OPENING THE INTERREGIONAL TRADE “BLACK BOX”:

AUTHORS:

Carlos Llano Economic Analysis Department. and L.R.Klein Institute-CEPREDE. Facultad de CC.EE y EE. Módulo E-XIV. Universidad Autónoma de Madrid. Campus Cantoblanco. 28049 MADRID (carlos.llano@uam.es)

Almudena Esteban. L.R.Klein Institute and CEPREDE (almudena.esteban@ceprede.es)

Julián Pérez. Applied Economics Department. L.R.Klein Institute and CEPREDE. Facultad de CC.EE y EE. Módulo E-XIV. Universidad Autónoma de Madrid. Campus Cantoblanco. 28049 MADRID; (julian.perez@uam.es)

Antonio Pulido. Applied Economics Department. L.R.Klein Institute and CEPREDE. Facultad de CC.EE y EE. Módulo E-XIV. Universidad Autónoma de Madrid. Campus Cantoblanco. 28049 MADRID: (antonio.pulido@uam.es)

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1 Corresponding author.
Abstract: Recent literature on border effect demonstrates that national trade (intra plus interregional trade) tends to be more intense than international trade. Unfortunately, due to the dearth of information on interregional economic relations, this important aspect of the economy has remained relatively ignored. In this paper we describe the methodology and main results of the largest estimation of Spanish interregional trade (1995-2005), carried out as part of the C-Interreg project. The results obtained highlight the importance of the internal trade and the validity of the gravity model. Although the estimation focuses on the Spanish economy, the methodology is easily applied to other EU countries. In the upcoming years, this innovative database will be further develop in all of its dimensions (space, time and sectors) to serve as a promising framework for the application of different techniques such as spatial interaction models or interregional input-output approaches.

1. Introduction

Despite the marked process of globalisation and integration of OECD economies, the main bulk of economic transactions still continue to take place within national boundaries. Indeed, recent literature on border effect indicates that a pair of regions within a country tends to trade 10 to 20 times as much as an otherwise identical pair of regions across countries.²

Another group of studies, this time focused on the US and Japan (Hewings et al., 1998, Munroe and Hewings, 1998, Hitomi et al., 2000), also found that within-country interregional trade is growing more rapidly than intraregional and international trade and that, in general terms, regions have become more closely linked. More recently, Jackson et al (2006) noted that US industries shipped approximately $7 trillion worth of goods inter-regionally in 1997 using the nation’s highways, railroads, waterways, pipelines and aviation systems (11 billion tons and 2.7

trillion ton-miles). This volume has increased by 18.8% (up to 14.5% and 9.9% for tons and ton-miles, respectively) since 1993. Hence, not only has the volume of interregional trade increased but trading patterns have become more complex too. The evidence from the European Union appears to confirm these findings. While the intensity of intra-European trade has grown in recent decades (Van der Linden and Oosterhaven, 1995; European Economy, 2005 and 1997), most of trade still continues to be concentrated within each country (Ferreira, 2008; Llano, 2004a, 2004b; Oliver et al, 2003). As a result, although regional dependence on international trade may have increased in the majority of Europe’s regions, one can expect most economic growth in a single region to be primarily explained by national causes (intra+interregional shocks) as opposed to international ones.

Unfortunately, the absence of information regarding interregional trade makes difficult to demonstrate such a hypothesis in the case of the majority of countries. Due to this lack of data, consequently, a key area of economic activity remains largely unknown, thus limiting possible analysis of the inter-sectoral and inter-regional linkages that account for the co-movements of regional cycles or interregional spillovers in terms of growth, employment or productivity.

The size of this ‘black box’ is enormous for most countries. For example, in the case of the Spanish economy, which occupies a mid-position in terms of its international openness ratio in the OECD context, over 80% of national output is purchased by the country itself, with only 20% exported abroad. In addition, given the highly decentralised territorial organization of the country, it is possible to conclude that many strategic decisions regarding the competitiveness of the different regions are being taken without the required relevant information.

To solve this issue, a group of researchers from the L.R. Klein Institute-CEPREDE and 11 out of Spain’s 17 regional governments launched the C-Intereg project (www.c-intereg.es), set up as a permanent initiative focused on interregional economic relations in Spain and the rest of Europe. The first outcome of the project is the largest estimation to date of Spanish interregional
trade of goods (1995-2005), including information on the spatial origin and destination of flows (regions NUTS-2 and provinces NUTS-3), 16 types of products and 6 types of transport modes.

The main objective of the present paper is to describe the methodology used in the estimation and analyse the main results obtained using the gravity model. In this regard, it is important to note that, although the estimation focuses on the Spanish economy, this methodology can be easily applied to other EU countries. Indeed, a recent work has employed a similar methodology to estimate interregional trade within Portugal and within the Iberian Peninsula as a whole (Ferreira, 2008).

The rest of the paper is structured as follows. In section 2 we provide a brief review of the most common approaches used to estimate interregional trade, both at international level and in the particular case of Spain. Section 3 focuses on the methodology used in the C-Interreg database, based on bilateral transport flows and regional prices. Finally, the interregional commodity flows for the period 1995-2005 are analysed in section 4 using the classical gravity model.

2. **Interregional trade: estimation methods and previous experiences**

Information concerning interregional commodity flows is scarce and incomplete in the majority of countries (Jackson et al., 2006). Interregional trade, therefore, has to be estimated through non-survey techniques, which are based on different hypotheses regarding the probability of interactions between a pair of points in space.

The current literature on international trade, transport economics and spatial interaction models sets out several approaches to estimate commodity flows in space, taking into account a number of critical variables such as distance, industry specialisation, infrastructure endowment and transport connectivity. Gravity models, spatial choice, entropy maximising paradigm and neuronal network models are among the best-known methods (see Wilson, 1970a, 1970b, 1973;
Moreover, the literature on interregional input-output modelling (Isard, 1951, 1953; Moses, 1955; Polenske, 1980; Kim et al, 1983; Oosterhaven, 1984; Miller y Blair 1985; Hewings et al, 1998; Hitomi and Hewings, 2000; Liu and Vilain, 2004; Kockelman et al., 2005; Ruiz and Kockelman, 2006;) and multiregional Computable General Equilibrium models and Social Accounting Matrices (Stone, 1961; Round 1995; Jackson et al., 2006; Bröcker and Schneekloth, 2006; Bröcker 1998) also offer interesting approaches to estimate interregional trade flows, linking the IO and SAM frameworks to interregional transport flows.

<< Table 1 about here>>

2.1 The estimation of interregional trade in Spain

Although several statistics with partial information on Spanish interregional trade are available (Table 2), their consistency and comparability remains insufficient. Given these limitations, the main objective of the C-Intereg Project was to estimate a permanent database with data on intra, interregional (and international) trade of all the Spanish regions, with different levels of sectoral and spatial disaggregation for both goods and services. The current database corresponds to the largest (1995-2005) estimation of interregional trade in goods at regional level (Eurostat Nuts2 level: 18 Spanish regions or ‘Autonomous Communities’) and the first at provincial level (Eurostat Nuts3 level: 52 Spanish provinces), including a detailed breakdown by types of product (30 categories of goods), transport mode (road, rail, ship, plane, pipe and electricity system) and units (Euros, Tons).

<< Table 2 about here>>
The methodology used for the estimates is based on previous works (Llano, 2004a, 2004b; Pulido et al. 2000; Oliver, 1997) and includes a number of improvements and extensions. It combines the most accurate data on Spanish transport flows of goods by transport modes (road, rail, ship, plane, pipe and the Spanish electricity system) with additional information used to estimate 52 specific export price vectors, one for each province of origin, transport mode and product type. The methodology also includes a process for debugging the original transport flow database that makes possible the identification and reallocation of multi-modal transport flows and international transit flows which may be originally hidden in the interregional flows. This procedure results in initial estimates of interregional trade flows in tons and current euros based on a combination of the transport and prices databases. Finally, a process of harmonization is applied to produce final figures in tons and euros consistent with the figures for total output from the Spanish Industrial Survey and National Accounts. It should also be noted that, at each stage up to the final aggregation into 16 types of product and the final process of harmonization with output figures, the methodology relies on the lowest level of disaggregation available. More specifically, the transport flows are based on classifications that range from 160 to 40 different types of product (depending on the 4 transport modes available) and price data on 11,000 different types of product.

3.  Estimating Spanish interregional trade in the C-Interreg Project

The methodology employed in the elaboration of the database can be divided into the six steps described in the following sections.

3.1  Harmonisation of transport flows and estimation of unavailable data:

For the sake of simplicity, although we use the general concept of “regions”, the methodology was applied to the 52 Spanish provinces (Nuts 3) and then aggregated to the 18 Spanish regions (Nuts 2). In addition, the method relays, at each successive step, on the highest level of disaggregation for each transport mode.
In this section, we review the situation of the Spanish statistics regarding the commodity transport flows, and the transformations required for obtaining a full coverage of the movements accounted within the country during the period under study. Before going into further detail, it is important to bear in mind that, for each year and transport mode, the goal is to estimate a set of origin and destination matrices (OD matrices) that capture all the deliveries in Tons (Tn.) by the largest possible product disaggregation. For the purpose of clarity, the procedure applied for each transport mode is explained separately using a similar notation.

