each shipment (recorded at the Nuts-5 municipal level). As a result, for each shipment, it is not necessary to approximate the distance as done in other studies working with databases that record the origin and destination of the shipment by municipal or ZIP codes (e.g., distance between the centroids of these areas), as the true travelled by the vehicle is reported.[10] Therefore, and thanks to this distinctive feature of the database, we can also research intra-municipal trade flows (trade within municipalities); a relevant micro level flow that is normally left out of the analysis when the database does not record the real distance of shipments.[11]

For the 2003-2007 period, the database contains more than 1.890.000 records involving, on average for all these years, 7.178 municipalities of origin from where a freight service is made and 7.913 destinations. However, most of these origins and destinations are municipalities of little relevance in terms of population and trade volumes. Therefore, so as to ease computations we have considered only municipalities that, on average for the period, had over 10.000 inhabitants. As a result, we get a sample of 633 municipalities whose trade volume by road represents a 75.5% of the total.

Since the survey does not provide information about the value of the traded goods, product prices (in euros per ton) are needed so as to obtain a magnitude of the total value moved once they are multiplied by the tons carried. These prices are not available at the municipal level (Nuts-5) in any of the official databases because of statistical confidentiality. To overcome this limitation, we rely on the alternative interregional trade flows database compiled by the C-intereg project. With this database we calculate a price vector, measured in euros per ton, for the whole period. However,

[8]This corresponds to the real load of the truck in tons. Note that the truck load may range from zero to 100%, so the database may record empty truck movements as a result of the vehicle moving to a destination where it will be eventually loaded.

[9]In the micro-database, commodities are classified attending to the Eurostat classification NST-R which differentiates between 180 products.

[10]Unfortunately, the database does not compile any information on the firms involved in the shipments. However, since we know the type of product being shipped we can approximate the production sector of the firm.

[11]We highlight that the RFTS database reports the precise door-to-door distance reported by the freight company for each shipment, offering a new level for intra-city or inter-city transport cost, which improves in itself the distance measures used in other studies that are based on area centroids.

these prices are calculated at the provincial level, therefore, we are forced to assume that prices at the municipal and provincial levels are equal. This assumption implies that the pricing rules determining their level at municipal level, i.e., costs and mark-ups over costs, are similar to those observed at provincial level, e.g., similar labor and intermediate costs.

2.2 The generalized transport cost (GTC)

Another novel aspect of this study is the use of a real (monetary valued) measure of transport cost that clearly improves those normally used as approximations, mainly geographical distance. This variable corresponds to a Generalized Transport Cost (GTC) definition corresponding to the least cost itineraries between an origin and a destination. The GTC is calculated using GIS software (Arc/GIS) with the digitalized road network, as discussed in Zofío et al. (2011). GTCs differentiate economic costs related to both distance and time. The distance economic cost (euros per kilometer) includes the following variables: Fuel costs (fuel price); Toll costs (unit cost per km, multiplied by the length of the road); Accommodation and allowance costs; Tire costs; and Vehicle maintenance and repairing operating costs. On the other side, the time economic cost (euros per hour) includes the following variables: Labor costs (gross salaries); Financial costs associated to the amortization; Insurance costs; Taxes; Financing of the truck (assuming that it remains operative only for a certain number of hours/year); and indirect costs associated to other operating expenses including administration and commercial costs.[12] In contrast with other studies that use national level operating costs for GTC measurement, the GTCs employed in this study are calculated considering prices at the provincial level; specifically those observed in the province where the shipments originates.

2.3 Trade flows decompositions

Thanks to our micro-dataset on trade, we decompose the value of trade flows into the extensive and the intensive margins. This procedure allows solving potential specification errors in the gravity model when trade flows are not decomposed into these two margins and when analyzing how trade barriers (frictions) affect them (Chaney, 2008;

[12] The minimum cost itinerary among the set of possible itineraries defines as follows: $GTC_{ij} = min(DistCost_{ij} + TimeCost_{ij})$.

Felbermayr and Kohler, 2006; Melitz, 2003). We rely on Hillberry and Hummels (2008) and define the total value of shipments between each origin-destination ij pair by T_{ij}, which can be decomposed in the following way:

$$T_{ij} = N_{ij}\overline{PQ}_{ij}, \tag{1}$$

where N_{ij} represents the total number of shipments (extensive margin) and $\overline{PQ}_{ij}$ is the average value per shipment (intensive margin). At a second level, the previous expression can be further broken down so that the total number of shipments N_{ij} equals the number of commodities (k) sent within the same pair ij (N_{ij}^k), multiplied by its frequency or trading pair (F); that is, the average number of shipments per commodity per ij (N_{ij}^F):

$$N_{ij} = N_{ij}^k N_{ij}^F. \tag{2}$$

With this expression, the extensive margin is decomposed according to the product extensive margin (N_{ij}^k) and the product intensive margin (N_{ij}^F), Mayer and Ottaviano (2008). Meanwhile, the intensive margin can be decomposed into the average price ($\overline{P}_{ij}$) and the average quantity ($\overline{Q}_{ij}$) for each pair ij:

$$\overline{PQ}_{ij} = \frac{(\sum_{s=1}^{N_{ij}} P_{ij}^s Q_{ij}^s)}{N_{ij}} = \frac{(\sum_{s=1}^{N_{ij}} P_{ij}^s Q_{ij}^s)}{(\sum_{s=1}^{N_{ij}} Q_{ij}^s)} \frac{(\sum_{s=1}^{N_{ij}} Q_{ij}^s)}{N_{ij}} = \overline{P}_{ij}\overline{Q}_{ij}, \tag{3}$$

where s indexes unique shipments. Additionally, to obtain regression results based only in physical units (tons) leaving aside prices, we also consider as dependent variable the shipped quantity:

$$Q_{ij} = (\sum_{s=1}^{N_{ij}} Q_{ij}^s) = N_{ij}\overline{Q}_{ij}. \tag{4}$$

In the database the observations are recorded for each origin-destination pair (ij), type of commodity transported and year.[13] To obtain yearly values of trade for each ij we aggregate observations such that, following Eq.(3), we calculate the average quantity ($\overline{Q}_{ij}$) and the average price ($\overline{P}_{ij}$) for all the shipments between each ij, thereby obtaining the average value per shipment by multiplication, ($\overline{PQ}_{ij}$). Afterwards, we multiply the average value per shipment by the total number of shipment (N_{ij}) obtaining

[13]Commodities are classified in ten groups, from agricultural products to manufactured goods, including products such as metallurgical, minerals, chemicals and fertilizers, and heavy machinery.

the total value of shipments Eq.(1). Additionally, we calculate the maximum number of different commodities transported between each ij and multiply it by its frequency (average number of shipments per commodity), so as to obtain Eq.(2). For the total trade in quantities Eq.(4), we multiply the average quantity moved between ij by the extensive margin Eq.(2).

2.4 Analysis in growth rates

The advantage of the GTC over its distance and time proxies is that it accounts for their associated transportation operating costs—see Combes et al. (2005); Zofío et al. (2014), thereby capturing the change in the transport service market as a result of changes in input prices (e.g., particularly fuel) and regulatory conditions (e.g., related to wages in the labor market).[14] We present evidence arguing that the GTC is the most suitable measure of transport cost over the years because it is the only one capturing simultaneously the improvements in road infrastructure as well as changing regulations. As shown in Table 1, distance remains mainly unaffected by road improvements over years (and it could even increase as a result of business by-pass routes). Because of this lack of variability in the distance variable over time, even if it may constitute a good proxy for transport costs in cross section studies, it is certainly inadequate in panel data studies where transport costs are expected to vary significantly as a result of improvements in road infrastructure and changes in operating costs. Correspondingly, while the time proxy for transports costs captures the improvements in road infrastructure, it cannot account for changes in the operating costs.[15]

Table 1 shows the average of each transport cost for the period 2003-2007, and for the individual years 2003, 2005 and 2007, plus their growth rates. GTC is the measure with the highest variation, while distance and travel time have changed to a lesser extent. By individual years, again the GTC has reduced more than its proxies. As a result, we should expect a higher impact of the GTC on trade flows along the period; i.e., distance and travel time have lower variation during 2003-2007.

To reinforce the suitability of the a GTC measure over its proxies we perform a set of

[14]Due to the lack of space, we only report results on GTCs as it is one main contribution. In Díaz-Lanchas et al., (2013) we also present the results for the distance and time measures (real distance in km and time in hours) testing the robustness of all results when the usual proxies of transport costs are confronted to a GTC measure in gravity equations.

[15]See Zofío et al. (2014) for a detailed discussion on how the variation of GTCs can be consistently decomposed into infrastructure and cost components using the economic theory approach to index numbers.

		Mean by years			
Transport Costs	Average 2003-2007	2003	2005	2007	Growth Rates
GTC	333.61	347.69	343.87	305.97	-12.00%
Distance	313.51	313.02	313.39	313.49	0.15%
Travel Time	287.19	290.21	286.58	284.16	-2.08%

Table 1: Transport costs variation along the period.