In general terms, the final aim is to estimate all the transport flows in tons described by $F^t_{rs,j}$ elements, which capture the flows $F$ of product $i$ in year $t$ with origin in region $r$ and destination in region $s$. Then, for each transport mode, we will define equivalent elements $F^{IR}_{rs,j}$, $F^{IT}_{rs,j}$, $F^{IS}_{rs,j}$, $F^{IA}_{rs,j}$, $F^{IP}_{rs,j}$, where the upper script “R” denotes the flows using road transportation, the “T” for train, the “S” for ship, the “A” for aircraft and the “P” for pipe.

<< Table 3 about here>>

a) Transport flows by road ($F^{IR}_{rs,j}$): removing intra-municipal flows and international transit flows

The Permanent Survey on Commodity Transport by Road (PSCTR), published by the Spanish Ministry of Public Works (Ministerio de Fomento), is one of the key sources of our original database on transport flows in tons (more than 80% of commodity flows in Spain are moved by road). Based on this key survey, for each year $t$ and each type of product ($i=160$), a large set of OD matrices of flows in tons were obtained. The main limitation of the original data is that, from 2000 onwards, the survey includes the intra-municipal flows (IMF). Due to the absence of this information for the period 1995-1999, and in order to assure the comparability of intra-regional flows along the whole period (1995-2005), intra-municipal flows have been removed.
from the road transportation database\(^4\). In addition to this, as we will see in section 3.2, the original flows recorded by the PSCTR required to be depurated to prevent the inclusion of international transit flows (ITF) hidden in the inter-regional deliveries. These processes are described in the following transformation:

\[
F_{rs,t}^{ir} = OF_{rs,t}^{ir} - IMF_{rr,t}^{ir} - ITF_{rs,t}^{ir}
\]

where \(OF_{rs,t}^{ir}\) represents the original OD flows from the PSCTR survey, \(IMF_{rr,t}^{ir}\) the intra-municipal commodity flows included in the survey after 2000 and \(ITF_{rs,t}^{ir}\) the international transit flows moved by road (see section 3.2).

\(\text{b) Transport flows by train } (F_{rs,t}^{iT})\): assessing sectoral disaggregation to containers

Information on commodity flows by train is provided by the national rail network RENFE (a former national monopoly). Commodities are moved either in “complete wagon” (\(CW\)) or “containers” (\(CNT\)) (30% of Tons were moved by \(CNT\)). Unfortunately, RENFE does not provide detailed information in relation to the types of products included in the containers. For this reason, the allocation of these flows to specific products is done employing the sectoral structure of railway flows that use “complete wagon”, have the same region of origin and can be transported in containers. Since not all type of products \(i\) can be transported in containers, we use super script \(j\) to denote those types of products that are usually transported in this sub-mode\(^5\). Accordingly, for each year \(t\), the final amount of flows by railway from origin \(r\) to destination \(s\) of product \(i\) \((F_{rs,t}^{ir})\) is obtained from the following expression:

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\(^4\) It should be noted that, in some cases, intra-municipal flows do not correspond to economic transactions but to the capillary distribution of commodities stocked and distributed within each municipality for final consumption. In this respect, the elimination of intra-municipal flows may be an advantage rather than a drawback because it helps to prevent the double counting of intra-regional flows. By contrast, the elimination of the intra-municipal flows will tend to decrease the intra-provincial trade and, therefore, the border effect at this spatial level.

\(^5\) Due to the absence of information on the specific commodities transported in the containers, and considering that the elimination of this sub-mode will lead to a decrease of 30% of flows by railway, we have suggested the methodology described above. Based on the RENFE’s qualitative information, we were informed that some commodities like raw materials, non transformed agricultural products, energetic products, minerals, etc, are not transported in containers. From this information we inferred that, for each origin, the containers will contain the same \((j)\) categories that were able to be transported in
\[ F_{rs,j}^{IT} = CW_{rs,i}^j + \left( \frac{CNT_{rs,i}^j \cdot CW_{rs,i}^j}{\sum_{i=1}^l CW_{rs,i}^j} \right) - ITF_{rs,i}^IT \] (2)

where \( CW_{rs,i}^j \) are the commodities of type \( i \) measured in tons transported in “complete wagon” from region \( r \) to \( s \), \( CNT_{rs,i}^j \) is the total amount of commodities in tons transported in containers from region \( r \) to \( s \), \( \frac{CW_{rs,i}^j}{\sum_{i=1}^l CW_{rs,i}^j} \) is the share of each commodities \( j \) that were transported in “complete wagon” (and can be transported in “containers”) with origin in \( r \) compared to the total amount of commodities \( j \) transported in “complete wagon” with origin in that region \( r \). Finally, \( ITF_{rs,i}^IT \) captures the international transit flows moved by train which, like in the case of commodity flows by road, required also to be depurated (see section 3.3).

c) **Transport flows by ship \((F_{rs,i}^{IS})\): Estimation of OD matrices using updated margins and old OD matrices**

Due to the absence of an up-to-date set of OD matrices by ship with the required sectoral breakdown, these are estimated by means of a common approach used in the input-output literature to update old intersectoral structures using new data for the margin totals. This procedure, based on previous works (Allen and Gossling, 1975; Dijkman H. and Burgess, 1994; Polenske and Möhr, 1987), uses the Long Scale Optimization procedure (Fylstra et al, 1998; Lasdon and Smith, 1992) to update the most recent OD matrices available (published by Spain’s State Ports Authority -Puertos del Estado- in 1989) with new data on the volume of containers, and were present in the production and exporting structure by railway of each exporting province. This assumption is based on the idea that if a province is specialised in producing and exporting commodities in “complete wagon”, similar firms within this province would deliver them in containers, with the limitation always on the nature of the product and the possibility to be transported in this mode.
commodities loaded/unloaded in each port (1995-2005 Statistical Yearbook. Puertos del Estado\(^6\)). This procedure can be briefly summarised in three steps:

1. First, based on the available information for 1989, we built a set of 1989 OD maritime flows \((F_{rs,ht})\) that consider \(r=27\) possible origins and destinations (the main Spanish ports at that time) and \(i=46\) types of product (corresponding to the CSTE -Commodity Classification for Transport in Europe-, that is, the classification used in the 1989 reference).

2. Secondly, we built a parallel database with the annual data published for domestic maritime volumes loaded and unloaded in the main Spanish ports for each year (1995-2005) and type of product \((i=40\) categories). At this stage, it is important to note that, for some years and types of product, the total amount of tons loaded \((l)\) and unloaded \((u)\) do not match. Given that in an OD matrix the sum along the rows must coincide with the sum along the columns, we re-scale the largest vector to the total of the shortest one, using the following procedure.

\[
\begin{align*}
\text{If} & \quad \sum_{s}^{\text{ts}} u_{s,t}^i < \sum_{r}^{\text{rtr}} l_{r,t}^i \quad \text{then} & \quad \tilde{l}_{r,t}^i &= l_{r,t}^i \times \frac{\sum_{r}^{\text{rtr}} u_{s,t}^i}{\sum_{r}^{\text{rtr}} l_{r,t}^i} \\
\text{If} & \quad \sum_{s}^{\text{ts}} u_{s,t}^i > \sum_{r}^{\text{rtr}} l_{r,t}^i \quad \text{then} & \quad \tilde{u}_{s,t}^i &= u_{s,t}^i \times \frac{\sum_{r}^{\text{rtr}} l_{r,t}^i}{\sum_{r}^{\text{rtr}} u_{s,t}^i} \\
\end{align*}
\]

where \(u_{s,t}^i\) is the original amount of commodity \((i)\) unloaded \((u)\) in region \((s)\) and year \((t)\), \(l_{r,t}^i\) is the original amount of commodity \((i)\) loaded \((l)\) in region \((r)\) and year \((t)\). Equivalently, where \(\tilde{u}_{s,t}^i\) we have the “new amount” of commodity \((i)\) unloaded in region \((s)\), while \(\tilde{l}_{r,t}^i\) denotes the “new amount” of commodity \((i)\) loaded in region \((r)\) and year \((t)\). As it is described in equation (3) the new amount is obtained re-scaling the larger with the lower total amount. Accordingly, for each year \((t)\), we obtain two new vectors of elements \(\tilde{u}_{s,t}^i\) and \(\tilde{l}_{r,t}^i\) that sum up the same amount of tons, and maintain the structure of the original vectors. Therefore, for each year \(t\) and

\(^6\) Puertos del Estado: \[\text{http://www.puertos.es/es/estadisticas/index.html}\]
product \( i \), these re-scaled vectors are now ready to be used as margins for updating the old OD matrices.