		Variables in Growth Rates		
	Variables	Total Value	Extensive Margin	Intensive Margin
Costs in Growth Rates	GTC	-0.0296**	-0.0355**	-0.0275*
	Distance	-0.00181	-0.00336	0.00433
	Travel Time	0.00281	0.000761	0.00461

Robust standard errors. Standard errors in parentheses. Significance level: ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table 2: Variation effect of transport costs on trade flows.

regressions based on growth rates of trade flows to study to what extent the variability of the total value of trade is explained by the variability of the alternative transport cost measures. Indeed, and according to the Table 1, we should expect a more significant and negative impact of the GTC on trade flows in comparison to its proxies.

$$\Delta T_{ijt} = \beta_0 + \beta_1 \Delta cost_{ijt} + year + \eta_{it} + \eta_{jt} + \epsilon_{ijt} \tag{5}$$

Table 2 shows the results of regressing the growth rate of trade flows and their margins against the growth rate of each measure, and including year fixed effects and origin and destination invariant fixed effect to control for unobserved heterogeneity and the effect of business cycles: Eq.(5).[16]

As expected, distance and travel time do not have significant effects either on the growth rates of trade flows or its margins, because their changes from one year to another are quite reduced. By contrast, the GTC has a negative and significant impact on the three endogenous variables, as contended. Indeed, a reduction in the GTC leads to an increase in trade flows; that is, only reductions in the shipment's real economic cost results in larger trade flows, particularly those related to truck efficiency

[16]We have chosen to include fixed effects in this equation instead of GDP by origin and destination because of the reduced variability shown by GPDs between years, resulting in non-significant estimations of these two variables.

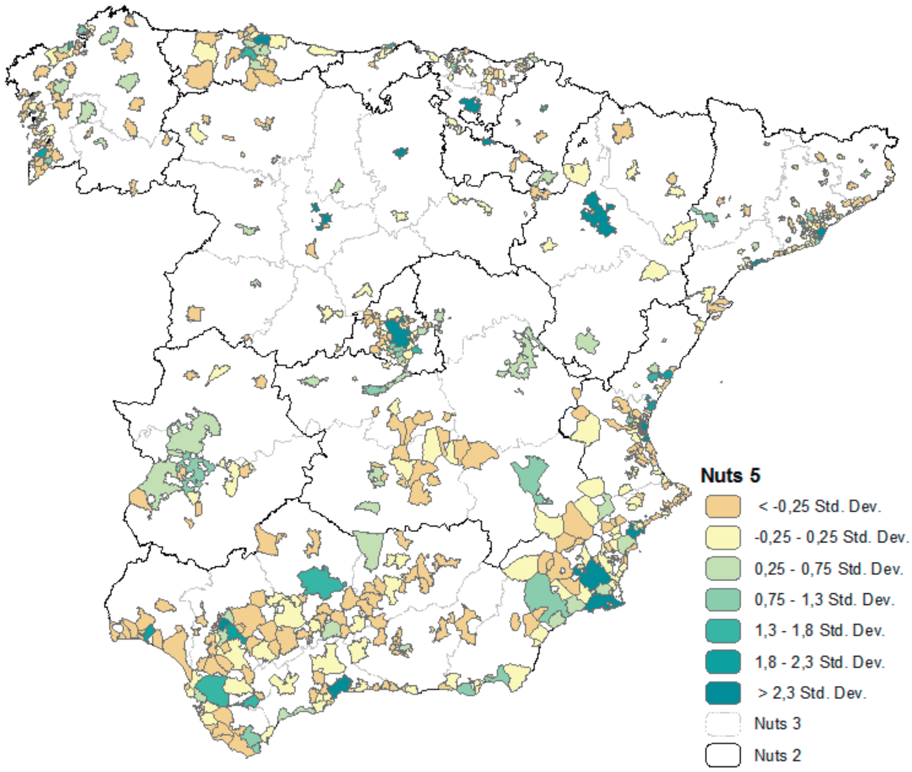


Figure 1: Standard deviation of the Total Trade for the 633 municipalities. Average Values (Exports+Imports). Period 2003-2007.

such as fuel saving, as well as the reduction of salaries –both the main components of trucking operating costs. These results confirm the GTC as the most suitable measure of transport costs in panel data studies, while distance and time are suitable proxies of trade costs valid only for cross-section estimations of gravity equations.

2.5 Descriptive analysis and Kernel regressions

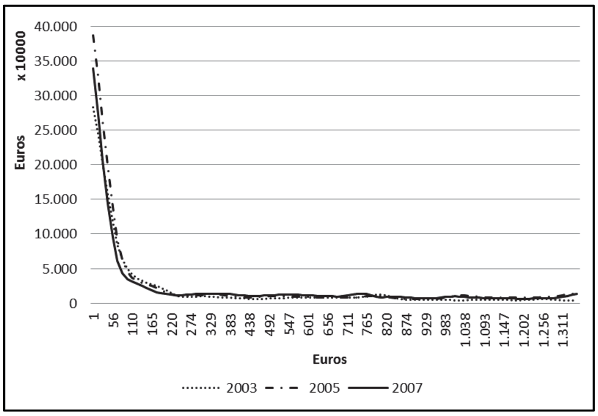
Figure 1 shows the 633 municipalities finally included in the regressions. The map shows the standard deviation of the municipal total trade value, i.e., exports plus imports, both in average values during the whole period. This sub-sample captures all trade between the largest cities (and metropolitan areas) in Spain. It also includes cities where main ports are located, as areas with high levels of trading activity.

The largest shipments are delivered from the most populated areas with the highest levels of economic activity (Madrid, the Mediterranean coast and the Basque Country), while less populated areas (south-west and north-west areas) only record trade around the largest cities. Also, trade volumes follow the corridors corresponding to major high capacity roads, indicating the strong inertia between trade and road infrastructures; i.e., firms choose locations with large accessibility defined in terms of market potential, Duranton et al. (2014).

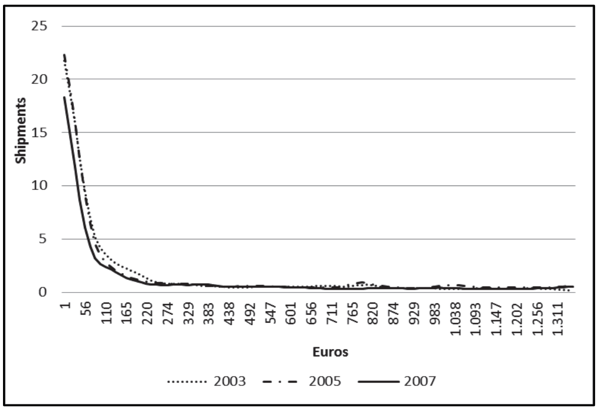
We use a non-parametric estimation (kernel analysis) to study how each trade variable in the decomposition behaves when considering the GTCs (in euros) between the 633 municipalities. The first level of the trade decomposition is illustrated in Figures 2a, 2b, and 2c, presenting total value, number of shipments, and average shipment value, respectively. The total value of shipments is lower in 2003 than in 2007, falling sharply in density as transport costs increase (2a). This same pattern is observed in the extensive margin (2b), where the number of shipments drops rapidly for all years as the GTC reaches the threshold of 150 euros, while the intensive margin (2c) shows a trend that even increases in transport costs. This increasing behavior in the intensive margin is due to its composition. As we will see below, delivered prices naturally increase with GTCs, while there exists greater density of tons at very short distances, mirroring the extensive margin behavior. Subsequently, after a certain threshold, they drop sharply remaining stable at medium distances. This trend reflects the accumulation of shipments within the main Spanish metropolitan areas (Madrid, Barcelona and Valencia), while beyond these ranges the number of tons reduces. As it can be observed, this price and tons composition is creating an increasing pattern on the intensive margin.

In sections 4 and 5 we argue that this trade pattern over short and long distances is precisely the result of the existence of market areas at different transport cost thresholds that mainly respond to the existence of an urban hierarchy between trading cities.

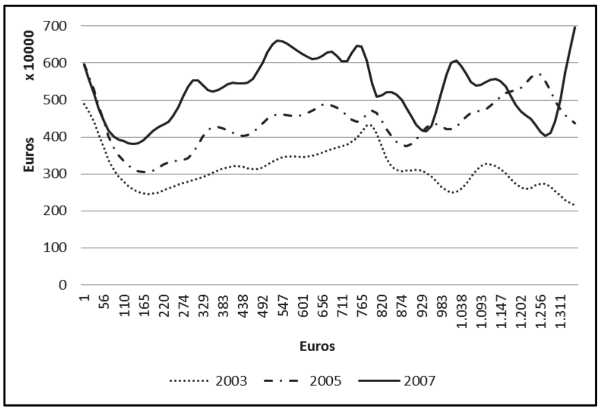
Figures 2 and 3 show the kernel estimations for the second level decomposition. Considering the extensive margin decomposition in Eq.(2), the number of commodities (Fig.3a) and its frequency (Fig.3b) exhibit a remarkable similar pattern and evolution; i.e., they rapidly reach their minimum values for GTC with an increase in density either at middle or high values. Decomposing the intensive margin into its average price and its average quantity as in Eq.(3), allows us to observe greater price variability, either between years or in one year. This variability may be due the specific product or the product mix of the shipment, which results in higher prices as a result of transport costs increases (Fig.4c); a sensible result for goods for which transport costs make up a large proportion of overall costs, that later on are passed on to delivered prices. Focusing on average tons (Fig.4d), they follow the pattern previously described; i.e., they are highly accumulated on short distances until a certain CGT threshold is reached, for



(a) Total Value of Trade



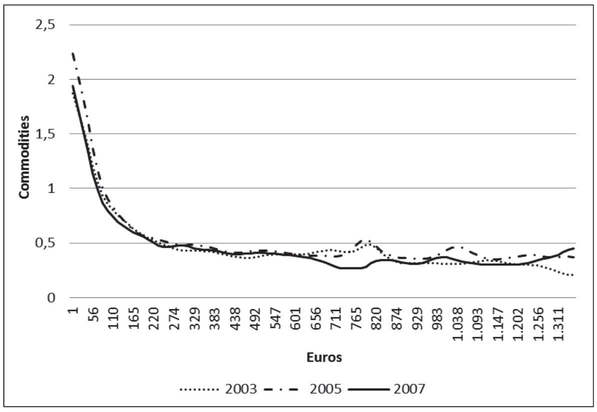
(b) Extensive Margin



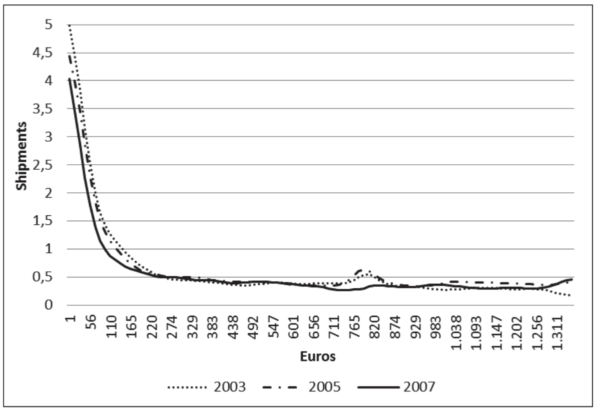
(c) Intensive Margin

Figure 2: Kernel regressions: Total value of trade, number of shipments (extensive margin) and average value per shipment (intensive margin) on GTC.

which they rapidly reduce and remain stable over medium and long distances. Indeed, in section 3 we study the existence of increasing returns in transport in the intensive (tons) margin; suggesting that for long distances it is more profitable from a logistics perspective to group shipments and send trucks with higher capacity and fully loaded, than making many individual shipments with low volume of tons, McCann (2005). Finally, the kernel regressions for total trade in physical quantities, Eq.(5), not presented here to save space, reflect the same trends and behavior as total trade in monetary units, i.e., the total amount falls steeply with increasing transport costs.



(d) Number of commodities



(e) Number of Shipments per Commodity

Figure 3: Kernel regressions: number of commodities and number of shipments per commodity (frequency) on GTC.

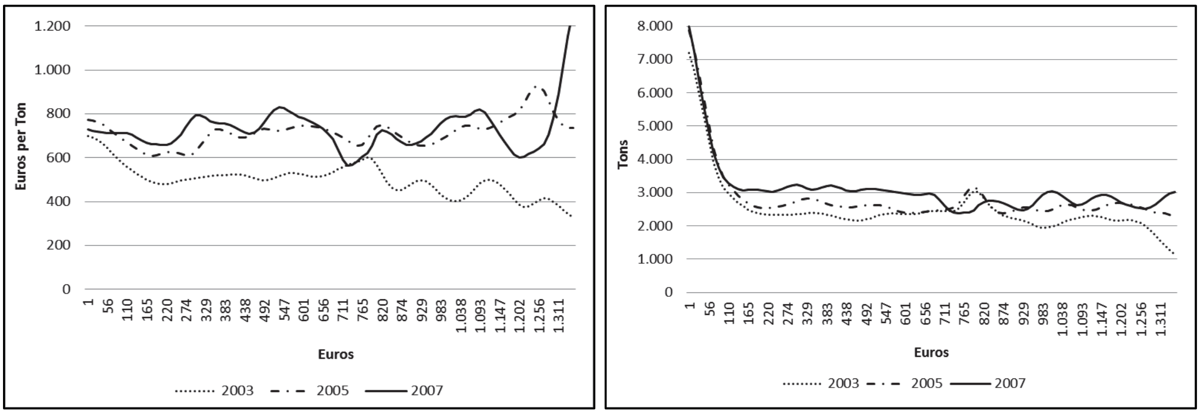
3 Econometric specification: The general gravity model

To structure the analysis in this section we present results for the standard naïve gravity model yielding average estimates for the whole sample without taken into account transport cost thresholds when determining their negative impact on trade flows. Specifically, we explore in detail the hypothesis about changing patterns in trade flows due to administrative boundaries. For this purpose we propose a set of regressions using equations (1) through (4) that allows us study how geographical frictions shape trade flows while taking into account different administrative boundaries, as well as to test whether these frictions may end up inducing a border effect in each of the different trade margins.

The set of PPML estimations regressing the value of trade and its components on geographical variables considering GTCs, a municipal contiguity variable and the three types of administrative boundaries: Regions (Nuts-2), provinces (Nuts-3), and municipalities (Nuts-5), are reported in Table 3.[17]

While trade data and transport cost measures have been extensively presented in section 2, we now discuss the remaining variables. To calculate the Contiguity variable, we use the GEODA software to code if the municipalities share a common border (first-order queen contiguity). It takes the value one if the origin and the destination

[17] In Díaz-Lanchas et al. (2013), we present robustness of our results controlling for GDP also. The municipal GDP has been obtained from the Servicio de Estudios de La Caixa.



(f) Average Price (g) Average Tons

Figure 4: Kernel regressions: average price and average tons on GTC.

of the shipment share a border, and also if the shipment takes place within the same municipality to correctly isolate the effect of the municipal boundary (Nuts-5). It permits us to capture how important are intra-municipal shipments over inter-municipal ones Hillberry (2002b), that is, coding shipments within municipalities as adjacent allows the next intradummy (Nuts-5) to isolate the additional local intensity of this type of shipments, relative to the local intensity tied to neighboring municipalities.[18]

For the administrative boundaries, we define three dummy variables as in Requena and Llano (2010). In this sense, the Nuts_5 variable (municipal boundary) is set to one if the shipment is performed within the same municipality, and zero otherwise. Subsequently, the Nuts_3 (provincial boundary) is one if the shipment is carried out between two municipalities that are in the same province but whose origin and destination are different.[19] Finally, the Nuts_2 variable (the regional boundary) captures if the shipment takes place between two municipalities that are located in different provinces, but in the same Nuts_2 region; in this case, it will take the value of one and zero otherwise. Additionally, the time dimension is reflected by a dummy variable for each year in the sample, Baldwin and Taglioni (2006). Finally, we include fixed effects by origin and by destination (Anderson and van Wincoop, 2003; Benedictis and Taglioni, 2011). As for the estimation method we rely on the pseudo-poisson maximum likelihood estimation,

[18]Coding the contiguity dummy as zero for intra-municipal shipments results in a larger value for the Nuts-5 dummy (and the remaining coefficients do not change), but the former effect cannot be decomposed.

[19]If the shipment is within the same municipality, the Nuts_5 variable will take the value one while the Nuts_3 and Nuts_2 variables are assigned a value of zero. Clearly, shipments between municipalities located in different regions are assigned zero values for all administrative boundaries.

PPML—see Santos Silva and Tenreyro (2006, 2010, 2011), considering the endogenous variables in levels. By resorting to the PPML we can accommodate the zero trade flows problem and correct for heterokedasticity. Thus, the final specification to be estimated has the form:[20]

$$X_{ijt} = \beta_0 + \beta_1 GTC_{ijt} + \beta_2 GTC\_sq_{ijt} + \beta_3 contiguity + \beta_4 Nuts\_5 + \beta_5 Nuts\_3 + \beta_6 Nuts\_2 + year + \eta_i + \eta_j + \epsilon_{ijt} \quad (6)$$

In this specification, the GTC enters in levels and in a quadratic form to capture the non-linearity between trade flows and transport cost at very short distances as shown by the kernel regressions. Thanks to this quadratic specification of transport costs we examine whether there are increasing returns in transportation; that is, distance has a negative effect, but marginally decreasing. In that case, we would expect a negative sign in the first term of the transport cost variable but a positive sign in the quadratic one (Combes et al., 2005). Finally, year corresponds to each dummy-year variable in the period and X_{ijt} stands for each one of the trade decomposition variables already mentioned.

Table 3 shows estimates for the first level of trade decomposition variables (the extensive and the intensive margin) taking into account the additional case of trade flows in quantities (tons), to compare it with trade flows in monetary units (total value of trade). Starting with the border or home bias effect while controlling for transport costs, the total value of trade taking place within the same municipality (Nuts_5) is much greater than inter-municipal trade flows, specifically it is 42 times larger.[21] In addition, the higher Nuts_5 coefficient in the regression of the extensive margin (number of shipments) is indicating that this margin drives intra-municipal trade to a larger extent than the intensive margin (average value per shipment).

Additionally, if we consider other administrative levels, provincial boundaries (Nuts_3) have a much lower effect on trade (5.52 times) than the Nuts_5 level, while regions (Nuts_2) loose importance as administrative boundary (1.4 times), with negligible effects (not even statistically significant) for trade in quantities. It turns out that the border

[20] In order to get a balanced panel, we have fulfilled the matrix with zeros to get all the possible pairs origin-destination (ij) obtaining 195,026 observations.