3. Next, for each year (1995 onwards) and type of product \( (i=40) \) and using a Long Scale Optimization procedure (Fylstra et al, 1998; Lasdon and Smith, 1992), we find an OD flow matrix where the sums along the rows and columns coincide with the corresponding totals loaded and unloaded in each port, by year and type of product. The interactive procedure begins with the 1989 actual OD matrix for each type of product and concludes with a complete set of OD flow matrices for 40 types of product from 1995 onwards. In line with Polenske and Möhr (1987), this step can be described as a maximization procedure of the non-null values subject to the margin constrains\(^7\).

\[
F_{rs,t}^{IS} = \text{Max} \left[ \sum_{r \in S} \sum_{s \in S} F_{rs,89} \right]
\]

(4)

Subject to:

\[
\sum_{r \in S} F_{rs,t}^{IS} = l_{s,t}^{i} \quad (s = 1,2,...,n)
\]

\[
\sum_{s \in S} F_{rs,t}^{IS} = u_{r,t}^{i} \quad (r = 1,2,...,n)
\]

where \( F_{rs,t}^{IS} \) is an element on the new OD flow matrix by ship \( (S) \) estimated for year \( t \) (1995 onwards) containing the flows in tons of product \( i \) moved from port \( r \) to port \( s \), \( F_{rs,89}^{IS} \) is an element on the old 1989 OD flow matrix by ship \( (S) \), containing the flow in tons of product \( i \) moved from port \( r \) to port \( s \); \( S = \{(r,s) | f_{rs} > 0 \} \) represents the non-null flows traded between the 27 main ports \( (r,s) \); \( \overline{l}_{r,t}^{i} \) is the vector of tons of product \( i \) loaded in the ports \( r \) in year \( t \), and \( \overline{u}_{s,t}^{i} \) is the vector of tons of product \( i \) un-loaded in the port \( s \) in year \( t \).

\(^7\) The problem could also be described as the minimization of the difference between the total sum of bilateral flows in each new OD matrix and the old ones, subject to the same marginal constraints (Allen and Gossling, 1975; Dijkman and Burgess, 1994)
d) **Transport flows by aircraft** \( (F_{rs,t}^{ia}) \): **assessing the sectoral disaggregation of domestic OD matrices**

Surprisingly, despite the existence of a single OD matrix of total domestic flows by aircraft in tons for each year \( (DF_{rs,t}^{A}) \), it has proven impossible to obtain detailed data with respect to each sectoral disaggregation. For this reason, for each year (1995-2005), the product disaggregation of this single matrix \( (DF_{rs,t}^{A}) \) has been deduced using the product specialisation of international flights \( (IF_{rs,t}^{IA}) \) for which data are available) for each airport of origin \( (r) \) and year \( (t) \). With this estimation, it is assumed that if a specific region has interregional exports of goods shipped by aircraft, the sectoral structure of its domestic outflows to any of its destinations will be the same as those observed in international exports from the same airport. In order to increase the plausibility of such an assumption, we only consider the international trade of Spanish regions with the nearest countries (France, Portugal, Germany, Italy and Morocco), where the same competition structures in terms of transport modes operate. The flows are divided according to the 160 categories considered in the NSTR-3 digits used for road flows.

\[
F_{rs,t}^{ia} = DF_{rs,t}^{A} \times \frac{IF_{r,t}^{ia}}{\sum_{i=1}^{160} IF_{r,t}^{ia}} \quad (5)
\]

where \( F_{rs,t}^{ia} \) is an element on the new OD flow matrix by aircraft \( (A) \) in year \( t \) containing the flows in tons of product \( i \) moved from airport \( r \) to airport \( s \). These sectoral flows are obtained departing from the total amount of commodities in year \( t \) moved from airport \( r \) to \( s \) \( DF_{rs,t}^{A} \), and the sectoral structure of the international flows \( (IF_{r,t}^{ia}) \) for each commodity \( (i=160) \) and airport of origin \( r \) in percentage of the total amount of commodities delivered by plane from the same origin.
e) Transport flows of oil refined products ($F_{rs,t}^{ip}$): reallocation of oil products delivered by pipe.

Due to the special distribution process of the oil refined products (gasoline, fuel-oil, kerosene...) in which pipelines are used to approach the product to the final markets from distant refineries, the pipe bilateral flows should not be aggregated to the other transport flows, but only used for the re-allocation of some road and rail flows of oil products. From our point of view, if a region $n$ with no refineries registers deliveries of oil products by road and train, it can be safely assumed that the exported product was originally produced in another region $r$ with refinery, which is serving the region $n$ by pipe. Consequently, the right allocation of the bilateral flows should first eliminate false exports attributed to the regions without refinery, and re-allocate them to the regions that originally produced the products and served them through the pipe.

In order to do this, some manipulations of the original flows ($OF$) are needed:

$$OF_{rs,t}^{i} = F_{rs,t}^{iR} + F_{rs,t}^{iP}$$

$$F_{rs,t}^{ip} = OF_{rs,t}^{i} - FR_{rs,t}^{i} + PF_{rs,t}^{i}$$  \hspace{1cm} (6)

$$PF_{rs,t}^{i} = FR_{rs,t}^{i} \sum_{s=1}^{S_{rs,t=1993}} \frac{F_{rs,t=1993}^{i}}{F_{rs,t=1993}^{i}}$$  \hspace{1cm} (7)

where $F_{rs,t}^{ip}$ is an element of the final OD matrix of oil products moved by road and railway, which is obtained by the addition of three elements (equation 6):

- a) The first one, $OF_{rs,t}^{i}$ denotes the original flows of oil-products $i$ moved by road ($F_{rs,t}^{iR}$) and train ($F_{rs,t}^{iP}$) in year $t$ with origin in region $r$ and destination in $s$.

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8 At this point it is helpful to consider the distribution structure of oil products. In Spain, most refineries are located in the coast, near the big ports where the imported crude is unloaded and refined. There is just one refinery located in an inner region (Castilla-La Mancha). Some refined products are pumped through the pipes to the main points of consumption, where they are stocked in tanks and re-distributed by trucks and trains. Trucks and trains can also depart from the refineries themselves to serve close markets. Based on this structure, we consider that pipe flows should be consider as “transit flows” from the refineries to the tanks. However, the pipe flows serve to re-allocate other flows of refined oil products that apparently were delivered from regions with no refineries.
b) the second, $FR_{rs,d}^i$, which is subtracted from the previous one, denotes an specific type of flows that fulfil the following requirements: 1) they are flows moved by road and railway of refined products $i$ that could be transported by pipe, and, 2) they were originated in regions $(r)$ with no refineries. Since we do not want to have regions without refinery exporting oil products to other regions, $FR_{rs,d}^j$ elements are, consequently, eliminated from the road and railway database.

c) The third element, $PF_{rs,d}^i$, captures the $FR_{rs,d}^i$ flows once they have been reallocated as exports from the regions with refineries which are more likely to have originally produced the oil\(^9\) and pumped it to the regions that, according to the original data, were exporting it by road and railway. As it is explained in equation (7), the reallocation of these flows is obtained by means of the only OD matrix available for the pipe, $F_{rs,d=1993}^{i,p}$, which was estimated for the year 1993\(^{10}\). Consequently, the re-allocation of the “apparent exports” by road and truck of regions without refinery to the regions with refinery is based on the percentages obtained from the most recent OD matrix available for flows of oil-products through pipe.

Following these transformations, the element $F_{rs,d}^{ip}$ captures the final flows of a subgroup of oil refined products that could be transported by pipe, that were transported by truck and railway and whose regions of departure $r$ have refineries. After this procedure, the obtained flows are then aggregated to the rest of the flows from the corresponding modes.

### 3.2 First debugging procedure for transport flows in Tons:

a) Debugging interregional flows from international transit flows

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\(^9\) Since exports with origin in regions without refinery become imports from the regions with refinery that served them, the transformed OD matrix $FR_{rs,d}^i$ is denoted as $FR_{rs,d}^j$.

\(^{10}\) A 1993 OD matrix calculated by THEMA-Consulting Group and the Ministry of Economic Development using data from CLH (the main Spanish oil distributor). Due to the liberalisation of the oil distribution sector in Spain, it has not been possible to obtain more recent information on OD flows after 1993.
Although all the information included in section 3.1 refers to interregional flows in tons, the transported products may have an international origin/destination. Most estimations of Spanish interregional trade tend not to have considered this complex issue (Ferreira, 2008; Oliver, 1997, Oliver et al, 2003). As a result, the international trade may be double-counted and the interregional trade of some specific regions overvalued. In the case of Spain, the highest risk in relation to international transit flows is associated with maritime-road and maritime-railway inter-modal connections\textsuperscript{11}. In previous works, Llano (2001, 2004a) has developed a meticulous approach for dealing with this problem. Now, given the vast amount of data considered for the whole 1995-2005 period, the identification of international trade in transit along Spanish roads is based on a more automatic procedure. The process of identification and elimination of international transit flows has focused solely on transport flows by road (which account for more than 90% of flows in Spain) and comprises the three steps described below:

1. For each year during the period 1995-2005, we have obtained a database with the road flows between the 52 provinces and the municipalities where the country’s 27 main ports are located. This database contains flows for each of the 160 types of product considered in Spain’s Permanent Survey on Commodity Transport by Road (PSCTR).

2. Using the comprehensive database of Spanish international trade (Spanish Tax Agency, \url{www.aeat.es}), we estimate the international flows that were exported/imported by ship and moved by road/railway from/to the point of origin/destination. The figures for each type of product and port are obtained by identifying, from the aforementioned database, flows matching the following restrictions: \textit{Transport Mode} = 1 (Ship); \textit{Exports}: the province of \textit{origin/destination} of the flow is different to the \textit{Customs} point where the export/import is cleared (only Customs in the 27 main Spanish Ports are considered).

3. Next, by comparing the two databases mentioned above for each of each of the 160 types of product, we eliminate flows from the PSCTR that can be considered ‘international transit flows’. Bearing in mind the different nature of the databases (the first is a survey

\textsuperscript{11} In Spain most international trade with non-European countries uses shipping as the transport mode. Trade by road tends to use international freight services, which are not included in our database.
based on a directory of transport companies, while the second is a register of all international trade operations) some limits are established to this debugging process: 1) non-negative figures may result: if the international flow is greater than the figure calculated in the PSCTR, the former can become zero but not negative; 2) for each product, the figures eliminated may be below 15% of the flow received (delivered) by the province from the same origin (destination)\(^\text{12}\).

\textit{b) Allocation of multi-modal flows:}

Another key limitation when estimating interregional trade using transport flows derives from the difficulty in identifying inter-modal flows corresponding to the same transaction. When this issue is not appropriately taken into account by the employed methodology, the growing complexity of current transport logistics may lead to an increasing bias in such estimations. In the case of Spain, the risk of inter-modal connections is mainly associated with interregional trade between the mainland, the Islands (Balearics, Canary Islands) and Ceuta and Melilla (in Africa). However, due to the existence of special fiscal regimes in some of these territories (Canary Islands, Ceuta and Melilla), we have been able to access detailed fiscal information on interregional trade between the mainland and the Canary Islands, as well as with Ceuta and Melilla (Spanish Tax Authority, \texttt{www.aeat.es}). To the best of our knowledge, this is the first time such high-quality data on actual interregional trade between the Spanish mainland and the Islands has been included in a comprehensive estimation of interregional trade.

\section{3.3 Estimating interregional trade prices}

In line with previous studies (Llano, 2004a; Oliver et al., 2003; Oliver, 1997; Pulido et al. 2000), interregional trade prices are estimated on the basis of \textit{value/volume} relations deduced from detailed statistics contained in the Spanish Branch Surveys and International Trade

\footnote{This threshold is based on the information available with respect to the importance of trucks/railways for the interconnection of ports and “production” and “consumption” spots for international flows. Since the comparability of the two databases is limited, the 15% threshold avoids a complete elimination of flows between each pair of provinces.}
databases. For each year, transport mode and type of product, we try to estimate 52 export price vectors (one for each Spanish province, Nuts-3), denoted by $P_{im}^{jm}$, at the lowest level of disaggregation, in order to capture price/quality differences among regions for the same product. For the sake of simplicity, we use superscript $m$ to denote the 4 transport modes considered explicitly ($R, T, S, A$). Regional (Nuts 2) and national prices are used when there is an absence of provincial data. The estimation methodology comprises the following two steps:

a) **Detailed estimation of prices (€/Tn.) for base year 2000**

- **Industrial products**: the prices are deduced by dividing the data on value and volume published by the Survey of Industrial Products (INE-2000) for each region (NUTS 2) and with a high level of product disaggregation (4digits-NACE). Due to the lack of information at provincial level, all provinces within the same region share the same prices for each product, year and transport mode.

- **Prices for agricultural products** are deduced from the National Survey on Agricultural Products (Eurostat and the Spanish Ministry of Agriculture, MAPA). Unfortunately these prices are not available at regional level. Alternative sources (Eurostat) have been used for some specific products like, for example, energy.

At the same time, an alternative database has been estimated using information on international export prices at the lowest level of disaggregation (11,000 products; Combined Nomenclature, CN-8digits) for each year and transport mode at provincial level. This database has been used as a reference to control for outliers in the previous estimation based on Branch Surveys.

b) **Price projection for the remainder of the period (1995-2001; 2002-2005).**

Based on the price levels estimated for the base year 2000, the prices for the remaining years are estimated individually for each region, transport mode and type of product using the available information on industrial and agricultural price indexes at the lowest level of disaggregation (Eurostat). Due to the lack of information at regional level, for each type of

---

13 Note that the pipe (P) was just used to re-allocate apparent exports by road and truck.
product the evolution of regional prices in 2000 follows the national growth rates for the remainder of the period. Before applying this procedure, we tested to verify that the use of price indexes induces lower levels of instability than other alternative procedures (Llano, 2004a; Pulido et al, 2000; Oliver, 1997), such as inferring them directly from branch surveys or international trade databases for each year.

3.4 Translation of OD debugged matrices from Tons into Monetary Units

Next, the 4 sets of OD matrices of flows in tons by transport modes are translated into monetary units (euros) by multiplying the corresponding 4 sets of price vectors estimated in section 3.4\(^{14}\).

Accordingly, transport flows in tons \(F_{rs,t}^i\) from region \(r\) to \(s\), of product \(i\) and year \(t\) are transformed into trade flows in euros \(M_{rs,t}^i\) with the same features, using specific export prices vectors \(P_{r,t}^i\).

All the OD matrices already valued in current euros are then aggregated according to the largest common classification that allows further comparisons and homogenizations (see section 3.5.).

\[
M_{rs,t}^i = (F_{rs,t}^i P_{r,t}^R) + (F_{rs,t}^i P_{r,t}^T) + (F_{rs,t}^i P_{r,t}^S) + (F_{rs,t}^i P_{r,t}^P) \tag{8}
\]

where \(M_{rs,t}^i\) are the OD trade flows in monetary units, where \(i\) denotes de type of product, \(r\) and \(s\) the origin and destination regions and \(t\) the year. At this step we use two different classifications: the main one, with 16 types of product (R-16), and an extended one featuring 30 types (R-30), which maintains the corresponding proportion with the first classification. These classifications (R-16 and R-30) are both based on the NACE official classification and the specific classifications of the transport mode already considered.

\(^{14}\) It should be noted that the OD matrices of refined oil products originally transported by trucks and trains and reallocated according to the pipe information are here finally included in the original transport modes. There are, accordingly, no OD matrices of pipe.
3.5 Final screening of the R-16 OD matrices of goods in Euros:

Finally, the trade flows for each of the 16 types of product (R-16) are harmonized with the total output by region/province and industry obtained from different sources:

a) Industrial products (R3-R15):

- For each of the 14 OD matrices of industrial activities (excluding energy products), intraregional and interregional flows were harmonised with the available data published by the Spanish Industrial Survey (SIS). At the regional (NUTS 2) and provincial level (NUTS 3), the SIS provides information on total output per region $r$ and industry $i$ ($O_{r,t}^i$) and its geographical distribution by large markets: own region ($X_{Inter}^i_{r,t}$); rest of Spain ($X_{Inter}^i_{r,t}$) and the rest of the world ($X_{WR}^i_{r,t}$).

\[
O_{r,t}^i = X_{Intra}^i_{r,t} + X_{Inter}^i_{r,t} + X_{WR}^i_{r,t}
\] (9)

- Based on this information, for each year and industrial sector $i$, the ‘sums along rows of all the off-diagonal elements’ in the OD matrix in euros $M_{rs,t}^i$ were harmonized with the “$X_{inter}$”, while the ‘on-diagonal’ elements were harmonized with the “$X_{intra}$”. Due to the lack of information on the ‘amount of products consumed’, no constraints were established for the ‘sums along columns’. Thus, new OD matrices for ‘adjusted monetary flows’ ($AM_{rs,t}^i$) are obtained for each year $t$ and sector $i$, where the row totals for intra and interregional flows coincide with the aggregated information from the SIS, while the bilateral structure is based on the whole set of OD matrices $M_{rs,t}^i$.

Interregional adjusted flows: $AM_{rs,t}^i = M_{rs,t}^i \times \frac{X_{Inter}^i_{r,s}}{\sum_{s=1}^{S(i \in r,t)} M_{rs,t}^i}$ (10)

Intraregional adjusted flows: $AM_{rr,t}^i = M_{rr,t}^i \times \frac{X_{Intra}^i_{r,t}}{M_{rr,t}^i}$ (11)

b) Agricultural products:
Since the SIS does not provide information on Agriculture, Fishing and Forestry products (R1), the adjusted flows for this sector \( (AM_{ri,j}^{R1}) \) are obtained from the harmonization of intra+inter-regional flows \( (M_{ri,j}^{R1} + M_{ri,j}^{R1}) \) to the 'domestic output (non exported abroad) of agricultural products' provided by the National Accounts \( (DO_{t}^{R1}) \). It should be noted here that the quality of this adjustment is weaker than in the previous case (industries) since it does not control for the output produced and sold on the national market by each region/province.

\[
AM_{ri,j}^{R1} = (M_{ri,j}^{R1} + M_{ri,j}^{R1}) \cdot \frac{DO_{t}^{R1}}{\sum_{s=1}^{r=52} (M_{rs,j}^{R1} + M_{rs,j}^{R1})}
\]  

(12)

3.6 Special cases:

a) R2.-Mining and refinery.