[21] The PPML estimation can be sensitive to extreme observations in the dependent variable causing this high value of the Nuts_5 level, Van der Marel (2012). However, it can correctly capture the amount of trade observed in short distances, besides additional econometric advantages, over alternative specifications such as OLS (Martin and Pham, 2008; Santos Silva and Tenreyro, 2006, 2010, 2011), as previously mentioned.

effects for relatively long shipments between regions is almost nonexistent, supporting the idea that the geographical reach of trade is mainly driven by local markets; i.e., the existence of natural trade areas in terms of transport costs that we study in the next section. Also, by using PPML and fixed effects by origin and by destination we are correcting for potential gravity problems, thus, we are able to reduce possible biased coefficient estimations than those obtained by Hillberry and Hummels (2008) and Borraz et al. (2012), indicating a higher impact of the municipal boundary on trade flows and their margins.

For the regressions of the aggregate extensive margin decomposition, the number of shipments per commodity (frequency) and the number of different commodities shipped explain approximately the same proportion of this margin for all administrative boundaries; particularly for the municipal border (Nuts_5) that shows a greater agglomeration of trade flows. The Nuts_3 and Nuts_2 variables reflect the same pattern as for the same first level decomposition; i.e., provinces (Nuts_3) reduce its importance as trade border while regions (Nuts_2) have a very reduced impact on trade flows.

For the aggregate intensive margin, the coefficient associated to average tons (physical quantities) is the most relevant explaining it. Average tons shipped within the municipality are higher than inter-municipalities ones, although showing a decreasing trend between borders, and even exhibiting a negative impact at the regional level (Nuts_2); i.e., the average tons of inter-regional flows are higher than intra-regional ones. Also, thanks to the inclusion of total trade in physical quantities, we confirm the robustness of the coefficients when considering monetary measures as in the intensive margin; especially for the regional dummy (Nuts_2), which shows a non-significant sign.

Variables	First Trade Decomposition Variables			Extensive Margin		Intensive Margin		
	Total Value of Trade (T_{ij})	Extensive Margin (N_{ij})	Intensive Margin ($\overline{PQ}_{ij}$)	N. of Commodities (N^K_{ij})	Trading Pairs (N^F_{ij})	Price ($\overline{P}_{ij}$)	Tons ($\overline{Q}_{ij}$)	Trade in Quantity (Q_{ij})
GTC	-0.266***	-0.290***	-0.0423***	-0.154***	-0.182***	-0.00772	-0.114***	-0.447***
	(0.0322)	(0.0142)	(0.00537)	(0.00467)	(0.00566)	(0.00469)	(0.00420)	(0.0292)
GTC Square	9.06e-11***	9.99e-11***	1.27e-11***	4.17e-11***	6.47e-11***	-1.09e-11***	4.41e-11***	1.88e-10***
	(1.70e-11)	(7.40e-12)	(3.12e-12)	(2.50e-12)	(2.89e-12)	(2.77e-12)	(2.28e-12)	(1.50e-11)
Contiguity	1.365***	1.126***	0.458***	0.659***	0.827***	0.123***	0.665***	1.262***
	(0.0708)	(0.0330)	(0.0311)	(0.0141)	(0.0264)	(0.0232)	(0.0222)	(0.0518)
Nuts_5	3.764***	3.236***	0.983***	1.507***	1.933***	0.504***	1.122***	3.495***
	(0.101)	(0.0496)	(0.0594)	(0.0333)	(0.0371)	(0.0435)	(0.0388)	(0.0792)
Nuts_3	1.717***	1.406***	0.320***	0.845***	0.781***	0.432***	0.438***	1.415***
	(0.0840)	(0.0392)	(0.0255)	(0.0169)	(0.0206)	(0.0208)	(0.0178)	(0.0655)
Nuts_2	0.346***	0.338***	0.0375	0.239***	0.139***	0.188***	-0.0321*	0.0767
	(0.0777)	(0.0354)	(0.0259)	(0.0168)	(0.0207)	(0.0207)	(0.0166)	(0.0554)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Origin F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Destination F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	195,026	195,026	195,026	195,026	195,026	195,026	195,026	195,026
R^2	0.708	0.879	0.087	0.076	0.146	0.512	0.344	0.624

Robust standard errors. Standard errors in parentheses. Significance level: ***$p<0.01$, **$p<0.05$,*$p<0.1$.

Table 3: Fixed effects estimation with GTC.

Looking at the coefficients corresponding to the GTCs, they present the expected signs in all trade decomposition variables, indicating the existence of increasing returns in transport. The Contiguity variable is significant in all regressions; that is, contiguous municipalities trade more among themselves than with more distant municipalities, reinforcing the market area interpretation of the distribution of trade flows. Finally, there is a good fit achieved by the model R^2 in explaining total trade flows and the extensive margin, although it is less clear for the intensive margin. Such goodness of fit is in contrast to the low values obtained by Hillberry and Hummels (2008).

With this first set of estimations we conclude that the use of very detailed measures of trade flows and transport costs reduces the impact of higher regional boundaries showing the existence of a weak internal border effect at the regional level that is only relevant when the municipal level is considered. It confirms the existence of a “illusory effect” at high regional boundaries once low-level administrative limits are controlled for. Also, it indicates a non-disruption of the market for large administrative levels, in contrast to other studies for the Spanish case: Garmendia et al. (2012); Requena and Llano (2010); or the Chinese case: Poncet (2005). These findings shed light on the idea that trade flows tend to concentrate in short distances, with their density reducing as distance increases, and drawing a trade pattern that motivates the use of structural tests to explicitly determine the point at which trade concentration finishes. Also, this stresses the importance of regionally disaggregating the trade flows and the transport costs if we want to measure the “real” border effect between areas.

In a further step, we are interested in studying the dynamics of the internal home bias effect. To achieve this goal, we estimate the same models resorting to a cross-section analysis instead of pooling the data in a whole panel database. Table 4 presents the results of regressing Eq.(6) with data corresponding to 2003 and 2007

GTC	Boundary	2003	2007
Total Value of Trade	Nuts_5	3.795***	2.835***
	Nuts_3	1.581***	1.079***
	Nuts_2	0.179*	-0.0313
Extensive Margin	Nuts_5	3.151***	2.555***
	Nuts_3	1.184***	0.906***
	Nuts_2	0.174*	-0.00365
Intensive Margin	Nuts_5	0.958***	0.841***
	Nuts_3	0.363***	0.291***
	Nuts_2	0.00161	0.0201

Table 4: Cross-section regressions for 2003 and 2007 (First Level Decomposition).

(initial and final years, respectively) but considering only the first level decomposition, Eq.(2); that is, the total value of trade, and the extensive and the intensive margins. To summarize the output table presents only the results for the three administrative boundaries, as we are interested on the dynamics of the effect of borders on trade margins.

All administrative boundaries reflect the same pattern for the total value of trade; i.e., there exists a slowdown trend between 2003 and 2007. This finding reflects that the internal home bias effect is not constant along the years.[22] Indeed, administrative levels do not concentrate the same amount of trade within themselves throughout the whole period. In 2003, the Nuts_5 is the one with the highest impact on trade flows, even larger than in the panel data regression. Meanwhile, it is confirmed that the Nuts_2 level exhibits a non-significant, or even negative, effect on trade flows, indicating again that regional borders are not as important as trade literature customarily remarks.[23] The extensive margin shows the same pattern as the total value of trade, whereas the intensive margin does not change to a greater extent during the period. We conclude that the reduction in the effect of administrative boundaries on trade flows

[22]We have performed a set of mean tests to analyze whether each administrative boundary is statistically different between 2003 and 2007. Thus, we reject the null hypotheses of equal coefficients.

[23]We stress that, in the Spanish case, the jurisdictional change associated to the regional administrative border (Nuts 2) is larger than to the provincial (Nuts 3) and municipal (Nuts 2) ones. For example, in all cases, the Spanish regions (Nuts 2) run their own budget (around 40% of the overall public expenditure), with a great autonomy in the field of economic and fiscal policy, as well as in the design of their own transport infrastructures. Moreover, in some cases, such administrative borders coincide with former kingdoms and historical territories, and the use of co-official languages. As a consequence, if the internal home bias were real and driven by exogenous barriers to trade, it should be expected to be significant at this administrative level.

arises mainly from the extensive margin.

4 Structural trade patterns: breakpoints analysis

We regard the standard regressions estimated in the previous section 3 as naïve gravity equations because they simply provide an average estimate of the effect of transport costs on trade flows, qualified by the customary second order effect. In this section we systematically undertake a series of structural tests to determine the transportation cost thresholds that define relevant discontinuities in their effect on trade flows. Based on them, we split the database to regress the same gravity specification but allowing for the different distance (GTC) thresholds. Additionally, the empirical evidence on the border effect phenomenon usually gives a "general" value for the border effect, which is corrected by different misspecifications such as Anderson and van Wincoop (2003) or Santos Silva and Tenreyro (2006, 2011), among others. Nevertheless, it does not consider the possibility of having different border effects once we control for multiple distance thresholds. In this sense, Eaton and Kortum (2002) propose different distance intervals that act as trade barriers. Nevertheless, these intervals are arbitrary as there is not an objective criterion to divide the transport cost data.