The SIS information with respect to the mining and refinery (R2) industry is biased due to the presence of the headquarters of the big multinational companies in certain regions, particularly in Madrid. This effect is not so apparent in other industries. As a result, SIS data has to be re-estimated in order to eliminate this 'headquarter effect'. The procedure uses the regional shares of Regional Accounts in terms of the gross value added (GVA) of this industry \( (i=R2) \).

\[
AO_{r,j}^{R2} = O_{r,j}^{R2} \cdot \frac{GVA_{r,j}^{R2}}{\sum_{r=1}^{52} GVA_{r,j}^{R2}}
\]  

(13)

---

15 Note that since National Accounts do not include the total output per year, in some years \( DO_{t}^{i=R1} \) must be deduced from the gross value added \( (GVA_{t}^{i=R1}) \) and the international exports \( (EXP_{t}^{i=R1}) \) in year \( t \), and the total output of the agricultural sector \( (GO_{t}^{i=R1}) \) published in the last input-output table \( (t=2000) \):

\[
DO_{t}^{i=R1} = GVA_{t}^{i=R1} \cdot \frac{GO_{t=2000}^{i=R1}}{GVA_{t=2000}^{i=R1}} - EXP_{t}^{i=R1}
\]
The adjusted interregional totals are: 
\[ AX\text{Inter}_{r,t}^{i-R} = AO_{r,t}^{i-R} \times \frac{X\text{Inter}_{r,t}^{i-R}}{O_{r,t}^{i-R}} \] (14)

The adjusted intraregional totals are: 
\[ AX\text{Intra}_{r}^{i-R} = AO_{r,t}^{i-R} \times \frac{X\text{Intra}_{r}^{i-R}}{O_{r,t}^{i-R}} \] (15)

- Next, the OD matrices of products corresponding to this industry are harmonized\(^\text{16}\).

Interregional adjusted flows: 
\[ AM_{rs,t}^{i-R} = M_{rs,t}^{i-R} \times \frac{AX\text{Inter}_{r,t}^{i-R}}{\sum_{s=1}^{52} M_{rs,t}^{i-R}} \] (16)

Intraregional adjusted flows: 
\[ AM_{rr,t}^{i-R} = M_{rr,t}^{i-R} \times \frac{AX\text{Intra}_{r}^{i-R}}{M_{rr,t}^{i-R}} \] (17)

\(^{16}\) It should be noted that we use \(s=51\) since there are 52 provinces. Additionally, it should be taken into account that as stated in section 3.2.e), interregional flows of some refined products moved by road and railway are subsequently reallocated according to the inter-provincial pipe network.

\[ b) \quad R16.-Production \text{ and distribution of electricity, gas and water.} \]

The OD matrices of these products are estimated using the following methodology:

- As in the previous case, the SIS information concerning this industry required correction to eliminate the ‘headquarter effect’. The procedure applied is the same as the previous one.

- Unlike the case of other commodities, there are no OD matrices in tons and euros at regional and provincial level for this industry. Consequently, the allocation of \( AX\text{Inter}_{r,t}^{i-R16} \) to bilateral flows needs to be based on an alternative procedure:
  a. For each year, an OD matrix of electricity flows in GW/h is obtained from the main Spanish operator (Red Eléctrica de España). The matrices are at the regional (NUTS 2) but not provincial level (NUTS 3).
  b. In order to estimate the OD flows at provincial level we build vectors of production \( ep_{r,t} \) and consumption \( ec_{s,t} \) of electricity by years \( t \) and provinces \( r \) and \( s \). Then, given the system for electricity distribution in Spain and the fact that inter-regional electricity exports are always based on proximity, a set of OD matrices are obtained using a bi-proportional RAS procedure (Allen, 1975; Polenske and Möhr 1980) based on the inter-provincial distance matrix as a prior. Thus, for each year, through a bi-proportion we obtain a matrix \( P_{rs,t}^{i-R16} \) that is nearest to another matrix \( D_{rs} \) (distance

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between provinces in Km) but with the row sums equal to \( e p_{r, t} \) and the column sums equal to \( e c_{r, t} \).

c. Next, the OD matrices for electricity at provincial level (NUTS 3) are harmonized according to the actual OD matrices at regional level (NUTS 2) and are then used to estimate the bilateral flows in coherence with the information obtained from the SIS:

\[
\text{Interregional adjusted flows: } AM_{rs, t}^{i=R16} = M_{rs, t}^{i=R16} \ast \frac{AXInter_{r, t}^{i=R16}}{\sum_{s=1}^{S} M_{s, rs, t}^{i=R16}} \tag{18}
\]

\[
\text{Intraregional adjusted flows: } AM_{rr, t}^{i=R16} = M_{rr, t}^{i=R16} \ast \frac{AXIntra_{r, t}^{i=R16}}{M_{rr, t}^{i=R16}} \tag{19}
\]

4. Data analysis

In this section we analyse the main results obtained, first, by using a descriptive approach and then, by means of a simple econometric model based on the classical gravity model.

4.1 Descriptive analysis: identifying the main flows

As it can be expected, the level of domestic trade (intra+interregional) in goods in Spain during the period 1995-2005 is clearly higher than for international trade (see Table 4). This is true for both exports and imports, for the economy as a whole and for the majority of Spain’s regions.

<< Table 4 about here >>

Regarding the balances obtained, only five regions have positive balances for interregional trade, compared to seven for international trade. The highest interregional surplus is found in Catalonia, followed by Galicia, the Basque Country, Navarre and Castilla-La Mancha. In some cases, the sign of the balance for the domestic market is the opposite of that for the foreign market. For example, whereas Catalonia, Galicia and Castilla-La Mancha showed positive balances in the national market and deficits in the international one, the reverse was true for regions like Aragon, Valencia, Castilla-Leon, Extremadura and La Rioja. The openness ratios are much higher than the ratio obtained when only international trade is considered. The highest
values are found in the smallest regions in terms of size, namely, Madrid, La Rioja, Canary Islands, Balearic Islands, Cantabria.

Despite the dominance of intra-national trade (intraregional + interregional trade), the evolution of inter-national flows is more dynamic: while inter-national imports and exports increased by 169% and 122% respectively between 1995 and 2005, inter-regional and intra-regional trade grew by just 82% and 80%. Consequently, although domestic trade still continues to account for the main bulk of activity in the Spanish economy, the process of globalization and EU integration appear to be gradually shifting natural economic relations away from regional neighbours towards foreign countries. Indeed, in some of the most important regions like, for instance, Catalonia and Madrid, although interregional exports continue to be higher than their international counterparts, the opposite is true in the case of imports.

Moreover, consistent with previous findings in the case of the US and Japan (Jackson et al, 2006), the evolution of interregional trade is more dynamic (79%) than intra-regional trade (73%). This result points to the increasing integration of Spain’s regions and may also be related to the fragmentation process of the production chain (Freenstra, 1998; Jones and Kierzkowski, 2005) and the hollowing out process described in the literature (Hewings et al. 1998; Munroe and Hewings, 1998, Hitomi and Hewings, 2000).

Using the relative share of each bilateral flow of total domestic trade, we identify the strongest trade flows during the period. Based on average figures for the period 1995-2005 (see Table 8 and 9 in the Annex), the most intense intra and interregional flows are usually associated with highly industrialized and heavily populated regions such as Catalonia, Madrid, Valencia and Andalusia. It is also interesting to note the existence of intense and stable commodity flows
connecting regions located far away from each other (e.g. Catalonia-Madrid, Catalonia-Andalusia)

<<Figure 3 about here>>

In addition to the main intra and interregional flows, we may want to identify those representing the highest levels of concentration of inflows or outflows for each region. These coefficients can help us identify the main suppliers and clients for each region. In this regard, it is particularly interesting to note that most of the biggest export and import shares are registered between contiguous regions. In Figure 4, for example, we show the highest bilateral import shares in 2005, with the regions coloured according to the regional axes of development usually considered in regional analysis of Spain. Furthermore, the stability of the main clients and suppliers for each region throughout the period indicates the presence of important interregional inter-sectoral linkages between them (see Table 8 and 9 in the Annex). In previous research (Pérez et al, 2008; Llano 2004a) we have already shown how these linkages act as transmission chains for interregional spillovers in terms of growth, employment and productivity. We expect to show soon further evidence in this respect, based on this extended data-base.

<<Figure 4 about here>>

Moreover, the tendency towards stable and intense flows between the strongest economies (Figure 3 and 5, and Table 7 and 8 in the Annex), together with the high market shares found between contiguous regions (Figure 4), point to the classical gravity model as the most appropriate candidate to explain the intensity of bilateral trade among Spanish regions. This hypothesis is tested in the next section.

4.2 Testing interregional trade using the classical gravity equation
The gravity equation has been widely and successfully used to analyse the intensity of bilateral trade between pairs of nations and regions. In its most basic formulation, bilateral trade between two geographic areas is directly proportional to their economic sizes and inversely proportional to the distance between them. More refined specifications of the model may include additional variables in order to capture other effects such as accessibility, sectoral specialization, historical and cultural inertias or network associations of all kinds, which would also condition the direction and intensity of the flows.