The existence of at least a relevant threshold in the transport cost-trade flows relationship for the whole sample can be easily established by simple visual inspection of the kernel regressions at an approximate value of 150 euros (Figure 2); that is, over very short distances trade flows are radically affected by relative low transport costs (extensive margin), while for larger values are less dependent and becoming relatively "flat" (intensive margin). But further thresholds against GTCs can exist at different values. Indeed, the previous regressions confirm the idea according to which trade flows tend to concentrate at the municipal level and are mainly predetermined by the extensive margin, which follows the same pattern on transport costs.

It is our understanding that one should control for this non-linear relationship when studying this trade concentration pattern on short distances. Thus, we argue that one should test whether trade flows change radically once they have reached a given transport cost threshold or breakpoint. In other words, we contend that trade flows present different structural relationships (structural stability) with transport costs, resulting in relevant changes in their negative effect on trade.

To determine these structural breakpoints we rely on Berthelemy and Varoudakis

(1996), who present an endogenous Chow structural test for cross-section studies to check the stability of the parameters.[24] The test is carried out by establishing first a model that poses the existence of the structural change and the threshold variable responsible for this breakpoint (non-linear relation in our endogenous variable). In our case, Eq.(6) represents the baseline model to develop such analysis identifying the GTC as the threshold variable (but without including them in quadratic form). We have performed the Chow test several times to check the existence of successive GTC thresholds.

To summarize the information, instead of performing the test for each year in the sample, we have chosen the mean of each variable in Eq.(6) so as to use single points for the whole period (2003-2007). Table 5 reports the breakpoints for the total value of trade and the extensive margin.[25] Unsurprisingly, the test fails in detecting breakpoints for the intensive margin as its components do not drive reductions in trade as shown in the kernel regressions (Fig. 2c),[26] in sharp contrast with the total value of trade the extensive margin. Finally, all breakpoints obtained are significant at the 5%, except otherwise indicated.

Table 5 corroborates Hillberry and Hummels (2008) findings but qualifies them as we consider the full spectrum of administrative borders, whose presence may not exist at each range of trade values (e.g., intra-municipal trade at a Nuts-5 level cannot be normally observed for shipments with transport costs over the first breakpoint corresponding to 189 euros, since no municipality is so wide geographically). These results provide strong evidence that the trade flows are caused by the extensive margin, specially for short-medium GTCs as the first and the second breakpoints are mostly the same as those obtained for the total trade flows. Additionally, trade flows are highly concentrated at low transport cost values (around 189 and 233 euros). But after these two thresholds the difference between breakpoints becomes larger, indicating a de-

[24]This test divides the sample in two sub-samples. Afterwards, it begins to perform several iterations with the number of observations in each sub-sample changing continuously until it finds a breakpoint, in terms of the threshold variable(GTC), in which the Chow test rejects the null hypotheses of the non-existence of a structural change in our model (at the 5% significance level). This test presents the advantage that it is not necessary to provide an exogenous point in which the researcher suspects the possibility of a structural change, as in time-series models. By contrast, it endogenously determines the exact GTC breakpoint at which the endogenous variable dependence changes significantly. This test has been recently made available in STATA by Diallo (2012).

[25]The number of breakpoints obtained is six because, for GTC values higher than 706€, the test starts to fail obtaining very high GTC values with no economic sense.

[26]Nevertheless, the breakpoints obtained for the total value of trade mainly correspond to the particular “peak” points observed in the kernel regression for the intensive margin (Fig. 2c).

clining tendency of trade flows on transport costs.[27]

To show further evidence in favor of the breakpoints obtained by way of the Chow test and stress their consistency with our trade database and the real distribution of cities, Figures 5a and 5b shows the specific GTC breakpoints obtained for the two largest Spanish cities: Barcelona and Madrid.[28] This map presents a first indication of natural trade areas in terms of the transport reach along the existing road network. The Arc/GIS Network Toolbox allows us to calculate the exact coordinates corresponding to the maximum distance given the type of road (arc) and its specific attributes as capacity, gradient, congestion level, etc. It can be observed that Barcelona and Madrid are linked to a further extent with those cities with a high volume of surrounding highways; i.e., each breakpoint represents an isocost line in terms of GTCs that is longer, the larger the high capacity road network. We term these market areas as natural trade areas, because they have been obtained by way of the objective procedure represented by the Chow's structural test.

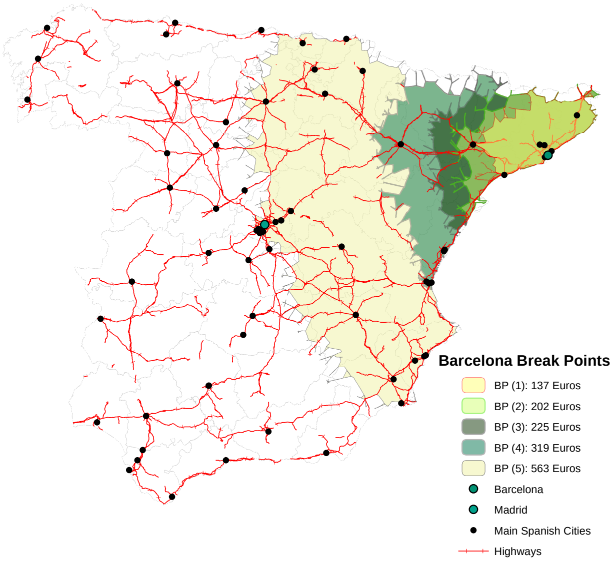
Observing these two maps multiple aspects can be remarked: i) the first breakpoint refers to the supply center between the city and its metropolitan area and other small cities not far from it; ii) the second point reaches some important cities (provincial capitals), especially from Madrid; iii) the third point presents the same pattern as the previous one, although it links to higher level and richer cities such as Valladolid, Burgos and Salamanca for the case of Madrid; iv) the fourth point appears as very relevant as it joins Madrid and Barcelona with the richest cities in Spain in terms of trade, these are mainly Valencia and Zaragoza; v) the last point directly links Madrid and Barcelona, indicating that trade flows overlap for the two largest Spanish cities.

An additional conclusion is that the road network centrality is highly important as Madrid's trade area is always larger than Barcelona's for all breakpoints: within the boundaries of Spain, Madrid almost reaches all regions within the last breakpoint, while Barcelona leaves half of the Iberian Peninsula out of its direct reach. It is important to note, at this point, that the map is only showing the points at which trade flows change structurally as given by the Chow Test; i.e., the geographical reach of each city

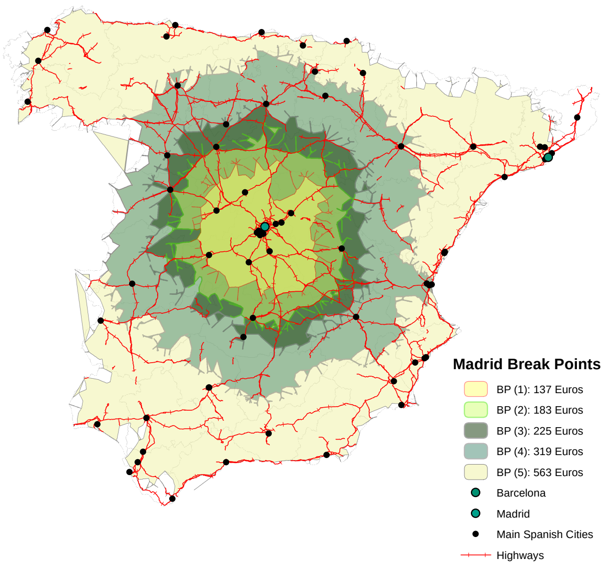
[27] In Díaz-Lanchas et al. (2013) the two distance and time proxies of transport costs present the same pattern as those of the GTCs, as they are highly correlated in cross-section estimations (0.91 and 0.95, respectively). Moreover, from the transport cost database it is possible to relate travel times with distance by considering the legal speed limit: 90 km/hour, while the relation between GTCs and distance is about 1.1€/km. With these equivalences we could approximate the relation between transport costs, obtaining similar distance and time values to those shown by the breakpoints.

[28] The GTC presented are in terms of distance equivalency as to correctly measure the market area on the Arc/GIS software.

given the GTC values obtained, and therefore does no reflect trade volumes. Indeed, Madrid and Barcelona present different trade patterns as we will show later. In this case, the map shows that the breakpoints obtained have an empirical correspondence with the actual geographical distribution of Spanish cities.



(h) Barcelona



(i) Madrid

Figure 5: Natural trade areas using GTC Breakpoints for the whole period 2003-2007.

With these findings we argue that the methodology based on the Chow structural test represents a promising procedure to determine trade areas because, as far as we know from the literature, there have not been direct empirical measurements of cities' market areas, Löffler (1998). Specifically, these empirical regularities are in line with the predictions of the Lösch and Christaller's model, whose analytical framework constitutes the core of the central place theory (CPT), and gives rise to the so-called urban hierarchical systems.[29] Although these ideas are undertaken in the next section, we now anticipate that, as predicted by these two models, these market areas represent geographical locations where cities compete with each other, with market areas reaching longer radii the higher the city-ranks.