Based on various contributions from the literature on empirical applications of the gravity model to international and interregional trade (Anderson and van Wincoop, 2003; Baldwin and Taglioni, 2006; Helpman et al, 2007; Cheng and Wall, 2005; Egger, 2005; LeSage and Pace; 2008a), equation (21) suggests a general specification that includes a group of variables for the origin and destination regions, stocked respectively in matrix $Xo_r$ (capacity of emission) and $Xd_s$ (power of attraction).

$$\ln Y_{rs} = \beta_0 + \beta_1 \ln Xo_r + \beta_2 \ln Xd_s + \beta_3 \ln dis_{rs} + \varepsilon_{rs}$$

(21)

where subscript $r$ indicates an exporting Spanish region and $s$ an importing Spanish region. $Y_{rs}$ are the exports from region $r$ to region $s$, expressed in current euros, and $dis_{rs}$ are the distances between region $r$ and $s$. Table 5 gives all the variables tested: the variables in **bold italics** are the ones finally included in the $Xo_r$ and $Xd_s$ groups of variables in the extended specifications of the model; variables in *pale grey* have been discarded or included in other variables. In order to analyse general relations during the period (1995-2005), the model is applied using average figures, both for trade flows and regressors. It should be noted here that the analysis is exclusively focused on total bilateral trade, leaving sector-specific flows for further analysis. All the variables are expressed in logs. The models were estimated by the Ordinary Least Square (OLS) procedure, using public domain routines programmed in Matlab (LeSage, 1999). In this
regard, several papers discuss the most appropriate method for estimating gravity models, both for cross section data (Anderson and van Wincoop, 2003; Baldwin and Taglioni, 2006; Helpman et al 2007) and panel data specifications (Cheng and Wall, 2005; Egger, 2005). Since the goal of our model is to evaluate the coherence of the database in the light of the gravity model, we adopt the most basic method of estimation (OLS), which might serve as a baseline for further development (LeSage and Pace, 2008; LeSage and Llano, 2008a, 2008b).

Before analysing the results obtained with the gravity model, it is interesting to observe the stability and persistence of the OD flows throughout the period (1995-2005). To this end, Figure 5 plots the distance and the OD flows in millions of euros between Spanish regions (Nuts 2), both expressed in log-scale and ranked according to the 1995 OD flows. Note that if the ascending ranking of the flows during the period 1996-2005 had coincided with the one observed in 1995, the shape of the resulting lines would have evolved in parallel. Although this is far from being the case, as it can be observed in Figure 5, we can still appreciate a great stability in the flows. In fact, the deviation from 1995 of the most intense flows (upper-right side of the figure) during subsequent years is much lower than in the weakest OD flows (bottom-left side of the figure). This tendency indicates the stability of the intensity of the flows and the persistence of the origin-destination structure throughout the period. Furthermore, when the distance between the origin-destination pairs is also ranked according to the 1995 ranking, we obtain an unstable distance curve that captures the presence of strong flows between non-contiguous regions. In spite of the irregular shape of the distance curve, the associated tendency-line clearly shows a negative slope. Consequently, we may expect that this negative relation between the intensity of trade and the distance between the producer and the consumer will be captured with a negative sign by the gravity model.

<<Figure 5 about here>>
Next, we focus on the results obtained using the basic specification of the model. Based on Table 6, interregional flows in logs are relatively well explained ($R^2=0.89$) by distance and by origin and destination GDP. The variables are highly significant and their signs coincide with the expected ones according to previous studies in the literature (positive in the case of GDP and negative in the case of distance).

Table 6 about here>

Taking the most basic specification as a baseline, we test nine more specifications that include some of the variables used in previous studies focusing on international and interregional trade in goods and services. In Model 2, following Kyriacos (2006), the basic specification is completed with the size of the origins and destinations in terms of population. The results obtained show no significant relation between the intensity of the bilateral flows and the population of the origin and destination regions.

In Model 3, the population is substituted by the per capita income of the origin and destination regions (O_income and D_income). Here, the significance of this variable is higher for the origin than for the destination. Furthermore, the different signs obtained point to an inverse relationship between the intensity of the flows and the relative wealth of the origins and destinations, given that the flow intensity increases with the prosperity of the origins and decreases with that of the destinations.

When income is substituted by the actual size of each pair of regions (Model 4), only the size of the destination regions appears to condition the flow intensity.

Models 5, 6 and 7 include some new variables that attempt to capture the relation between the intensity of bilateral flows, accessibility and transport infrastructure endowment. The variables included in Model 5 (O_acc_min, D_acc_min) consider the minimum time a truck spends
travelling from each region to the nearest one. According to the results obtained, the intensity of the flows increases when origins are more accessible, whereas the accessibility of destinations does not appear to have a significant influence. In Models 6 and 7, the accessibility variables are substituted by a measure of relative infrastructure endowment (\textit{O_infras; D_infras}) or the \textit{remoteness index} used in previous works analysing international trade (Kimura and Lee,. 2006).

In the case of Model 6, although only the destination variable is significant, it is important to highlight the negative relations obtained, both for origins and destinations, between infrastructure endowment and the intensity of the bilateral flow. This somewhat surprising result can be caused by the definition of the variable in relative terms, which might tend to reduce the relative importance of such infrastructures in certain larger regions (such as Catalonia, Valencia, the Basque Country or Andalusia) which are also the main origin of interregional trade flows. On the other hand, a relatively high endowment of infrastructures in small regions may also coincide with strong interregional inflows (i.e. Madrid, Navarre, La Rioja, Murcia…). In the case of Model 7, the relation between the flow intensity and the remoteness index is also negative and significant, both for origins and destinations. In this case, the results obtained match those that can be expected, since the intensity of the flows decreases when the origin and destination regions are located far from the regions with the largest GDPs. By contrast, the main drawback of this specification is the reduction of the relevance of \textit{O_gdp} and \textit{D_gdp}, which seems to compete with the \textit{remoteness} variables.

In Model 8 we explore the relation between the intensity of interregional bilateral trade and the importance of the origin and destination regions in terms of international goods trade. The results obtained for these four new variables (\textit{O_export, O_import, D_export, D_import}) require a more detailed analysis. First, it should be stressed that all but \textit{O_import} are significant. Second, the signs obtained reveal interesting information with respect to the interrelation between national and foreign markets. For example, the negative coefficient obtained in the case of \textit{O_imports} and \textit{D_imports} suggests some kind of competition between markets, since high interregional commodity outflows in origin and destination regions correlate
negatively with high international imports arriving to these regions. Conversely, the positive
sign obtained for O_exports and D_exports implies that strong interregional outflows and
inflows are associated with high levels of international exports, both in origin and destination
regions. This result is perhaps capturing the spatial dimension of the typical intermediate-final
value-chain in the exporting sectors (Hitomi and Hewings, 2000).

Finally, Models 9 and 10 attempt to combine the best variables tested in the previous modes. In
the case of Model 9, only four out of the eight variables included are significant (O_gdp, O_exports, D_gdp, Distance), whereas in Model 10 all the variables are clearly significant and
the explanatory power reaches its highest value ($R^2 = 0.908$). According to this final
specification, the intensity of the bilateral flows is positively correlated with origin and
destination GDP and international exports in the origins, but decreases with the remoteness of
the destinations and the distance between them.

In relation to the distance variable, it is interesting to note that in all the specifications
Log_distance is always significant, with negative coefficients between -1.06 and -1.13. This
result indicates that, on average, an increase of one unit in the distance between two points in
Spain is associated with a decrease of one unit in the intensity of the flow.$^{17}$

5. Conclusion

According to the first law of geography and more recent research concerning ‘border effect’,
one can expect to find higher levels of integration between regions within a country than
between countries themselves. Paradoxically, the available information on economic
interactions between countries is more extensive and detailed than between regions within the
same country.

$^{17}$ Note that although trade flows are in euros and distance in kilometres, all variables in the model are
included in logs.
In this paper we have explored the main features of the **C-Intereg database** for Spanish interregional trade. Beginning with a brief review of the literature on interregional trade, we have described the methodology employed in the estimation of the **C-Intereg database**, which is based on the use of transport flows and prices at the lowest level of disaggregation. Next we have provided an overview of the spatial structure of the Spanish interregional trade, that allows us to identify the most intense flows during the period 1995-2005. Finally, the data set has been analysed in further detail using ten alternative specifications of the classical gravity model.

In the immediate future, we hope to develop the **C-Intereg project** in all its dimensions (time, space, sectors) to produce estimates for upcoming years and for new types of commodities and services. It is also expected that this database will eventually serve as a promising framework for the application of different techniques such as spatial interaction models or interregional input-output approaches (LeSage and Llano, 2008a, 2008b; Requena and Llano, 2008; Hewings et al., 2008; Sonis et al., 2008; Pérez et al, 2008; Artal et al., 2009).

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6. References


7. Tables

Table 1: Interregional trade: possible approaches

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Table 2: Basic Statistics on Spanish interregional trade

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Table 3: Transport statistics used to estimate Spanish interregional trade

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| ROAD | **Permanent Survey on Goods Transport by Road (Encuesta Permanente de Mercancías por Carretera)**  
  - Source: Ministerio de Fomento (Spanish Ministry of Economic Development)  
  - Product Disaggregation: 160 products (class. NSTR-3 digits)  
  - Available since: 1995-onwards  
  - Remarks:  
    - Permanent survey (weekly basis) on the activity of a large sample of trucks in Spain: each trip includes origin-destination, type of product, volume, distance (km)...  
    - Survey may also include international transit flows moved from ports/airports to final locations.  
    - It should be noted that the figures obtained from truck surveys may not be consistent with figures on production/purchases from firms/household surveys. |
| RAIL | **RENFÉ statistics on Complete Wagon and Container flows**  
  - Source: information from the Statistics Department of RENFE  
  - Product Disaggregation: aprox. 40 categories (RENFE own classification)  
  - Remarks:  
    - Every domestic flow recorded: high quality, low product detail.  
    - No information on products transported by Container (30% of rail flows). |
| SHIP | **Statistics from Spanish Ports (Puertos del Estado)**  
  - Indirect estimation of interregional flow matrices using optimization procedure based on:  
    a) Tons loaded/Unloaded by each Spanish Port, kind of flow, and type of product. **Source:** Statistical Yearbook. Puertos del Estado.  
    - Data: Annual. 27 Spanish ports.  
    - Product Disaggregation: 40 products (Spanish Ports’ own classification)  
    b) Set of Spanish domestic flow matrices with Ports of Origin and Destination.1989. **Source:** Domestic maritime flows by Origin and Destination.1989. Puertos del Estado:  
    - Data: Annual. 38 largest Spanish ports (at that time).  
    - Product Disaggregation: 52 products (CSTE) |
| AIRCRAFT | **O/D Matrices of domestic flows of goods by airport of Origin and Destination 1995. AENA.**  
  - Source: AENA & Ministerio de Fomento (Spanish Ministry of Public Works).  
  - Data: Annual. Main Spanish Airports.  
  - Product Disaggregation: None  
  - Remarks:  
    - No information on sectoral disaggregation of domestic flows by air. |
| PIPE | **O/D matrix of oil flows using pipe 1995**  
  - Product Disaggregation: None  
  - Remarks:  
Table 4: Spatial distribution of trade (intraregional, interregional and international)

*All goods, R1-R16. Millions of Euros.*

<table>
<thead>
<tr>
<th>Region</th>
<th>Intra-Region</th>
<th>Exports to World</th>
<th>Imports from Spain</th>
<th>Imports from World</th>
<th>Balance Spain</th>
<th>Balance World</th>
<th>Openness* Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>Andalusia</td>
<td>15,836.3</td>
<td>19,832.1</td>
<td>9,786.4</td>
<td>20,318.4</td>
<td>-486.3</td>
<td>774.1</td>
<td>133%</td>
</tr>
<tr>
<td>Aragon</td>
<td>4,642.2</td>
<td>10,933.3</td>
<td>5,487.0</td>
<td>5,049.2</td>
<td>-2,395.8</td>
<td>437.8</td>
<td>165%</td>
</tr>
<tr>
<td>Asturias</td>
<td>4,261.5</td>
<td>5,037.0</td>
<td>1,644.9</td>
<td>1,874.6</td>
<td>-176.9</td>
<td>229.6</td>
<td>126%</td>
</tr>
<tr>
<td>Balearic Islands</td>
<td>2,027.7</td>
<td>735.5</td>
<td>868.3</td>
<td>4,353.7</td>
<td>-3,618.3</td>
<td>-615.0</td>
<td>205%</td>
</tr>
<tr>
<td>Canary Islands</td>
<td>3,300.0</td>
<td>1,657.2</td>
<td>718.0</td>
<td>8,019.7</td>
<td>-6,362.5</td>
<td>-2,534.8</td>
<td>240%</td>
</tr>
<tr>
<td>Cantabria</td>
<td>1,297.7</td>
<td>3,183.1</td>
<td>1,306.8</td>
<td>4,387.8</td>
<td>-1,204.7</td>
<td>-169.9</td>
<td>179%</td>
</tr>
<tr>
<td>Castilla-Leon</td>
<td>9,318.3</td>
<td>15,450.4</td>
<td>7,241.0</td>
<td>17,409.4</td>
<td>-1,959.1</td>
<td>51.1</td>
<td>148%</td>
</tr>
<tr>
<td>Castilla-La Mancha</td>
<td>3,523.5</td>
<td>12,373.4</td>
<td>1,844.8</td>
<td>12,200.6</td>
<td>172.8</td>
<td>-1,345.1</td>
<td>167%</td>
</tr>
<tr>
<td>Catalonia</td>
<td>37,817.7</td>
<td>42,616.6</td>
<td>31,229.9</td>
<td>44,801.7</td>
<td>17,362.5</td>
<td>-13,571.8</td>
<td>129%</td>
</tr>
<tr>
<td>Valencia</td>
<td>14,479.7</td>
<td>20,416.7</td>
<td>14,423.8</td>
<td>22,179.3</td>
<td>-1,762.6</td>
<td>2,341.1</td>
<td>140%</td>
</tr>
<tr>
<td>Extremadura</td>
<td>1,631.6</td>
<td>2,574.9</td>
<td>764.3</td>
<td>4,860.0</td>
<td>-2,285.1</td>
<td>370.7</td>
<td>173%</td>
</tr>
<tr>
<td>Galicia</td>
<td>7,246.2</td>
<td>12,061.3</td>
<td>7,618.8</td>
<td>8,229.1</td>
<td>3,832.2</td>
<td>-497.2</td>
<td>134%</td>
</tr>
<tr>
<td>Madrid</td>
<td>12,814.2</td>
<td>23,211.1</td>
<td>12,376.1</td>
<td>36,641.4</td>
<td>-1,809.6</td>
<td>-24,265.3</td>
<td>201%</td>
</tr>
<tr>
<td>Murcia</td>
<td>2,737.7</td>
<td>6,622.3</td>
<td>3,044.7</td>
<td>7,346.9</td>
<td>-724.5</td>
<td>-673.5</td>
<td>167%</td>
</tr>
<tr>
<td>Navarre</td>
<td>2,250.5</td>
<td>6,661.0</td>
<td>4,162.9</td>
<td>6,476.3</td>
<td>184.7</td>
<td>828.8</td>
<td>158%</td>
</tr>
<tr>
<td>Basque Country</td>
<td>8,965.3</td>
<td>17,771.5</td>
<td>10,482.5</td>
<td>14,969.8</td>
<td>2,801.7</td>
<td>1,348.0</td>
<td>141%</td>
</tr>
<tr>
<td>La Rioja</td>
<td>754.9</td>
<td>2,930.6</td>
<td>781.1</td>
<td>3,377.3</td>
<td>-446.7</td>
<td>183.4</td>
<td>172%</td>
</tr>
<tr>
<td>Ceuta and Melilla</td>
<td>6.2</td>
<td>108.9</td>
<td>56.8</td>
<td>1,230.6</td>
<td>-1,121.7</td>
<td>-274.1</td>
<td>1005%</td>
</tr>
<tr>
<td>Total</td>
<td>132,911.2</td>
<td>204,176.8</td>
<td>113,838.3</td>
<td>204,176.8</td>
<td>153,227.8</td>
<td>0.0</td>
<td>-39,389.5</td>
</tr>
</tbody>
</table>

Source: Interregional trade is obtained from the C-Interreg database; International trade from Spanish Customs (AEAT).

* Openness ratio: since trade does not include services, openness is calculated by the following expression instead of the commonly-used one: (X+M)/GDP
Table 5: Variables included in the gravity model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pop</strong></td>
<td>Population by regions Nuts-2 in each year. INE (National Institute of Statistics)</td>
</tr>
<tr>
<td><strong>Gdp</strong></td>
<td>GDP by regions in current prices for each year. INE</td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td>Per capita income by region (GDP/POP). INE</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Size by regions Nuts-2 in Km$^2$. INE</td>
</tr>
<tr>
<td><strong>Export</strong></td>
<td>International exports of goods by regions for each year. AEAT(Tax Authority)</td>
</tr>
<tr>
<td><strong>Import</strong></td>
<td>International imports of goods by regions for each year. AEAT</td>
</tr>
<tr>
<td><strong>Acc_min</strong></td>
<td>Minimum driving time by truck from one region to the nearest one. 2002. EUROSTAT (Regio DB)</td>
</tr>
</tbody>
</table>
| **Infras** | This variable attempts to capture the relative situation of each region in terms of transport infrastructure endowment relative to its size:  
\[
\text{Infras}_r = \left( \frac{\text{Km}^2\_\text{motorway}_r + \text{Km}^2\_\text{rail}_r}{\text{Km}^2\_\text{surface}_r} \right) \]  |
| **Remot** | This variable is taken from Kimura et al. (2006): REMOTENESS, defined as the log of relative distance of region \( r \) in year \( y \):  
\[
\text{Remot}_r = \log \left( \frac{1}{\sum_{r} \frac{\text{gdp}_r}{\sum_{r} \text{gdp}}} \sum_{r} \frac{\text{dist}_r}{\text{gdp}_r} \right)  
\]  |
| **Distance** | Physical distance in Km between the capitals of provinces. INE |
| Kstock    | Capital Stock by regions. For each year. FBBVA-IVIE |
| Motorway  | Km2 of highways by regions. EUROSTAT (Regio DB) |
| Rail      | Km2 of railways by regions. EUROSTAT (Regio DB) |
| M2retail  | Size of retailing centres by regions (sq. meters) in each year. La Caixa Bank (Statistical Yearbook) |
| Tripsintra| Number of trips by HGV trucks within the region in each year. EUROSTAT (Regio DB) |
| Hempl     | Number of employees in High Technology industries by regions for each year. EUROSTAT (Regio DB) |
Table 6: Gravity Model Estimates by OLS.