Once we have determined the exact breakpoints where the effect of each transport cost on trade flows change, we split our database according to these thresholds. We perform a set of regressions using Eq.(6) but, as anticipated, we have eliminated the administrative boundary for the interval in which, on average, no observation is recorded. As a clear example, for a transport cost interval of 285-513 euros (breakpoints 3 and 4) there are no shipments either at the intra-municipal level or between contiguous municipalities; and therefore these variables must be dropped in the regressions for this interval. We follow the same rationale for the rest of transport costs intervals. In fact, we contend that this is the correct methodology for measuring the effect of transport costs and administrative boundaries on trade flows when accounting for the precise transport cost-trade value (non-linear) relationship; otherwise we would obtain an overall home bias effect which is not real in the sense that it would not attend to the specific characteristic of each shipment. To demonstrate this idea, we include in the same table a "general specification" (a naïve gravity equation) using again equation Eq.(6) but without controlling for distance thresholds, and resorting to the quadratic GTC as way to control for the non-linear effect of transport costs on trade flows. As we show in what follows, administrative boundaries overestimate the effect of the border effect in short distances, meanwhile it has a different effect when we split the distance by thresholds.

[29] CPT establishes that cities have market areas that are decreasing on transport costs, and where the largest cities producing diversified goods under increasing returns to scale can reach the furthest locations, meanwhile smaller cities have a reduced influence because they provide more standardized goods normally characterized by constant returns to scale.

	GTC Thresholds					General
Variables	(0€-189€]	(189€-285€]	(285€-513€]	(513€-706€]	(More than 706€)	Specification
GTC	-0.0145***	0.00262**	-0.00243***	-0.00329***	-0.00142***	-0.00525***
	(0.000339)	(0.00127)	(0.000185)	(0.000309)	(0.000125)	(0.000339)
GTC Square	—	—	—	—	—	3.69e-06***
						(2.47e-07)
Contiguity	0.911***	—	—	—	—	1.232***
	(0.0335)					(0.0702)
Nuts_5	3.022***	—	—	—	—	3.269***
	(0.0421)					(0.0836)
Nuts_3	1.059***	2.233***	—	—	—	1.247***
	(0.0348)	(0.318)				(0.0645)
Nuts_2	0.427***	0.0184	0.189***	1.347***	—	0.0945
	(0.0374)	(0.117)	(0.0708)	(0.102)		(0.0692)
F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,532	4,493	7,914	4,720	4,386	39,045
R^2	0.957	0.739	0.675	0.825	0.638	0.939

Robust standard errors. Standard errors in parentheses. Significance level: ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table 6: Total Value of Trade by GTC thresholds.

	GTC Thresholds						General
Variables	(0€-185€]	(185€-246€]	(246€-321€]	(321€-582€]	(582€-655€]	(More than 655€)	Specification
GTC	-0.0140***	-0.00357***	-0.00528***	-0.00175***	-0.00231***	-0.00133***	-0.00725***
	(0.000199)	(0.000572)	(0.000558)	(0.000143)	(0.000858)	(7.74e-05)	(0.000233)
GTC Square	—	—	—	—	—	—	4.48e-06***
							(1.64e-07)
Contiguity	0.767***	—	—	—	—	—	1.037***
	(0.0171)						(0.0359)
Nuts_5	2.556***	—	—	—	—	—	2.870***
	(0.0232)						(0.0518)
Nuts_3	0.808***	1.276***	1.553***	—	—	—	1.060***
	(0.0198)	(0.0789)	(0.101)				(0.0436)
Nuts_2	0.293***	-0.0164	0.161***	0.553***	—	—	0.118***
	(0.0231)	(0.0363)	(0.0487)	(0.0578)			(0.0423)
F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,316	3,172	2,860	8,607	1,834	5,256	39,045
R^2	0.959	0.880	0.809	0.613	0.896	0.736	0.946

Robust standard errors. Standard errors in parentheses. Significance level: ***p<0.01, **p<0.05, *p<0.1.

Table 7: Extensive Margin (Number of Shipments) by GTC thresholds.

	GTC Thresholds					General
Variables	(0€-189€]	(189€-285€]	(285€-513€]	(513€-706€]	(More than 706€)	Specification
GTC	-0.00422***	8.78e-05	-0.000507***	-0.000861***	-0.000811***	-0.000485***
	(0.000149)	(0.000372)	(9.97e-05)	(0.000194)	(6.84e-05)	(0.000108)
GTC Square	—	—	—	—	—	2.15e-07**
						(8.41e-08)
Contiguity	0.286***	—	—	—	—	0.456***
	(0.0153)					(0.0315)
Nuts_5	0.847***	—	—	—	—	0.978***
	(0.0254)					(0.0607)
Nuts_3	0.257***	0.608***	—	—	—	0.314***
	(0.0161)	(0.0759)				(0.0293)
Nuts_2	0.138***	0.150***	0.0466	0.112*	—	0.0384
	(0.0165)	(0.0349)	(0.0467)	(0.0670)		(0.0271)
F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,532	4,493	7,914	4,720	4,386	39,045
R^2	0.406	0.575	0.387	0.445	0.444	0.288

Robust standard errors. Standard errors in parentheses. Significance level: ***p<0.01, **p<0.05, *p<0.1.

Table 8: Intensive Margin (Average Value per Shipment) by GTC thresholds.

Tables 6, 7 and 8 show the results for the fixed effects estimation by GTCs thresholds for the total value of trade (table 6), the extensive margin (table 7) and the intensive margin (table 8). The GTC is highly penalizing in short distances, while it reduces its negative impact on trade flows as distance increases. It confirms that transport costs do not have the same negative linear effect on trade flows along the spectrum of distances, but it also indicates that transport costs are not as detrimental to trade as normally thought. Administrative boundaries are very penalizing on the first threshold, especially the municipal border, as in the naïve regression for the whole sample in Table 3. The fact of having a high impact of the Nuts_3 and Nuts_2 levels in this GTC-interval, is reflecting those municipalities that are geo near each other graphically, although in different provinces or regions; but at the same time they are concentrating trade within their own boundaries (the Nuts_5 mainly). Nuts_2 increases in value and significance as GTCs increase; meanwhile it is non-significant for intermediate distances as the Nuts_3 level captures the border effect. We have performed several analyses to confirm this idea. Finally, if we compare the analysis with the general specification, all coefficients are distorted or even overestimated if we do not control for the GTC thresholds. Indeed, the effect of transport costs in quadratic terms results underestimated for shorter distances whereas it is overestimated for intermediate and longer distances.

The extensive margin (Table 7) and the intensive margin (Table 8) present the same decreasing pattern on distance as the total value of trade. Nuts_3 presents an increasing impact on trade flows, while Nuts_2 has the same evolution but for the third and the fourth thresholds; i.e., higher order boundaries present higher impacts on trade as long as the GTC increases. It could be indicating that the impediments to trade traditionally obtained in the literature is not correctly capturing this effect according to which, higher regional borders present higher impacts on trade when the distance is large. Thanks to the use of the Chow's structural test, we obtain a specific geographical threshold where the main concentration of trade takes place and changes structurally in term of transport costs (GTC), qualifying the results obtained by Hillberry and Hummels (2008). That is why we conclude that the border effect calculated in the trade literature is biased in the sense that it does not control for the specific (and non-linear) relationship between trade flows and transport costs. Also, this high density of trade areas within short transport cost values corroborate the existence of trade areas defined by these value thresholds, whose existence is explained in the literature by agglomeration economies, either external or internal to the firm.

5 Trade areas and the hierarchy of Spanish cities

The breakpoints previously calculated and the accumulation of the trade flows in short distances convey relevant empirical findings in terms of the central place theory and its associated hierarchical urban system (Hsu, 2012; McCann, 2001; Mulligan et al., 2012; Parr, 2002; Tabuchi and Thisse, 2011). Following this literature based on the Lösch and Christaller's model, we would expect areas of influence whose geographical reach is driven by transport costs; that is, consumers and firms will locate in places where they can be supplied by different cities (municipalities in our case) and taking into account the transport costs in which they incur because of their consumption or production processes. In the model, cities cover all locations as long as consumers and firms are willing to cover the transports costs of having the goods shipped to their particular location. As a result of this demand schedule, cities' market areas show a decreasing trend in shipments as transport costs increase, eventually coming into spatial competition with each other for the geographical space where their areas of influence overlap.[30]

This competition between locations as predicted by the CPT can be shown resorting to our data—Figures 8 and 9 in Appendix 2.A. Both figures show the kernel distributions of trade for the two largest Spanish municipalities (Nuts-5) and provinces (Nuts-3) corresponding to Barcelona and Madrid. It is clear that both market areas overlap in space, although they present interesting differences in their trade patterns

[30] The reduction in the level of trade and the number of shipments (extensive margin) because of the geographical increment in the market area, has been clearly shown by the GTC breakpoints and the corresponding regressions in the Tables 6 and 7.

depending on the geographical location (coastal and land-lock, respectively), but also on the level of data aggregation. Looking at municipal data in Figure 8, while Barcelona spreads along the geography, i.e., it presents a larger density for medium range GTC values, Madrid shows a higher density of trade on short distances, which is related to its larger metropolitan size concentrating more economic activity than Barcelona, as it distributes larger quantities within itself to meet intermediate production processes (vertical linkages) and final demand (population). This is due to the fact that Madrid incorporated many of its surrounding (industrial) municipalities in 1948; an annexation process that did not take place in Barcelona, and that conditions the density of the trade flows within both municipalities (along with the sea transport mode in Barcelona as a coastal city supplying neighborhood locations).[31]