<table>
<thead>
<tr>
<th>Models</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.891</td>
<td>0.892</td>
<td>0.895</td>
<td>0.895</td>
<td>0.894</td>
<td>0.895</td>
<td>0.898</td>
<td>0.907</td>
<td>0.908</td>
<td>0.908</td>
</tr>
<tr>
<td>$\bar{R}^2$</td>
<td>0.889</td>
<td>0.890</td>
<td>0.892</td>
<td>0.892</td>
<td>0.892</td>
<td>0.892</td>
<td>0.895</td>
<td>0.904</td>
<td>0.905</td>
<td>0.906</td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>0.227</td>
<td>0.226</td>
<td>0.221</td>
<td>0.220</td>
<td>0.221</td>
<td>0.221</td>
<td>0.214</td>
<td>0.196</td>
<td>0.195</td>
<td>0.192</td>
</tr>
<tr>
<td>D-Watson</td>
<td>1.373</td>
<td>1.408</td>
<td>1.412</td>
<td>1.386</td>
<td>1.389</td>
<td>1.380</td>
<td>1.372</td>
<td>1.573</td>
<td>1.538</td>
<td>1.608</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coefficients (* if t-prob&lt;0.05; ** if t-prob&lt;0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
</tr>
<tr>
<td>O_pop</td>
</tr>
<tr>
<td>O_gdp</td>
</tr>
<tr>
<td>O_size</td>
</tr>
<tr>
<td>O_income</td>
</tr>
<tr>
<td>O_export</td>
</tr>
<tr>
<td>O_import</td>
</tr>
<tr>
<td>O_acc_min</td>
</tr>
<tr>
<td>O_remot</td>
</tr>
<tr>
<td>O_infras</td>
</tr>
<tr>
<td>D_pop</td>
</tr>
<tr>
<td>D_gdp</td>
</tr>
<tr>
<td>D_size</td>
</tr>
<tr>
<td>D_income</td>
</tr>
<tr>
<td>D_export</td>
</tr>
<tr>
<td>D_import</td>
</tr>
<tr>
<td>D_acc_min</td>
</tr>
<tr>
<td>D_remot</td>
</tr>
<tr>
<td>D_infras</td>
</tr>
<tr>
<td>Distance</td>
</tr>
</tbody>
</table>
Figure 1: C-Intereg commodity database. Estimation process

O-D Matrices in Tons
- Road (160)
- Railway (40)
- Ship (40)
- Aircraft (160)

Prices
- NC-8D
  - 11,000 products

1995-05

R-16 goods
- Road
- Railway
- Ship
- Aircraft

Total Transport modes

Intra-inter totals per industry

Domestic Output per sector
NAccounts-INE

R-30 goods
- Road
- Railway
- Ship
- Aircraft

Figure 2: Evolution of international and domestic trade in goods (1995-2005)
Growth rates of trade in current prices. Millions of Euros. All types of goods (R1-R16).

Exportations interregionales (C-intereg)

Comercio intra-regional (C-intereg)

Ex HACOS (AEAT)

Imports (AEAT)

Interregional exports (C-Intereg)

Intra-regional trade (C-Intereg)

International exports (AEAT)

International imports (AEAT)
Figure 3: Strongest interregional flows in 2005
All goods, R1-R16. % of total interregional trade in Millions of Euros

Figure 4: The largest import shares in the Spanish interregional trade. 2005
All goods, R1-R16. % of an inflow on the total interregional imports of a region. Millions of Euros.
Figure 5: Ranked interregional bilateral flows for the period 1995-2005 and distance (km). Log scale. All OD flows and distance are ranked according to the 1995 flow order.
8. Annex

Table 7: Ranking of the main intra-regional flows (% over intra+interregional trade)
All goods, R1-R16. Millions of Euros.

<table>
<thead>
<tr>
<th>Origin=Destination</th>
<th>1995 (%)</th>
<th>Origin=Destination</th>
<th>2000 (%)</th>
<th>Origin=Destination</th>
<th>2005 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Catalonia</td>
<td>11.63%</td>
<td>Catalonia</td>
<td>11.13%</td>
<td>Catalonia</td>
<td>10.12%</td>
</tr>
<tr>
<td>2 Andalusia</td>
<td>4.75%</td>
<td>Andalusia</td>
<td>4.18%</td>
<td>Andalusia</td>
<td>4.86%</td>
</tr>
<tr>
<td>3 Valencia</td>
<td>4.23%</td>
<td>Valencia</td>
<td>4.12%</td>
<td>Valencia</td>
<td>4.43%</td>
</tr>
<tr>
<td>4 Madrid</td>
<td>4.03%</td>
<td>Madrid</td>
<td>3.89%</td>
<td>Madrid</td>
<td>3.45%</td>
</tr>
<tr>
<td>5 Castilla-León</td>
<td>3.07%</td>
<td>Castilla-León</td>
<td>2.74%</td>
<td>Basque Country</td>
<td>2.78%</td>
</tr>
<tr>
<td>6 Basque Country</td>
<td>2.30%</td>
<td>Basque Country</td>
<td>2.55%</td>
<td>Castilla-León</td>
<td>2.62%</td>
</tr>
<tr>
<td>7 Galicia</td>
<td>2.16%</td>
<td>Galicia</td>
<td>2.32%</td>
<td>Galicia</td>
<td>2.18%</td>
</tr>
<tr>
<td>8 Aragon</td>
<td>1.44%</td>
<td>Asturias</td>
<td>1.34%</td>
<td>Aragon</td>
<td>1.34%</td>
</tr>
<tr>
<td>9 Asturias</td>
<td>1.32%</td>
<td>Aragon</td>
<td>1.30%</td>
<td>Castilla-La Mancha</td>
<td>1.14%</td>
</tr>
<tr>
<td>10 Castilla-La Mancha</td>
<td>1.02%</td>
<td>Castilla-La Mancha</td>
<td>0.89%</td>
<td>Asturias</td>
<td>1.11%</td>
</tr>
<tr>
<td><strong>INTRA+ INTER</strong></td>
<td><strong>263,396</strong></td>
<td><strong>INTRA+ INTER</strong></td>
<td><strong>349,310</strong></td>
<td><strong>INTRA+ INTER</strong></td>
<td><strong>442,272</strong></td>
</tr>
</tbody>
</table>

Source: own compilation, based on C-Intereg database.

Table 8: Ranking of the main inter-regional flows (% of total inter-regional trade)
All goods, R1-R16. Millions of Euros.

<table>
<thead>
<tr>
<th>Origin</th>
<th>Destination</th>
<th>1995 (%)</th>
<th>Origin</th>
<th>Destination</th>
<th>2000 (%)</th>
<th>Origin</th>
<th>Destination</th>
<th>2005 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Catalonia</td>
<td>Valencia</td>
<td>4.03</td>
<td>Catalonia</td>
<td>Valencia</td>
<td>3.88</td>
<td>Catalonia</td>
<td>Valencia</td>
<td>2.94</td>
</tr>
<tr>
<td>2 Catalonia</td>
<td>Madrid</td>
<td>3.11</td>
<td>Catalonia</td>
<td>Aragon</td>
<td>3.00</td>
<td>Catalonia</td>
<td>Aragon</td>
<td>2.80</td>
</tr>
<tr>
<td>3 Catalonia</td>
<td>Aragon</td>
<td>3.11</td>
<td>Catalonia</td>
<td>Madrid</td>
<td>2.62</td>
<td>Catalonia</td>
<td>Madrid</td>
<td>2.21</td>
</tr>
<tr>
<td>4 Valencia</td>
<td>Catalonia</td>
<td>2.67</td>
<td>Valencia</td>
<td>Catalonia</td>
<td>2.44</td>
<td>Castilla-La Mancha</td>
<td>Madrid</td>
<td>2.02</td>
</tr>
<tr>
<td>5 Catalonia</td>
<td>Andalusia</td>
<td>2.35</td>
<td>Castilla-La Mancha</td>
<td>Madrid</td>
<td>1.81</td>
<td>Valencia</td>
<td>Catalonia</td>
<td>1.96</td>
</tr>
<tr>
<td>6 Madrid</td>
<td>Andalusia</td>
<td>1.87</td>
<td>Catalonia</td>
<td>Andalusia</td>
<td>1.81</td>
<td>C. Madrid</td>
<td>Castilla-La Mancha</td>
<td>1.95</td>
</tr>
<tr>
<td>7 Catalonia</td>
<td>Basque Country</td>
<td>1.84</td>
<td>Catalonia</td>
<td>Castilla-León</td>
<td>1.73</td>
<td>Catalonia</td>
<td>Castilla-León</td>
<td>1.82</td>
</tr>
<tr>
<td>8 Valencia</td>
<td>Andalusia</td>
<td>1.77</td>
<td>Madrid</td>
<td>Andalusia</td>
<td>1.71</td>
<td>Aragon</td>
<td>Catalonia</td>
<td>1.74</td>
</tr>
<tr>
<td>9 Castilla-La Mancha</td>
<td>Madrid</td>
<td>1.76</td>
<td>Aragon</td>
<td>Catalonia</td>
<td>1.69</td>
<td>Cataluña</td>
<td>Andalusia</td>
<td>1.73</td>
</tr>
<tr>
<td>10 Madrid</td>
<td>Catalonia</td>
<td>1.71</td>
<td>Basque Country</td>
<td>Castilla-León</td>
<td>1.67</td>
<td>Andalusia</td>
<td>Madrid</td>
<td>1.67</td>
</tr>
<tr>
<td><strong>TOTAL INTER</strong></td>
<td><strong>149,597</strong></td>
<td><strong>TOTAL INTER</strong></td>
<td><strong>215,335</strong></td>
<td><strong>TOTAL INTER</strong></td>
<td><strong>272,062</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: own compilation, based on C-Intereg database.