In a stylized and simple version of the CPT model, these market areas are spatially represented by nested hexagons within a geographical lattice, where the city is in the middle of each hexagon and its radii of influence are increasing in city's size. It means that, when the radii reach a specific point (breakpoint in our previous analyses), the market area changes its pattern radically until it eventually disappears for the case of smaller cities. Specifically and following the theoretical foundations presented by Behrens (2005); Cavailhes et al. (2007); Tabuchi and Thisse (2011), an urban hierarchy à la Christaller emerges because, considering a range of different goods, few cities can serve high-order items (specialized goods) which results in larger GTC thresholds. Meanwhile, as the order-scale of items reduces (low-order items), smaller cities provide more standardized products. In this sense, "the most central location in the entire system provides all of its goods and services (...). But, moving down through this functional continuum (of goods), other locations on the landscape are sufficiently well located to provide some, but not all, goods that are provided at the most central location" (voir Mulligan et al., 2012, pp. 404). So, according to Christaller's framework we should expect that, within a country, a hierarchical system of cities emerges where few cities (Rank 1 cities or Dominant cities) present the largest market areas supplying the full range of products; a second group of big cities (Rank 2 cities) serves a

[31]Although it is beyond the scope of this paper, the relative position of the cities within a given rank level (e.g., Madrid and Barcelona as dominant first level cities) is prone to the modifiable areal unit problem. Nevertheless, to show the robustness of the results as regards to a fairly broad level of aggregation, Figure 9 portraits the kernel density functions aggregating trade flows at the provincial Nuts-3 classification (two levels of aggregation above Nuts-5 municipalities). With a similar extension around 8,000 km^2 results show that the Barcelona province now exhibits higher trade densities at higher GTC values, but the general classification of these two locations within the dominant category does not change.

huge variety of commodities with a large market area too; while in the next levels other medium size and small cities (Rank 3 cities and Rank 4 cities) are scattered geographically between these two previous city-ranks, presenting more standardized products with a lower or even insignificant market areas only supplying the most homogeneous goods needed for consumption.

Although the theoretical predictions about the existence of an urban hierarchy system is related to the magnitude of trade flows and its associated product mix, empirical studies have only focused on a proxy corresponding to cities populations, showing that the larger the population, the higher will be its rank within the country. The underlying assumption is that population size is not only a good proxy of city's size, but also implies a more diversified demand that supports the production of a wider range of products. Despite this attempt to relate the city's size with its market area, we consider that there is lack of empirical evidence based on relevant trade flows. That is why, so as to study the concentration of trade flows in shorter distances, and to complement and reinforce our breakpoint thresholds and home bias (border) effect analyses, we rely on our empirical data to provide evidence that supports the existence of an urban system based on the volume and sectoral characteristics of the distribution of trade flows, i.e., the number of commodities and trading partners that each city shows, and its relation with the city's market area.

Table 9 shows these distributions in 2003 and 2007, differentiating by intervals the number of commodities shipped and the numbers of cities with which shipments take place. Data are given as percentage over the total number of municipalities, indicating the amount of municipalities that trade a determined number of commodities and the number of different municipalities with which they trade.[32] It can be observed that the largest number of municipalities trade between 10 to 50 commodities with a set of 10 to 50 municipalities interval, although this percentage has shifted in 2007 as the number of commodities shipped to the same number of municipalities increases, showing a diversification in the shipments' product composition, as well as a wider array of destinations. In fact the percentage of shipments in the upper intervals, greater than 10 commodities and 10 municipalities, increase from 87.86% in 2003 to 91.55% in 2007. Finally, there has been an increase in the number of municipalities that trade more than 100 commodities to more than 100 counterparts; from 14.19% to 15.50%, respectively.

[32]The intervals considered are in line with Mayer and Ottaviano (2008) for the case of exporting firms, but adding some intervals to better disentangle the regional and sectorial shipments distributions.

2003	Number of Municipalities					
Number of commodities	1	(1-5]	(5-10]	(10-50]	(50-100]	More than 100
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
(1-5]	0.00%	0.16%	1.12%	3.19%	0.00%	0.00%
(5-10]	0.00%	0.32%	1.44%	5.42%	0.16%	0.00%
(10-50]	0.00%	0.00%	0.32%	38.6%	11.0%	0.16%
(50-100]	0.00%	0.00%	0.00%	1.91%	17.3%	2.71%
More than 100	0.00%	0.00%	0.00%	0.00%	1.91%	14.19%
2007	Number of Municipalities					
Number of commodities	1	(1-5]	(5-10]	(10-50]	(50-100]	More than 100
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
(1-5]	0.00%	0.16%	1.12%	1.60%	0.00%	0.00%
(5-10]	0.00%	0.00%	0.64%	3.83%	0.00%	0.00%
(10-50]	0.00%	0.00%	1.12%	42.1%	8.31%	0.00%
(50-100]	0.00%	0.00%	0.00%	1.76%	19.1%	1.60%
More than 100	0.00%	0.00%	0.00%	0.00%	3.04%	15.5%

Own elaboration from the Road Freight Transportation Survey data.

Table 9: Shipments distribution by municipalities and products.

Table 9 sheds light on the urban hierarchy system. The main diagonal characterizes different types of cities; that is, a huge proportion of cities represents medium-small cities (Rank 4 and 3 cities in CPT terminology), other group of cities trade more commodities with more cities (Rank 2 cities); meanwhile only a few proportion of cities trade a huge number of varieties with a huge number of other cities (Rank 1 cities). That is, large cities supply more goods to more different destinations than small cities, Tabuchi and Thisse (2011). Specifically, we have clustered the municipalities according to these two variables, the number of different commodities that they ship and the number of trading partners, in order to split the sample attending to an objective criteria and using the two variables predicted by the CPT as indicators for varying market areas. We have used cluster techniques obtaining four different groups corresponding to the Christaller's idea about product diversity and geographical reach/rank. Concretely, we have performed the analysis using the raw data from the RFTS. Table 10 on the following page shows the city-type clusters obtained after applying the cluster analysis (K-means based on centroid distances).[33] This city-type distribution remarkably

[33]Based on the dendogram, we decided to form four groups of cities for, in a subsequent step, using the K-means analysis to obtained the four groups after 25 iterations

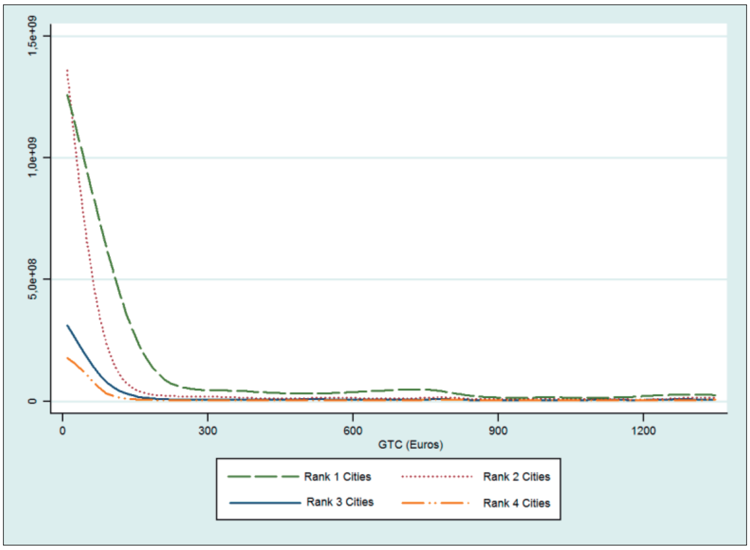


Figure 6: Kernel regressions for different city-cluster.

matches the real economic distribution of Spanish cities.

City Rank	Number of Cities
Rank 1	4
Rank 2	21
Rank 3	101
Rank 4	507

Table 10: Number of Cities by Cluster-Type.

According to the theory, each of these city-groups should present different market areas that shrink with the rank of the city. Figure 2.6 depicts the specific relationship by showing different kernel regressions for each cluster of cities.[34] As expected, cities with a higher rank present higher densities for all distances, thereby enveloping the distributions of lower rank cities–both at any trade cost value and threshold. Moreover, the elasticity of trade flows to GTCs is lower for all transport costs; i.e., over short distances Rank 3 and Rank 4 cities are not as sensitive to GTCs as higher rank cities. Indeed, the concentration of trade flows in short distances observed in Figs.2a-c is clearly driven by these two city-clusters.

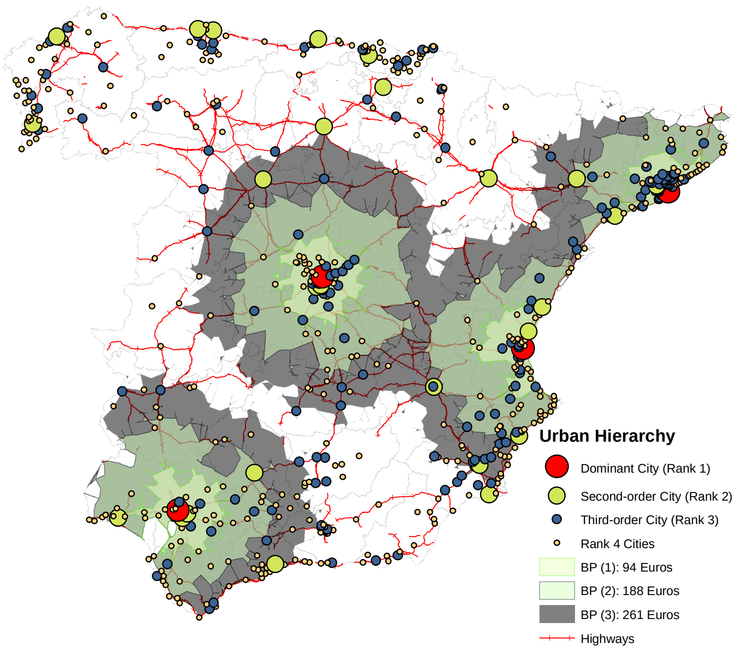
[34] As in the first kernel regressions, we regress the total value of trade against the GTCs in euros but accounting for each type of city.

We map this information to show a detail representation of the Spanish urban hierarchical system. As far as we know Figure 2.7 is the first illustration of an actual hierarchical system based on trade flows. It illustrates cities in relation to the four city-type already calculated. Additionally, we map the breakpoint thresholds for the dominant (Rank 1) cities after applying again the Chow test only for this group of four cities (Madrid, Barcelona, Valencia and Seville). It can be observed that the first threshold covers the metropolitan area of these big cities, while the second and the third breakpoints reach Rank 2 cities or even intermediate (Rank 3) cities as predicted by the central place theory. Indeed, it seems that the map is a remarkable representation of the geometry proposed by Christaller (Parr, 2002); specially, if we consider that his theoretical representation was simply based on a homogeneous space with constant distance-decay transport costs function. Moreover, it is clear that the geographical reach of these breakpoints exceeds all administrative levels of the spatial units; particularly, Nuts-5 (municipal) and Nuts-3 (provincial) territorial units, i.e, again trading activity spreads over administrative levels. Also, there exists an additional breakpoint at the value of 665€, although we have not shown it to summarize the map information. This last breakpoint represents again the distance between the main Rank 1 cities, particularly Madrid and Barcelona, which emphasizes the results obtained in the previous section.[35] This pattern explains the high concentration (home bias effect) found at the municipal level in Table 3, indicating that it is precisely the trade flows between first rank () cities what shapes the structural trade distribution of the data, thereby resulting in high market areas, i.e., large breakpoints. In fact, and taking into account that each successive breakpoint entails lower levels of trade flows, this result points out that trade flows within a country tend to concentrate because of the existence of market areas that surround the largest cities. More concretely, these market areas are creating an urban hierarchical system where only few cities perform the main part of the trade flows.

6 Conclusions

This study aims to develop a research strategy that validates an improved methodology to assess and explain intra an inter-municipal trade flows based on real transport

[35] Additionally, calculating the breakpoints for Rank 2 cities we obtain a third point that exactly matches the same GTC value (261€), that is obtained for Rank 1 or Dominant cities. This finding emphasizes the idea of competing market areas—Cavailhes et al. (2007); Tabuchi and Thisse (2011).



Note: The fourth breakpoint is equal to 665€.

Figure 7: Urban Hierarchy and Natural Trade Areas for Dominant Cities. First, Second and Third GTCs Breakpoints.

costs rather than on its distance and time proxies. It establishes the non-linear relationship between trade flows and transport cost in terms of suitable thresholds that are identified by way of Chow's test for structural breaks. These breakpoints are later used to: i) qualify the existing results that place an (overstated) explanatory premium on administrative (border) effects within countries; i.e., the administrative border effect hampering trade is unlikely to hold, and ii) define trade areas that convincingly portrait an urban hierarchy system based on the geographical reach and diversity of trade.

Specifically, making use of two novel micro databases in the literature on international and interregional trade flows we analyze the agglomerating patterns of trade flows around specific areas, i.e., cities. The first database compiles information about freight shipments transported by trucks between Spanish municipalities for the period 2003-2007. The second one involves the calculation of an alternative and very precise monetary measure of transport cost between cities (the generalized transport cost, GTC). We show that this GTC measure is the most suitable measure of transport cost when explaining trade flows within a panel data structure–in contrast to distance and travel time normally used in the literature. This is because GTC is the only measure capturing the real dynamics and effects on trade flows of changes in operating costs over the years.

Thanks to the detailed information on shipments, we decompose aggregate trade flows into their extensive and intensive margin, so as to determine, in a first step, the effects of the geographical frictions corresponding to the three internal territorial boundaries existing in Spain (border effects) on each one of them, while controlling for the precise generalize transport cost measure. In a first naïve analysis, we conclude that the effects of the internal administrative levels on trade flows are higher than the ones reported by Hillberry and Hummels (2008) for low transport cost values. However, allowing for a precise trade flows-transport cost relationship, we show that regional borders have a much reduced, or even negative, impact on the trade flows taking place within them; while intra-municipal trade (or surrounding areas) tends to concentrate the largest share of trade flows. In contrast to Hillberry and Hummels (2008), which suggest that this city's border effect is a reductio ad absurdum on the "home bias" literature, we argue that this higher density has nothing to do with border impediments, but it arises as a result of transport cost thresholds that define the geographical scope of agglomeration economies, which mass shipments around Rank 1 or dominant cities resulting in large market areas.

To show this idea we introduce the endogenous Chow Test into the trade literature, allowing us to determine the transport costs thresholds at which the trade flows–transport cost relationship changes structurally. Thanks to this methodology, we run equivalent regressions for each range of shipments within subsequent breakpoints, so as to correctly measure the impact of administrative boundaries on trade flows within a country defining a series of cities' market areas. In this respect we confirm the high density of shipments at GTC values below 189€ (170km or 150 minutes), presenting strong evidence on how agglomeration economies shape market areas and an urban hierarchy based on trade flows. In this respect we present empirical evidence by which few large cities dominate geographically and account for the largest trade share, while small cities spread along the geography without significant influence areas in terms of market size. We argue that these results are in line with the empirical predictions emanating from the Central Place Theory, producing the first map of an urban hierarchy system based on actual trade flows. Moreover, we provide evidence corroborating the hypothesis that associates the ranking of the cities not only to trade volumes, but most importantly to the diversity of the goods being shipped (production mix) and their multiple destination geographical reach.

All these results call for future studies based on how this very sharp picture of trade flows and market areas, emerges in an urban hierarchy. In this sense, it is necessary to expand the analysis focusing on the intensive margin (average value of each shipment) at the sectorial level, so as to understand in what sense it leads to the specialization of the economic structure of Spanish cities. Finally, focusing on sectorial analyses, it is worth explaining the existence of large trade flows between far away (rank 1 or dominant) cities, which in turn implies the study of the value transport cost relative to the origin (mill) and destination process subject to high transport costs; i.e., a challenging analysis in terms of relative prices, Alchian-Allen effects and related demand analysis. Particularly, establishing whether goods that are shipped far away are highly differentiated (heterogeneous) as opposed to goods that are traded over very short distances and would present close substitutes (homogenous goods).

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8 Appendix: Kernel Regressions

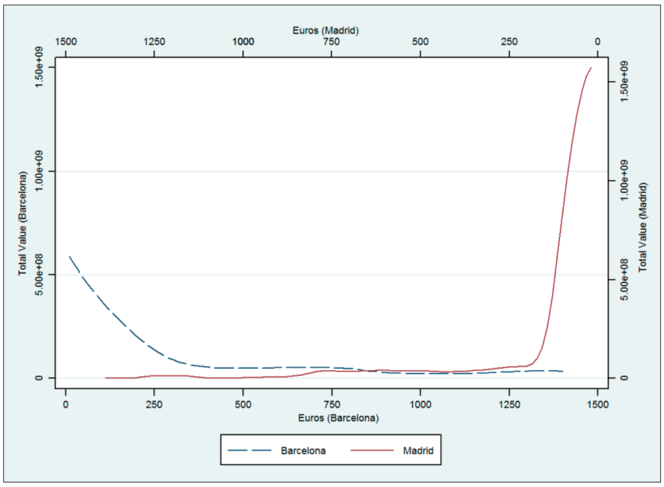

Figure 8: Trade areas competition for Madrid and Barcelona municipalities (NUTS-5).

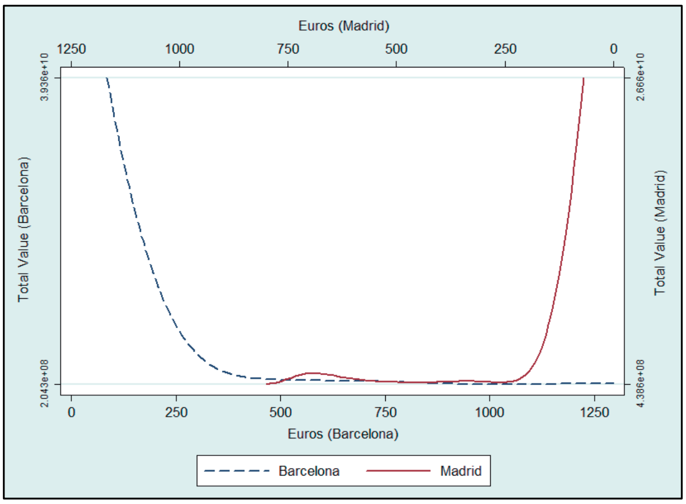

Figure 9: Trade areas competition for Madrid and Barcelona provinces (NUTS-3).