# Regional integration and growth: The Spanish case

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**Abstract**

In this paper we use data on goods exchanges between Spanish regions to explore their effects on regional growth. We first describe these exchanges and define several indicators of economic integration between regions looking basically at flows and relationships of various kinds. We then look at the determinants of interregional flows with the help of a gravitational model that stresses the role of distance between regions and market size. Finally we look at the relationship between the degree of regional integration and regional growth.

JEL Codes: R11, R15.

Key words: regional integration, interregional flows, growth

## 1. Introduction

Will active relationships between regions in a given country enhance mutual growth? What are the factors influencing the intensity of interregional relationships? These questions have been traditionally posed concerning countries engaged in international trade and indeed, traditional models of economic integration show that trade determines growth (Frankel and Romer, 1996) and, in turn, it is determined by market size and distance (Pöyhönen, 1963; Deardorf, 1995). Trade, in fact, seems to act as an active channel through which many influences flow (Moreno and Trehan, 1997).

Regions are small specialised open economies where exchanges with other regions, within a given country, is intense and distances are short. Moreover, regions within a country share to a very large extent common institutions, language and economic policies. So that the above questions apply naturally to their case. Recent Spanish literature has shown that mutual growth amongst neighbouring regions is common (Vayá *et al*, 1998; López-Bazo *et al*, 1998) while the role of distance for the economic integration of regions has also been established (Hernández, 1998).

In this paper we intend to offer further evidence on the role that distance and market size play in determining regional exchanges and how these exchanges transmit growth amongst regions. Or, in a more compact way, how trade between regions acts as a channel for interdependent regional growth in Spain. We use homogeneous recent data produced by the Spanish Department of Transport on regional exchanges of goods transported by heavy lorry between the fifteen contiguous Spanish Autonomías as a proxy for trade between regions given the extreme scarcity of true interregional trade flows. In the following section we review a simple model of interdependent growth to support intuitively the empirical model used afterwards. Section 3, describes in detail our data set on interregional flows and presents some definitions to be used latter in the text, in particular we construct a measure of effective distance between regions that shows variation not only across space but also across time. In section 4, we estimate a gravity equation to explain the observed interregional flows where the emphasis is put on effective distance and market size. Section 5 deals with the issue of interdependent growth and economic integration and section 6 concludes the paper.

## 2. Models of territorial integration and interdependent growth

Let us start by the standard growth equation $Y_i = A_i K_i^{\alpha} L_i^{\beta}$ with $\alpha + \beta < 1$. Now let us assume that there is a "thick markets" externality captured in parameter *A*, that is, $A_i = \eta_i Y_i^{\mu}$, what makes explicit the market size dimension in growth. Endogenous growth will be possible when $\frac{\alpha + \beta}{1 - \mu} > 1$but the market size externality does not guarantees this *per se*.

Now consider wider markets, namely the national or international market a given region's industries supply. The production function's technological parameter can be then defined as $A_i = \eta_i \prod_{j=1}^{J} Y_j^{\mu_j}$ where the possibility of (interdependent) endogenous growth gets reinforced.[1] This formulation implies that if, ceteris paribus, certain regions suffer negative shocks, then growth diminishes everywhere and, conversely, growth in one region reinforces growth everywhere. The parameters $\mu_j$ may be dependent on openness, flows intensity, distance, etc. This introduces economic integration factors into the equation for interdependent growth.

1 This formulation follows Bertola (1992) where interdependence is established through capital stocks. Thick markets, however, seem to be specially relevant to deal with integration issues.

## 3. Spatial economic relationships

By this we mean basically flows, of any kind, material or not, between different territories. Unfortunately, data availability on these flows is very limited preventing many statistical exercises to be performed. At most an incomplete description can be attempted. Although goods carried between two regions are the primary candidates for any description of interregional flows, one can think of many other varieties: phone calls or internet trips, air traffic, financial flows, passengers moved on any transport mode, etc. All these flows do certainly generate or respond to economic activity and generally serve as connections between economic origins and destinations more profitable that if done locally or even only possible when established between distant territories.

As territories get more integrated, through larger and deeper exchanges, markets widen making possible larger production scales. In other words, markets thicken. With this precise idea in mind we develop the analysis in this section, that is, we tend to see increased interregional flows as more integration and the source of a growth externality related to thicker markets at the reach of producers everywhere.

### The data on interregional flows

We use data on tons moved by road transport (heavy lorry) firms between and within the fifteen contiguous Spanish *autonomías* for the years 1993 through 1996. These data are produced regularly by the Department of Transport that conducts a permanent survey of road transport and published as origin-destination matrices. We reproduce and use these matrices to compute a series of indicators to illustrate interregional relationships such as "export" specialisation and other to be immediately defined. Flows in thousand tons are presented in Table 3.1. Total tons transported in 1996 sum up to 545 millions of which 27.4 per cent were actually moved from any one region to the rest. Intra-regional flows amount thus to 72.5 per cent of total tonnage transported. These are physical data as no value for them is published so that bulk products are treated together with value added goods. In Table 3.2 it can be more clearly seen that the more active regions in inter-regional flows are *Andalucía*, *Aragón*, *Cataluña*, both *Castillas*, *Madrid*, *País Vasco* and *Valencia*, not necessarily those with the highest total tonnage of goods transported.

**Table 3.1**

**Goods transported by origin and destination region (thousand tons). 1996**

| Orig. | Dest. | Andal. 1 | Aragón 2 | Asturias 3 | Cataluña 4 | C-LM 5 | C-León 6 | Cantab. 7 | Extrem. 8 | Galicia 9 | La Rioja 10 | Madrid 11 | Murcia 12 | Navarra 13 | P. Vasco 14 | Valencia 15 | Exp. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Andal.** | **1** | **62,998** | 323 | 175 | 998 | 1,226 | 542 | 61 | 2,154 | 320 | 66 | 1,339 | 1,026 | 126 | 343 | 1,373 | **10,072** | **73,070** |
| **Aragón** | **2** | 397 | **14,617** | 159 | 3,589 | 491 | 883 | 71 | 18 | 216 | 281 | 1,098 | 151 | 817 | 913 | 1,633 | **10,717** | **25,334** |
| **Asturias** | **3** | 248 | 163 | **13,410** | 266 | 128 | 1,823 | 301 | 19 | 986 | 75 | 414 | 36 | 101 | 712 | 218 | **5,490** | **18,900** |
| **Cataluña** | **4** | 1,795 | 4,238 | 162 | **88,675** | 677 | 1,300 | 244 | 103 | 686 | 246 | 2,124 | 580 | 780 | 1,370 | 4,210 | **18,515** | **107,190** |
| **C-LM** | **5** | 1,906 | 394 | 136 | 935 | **18,506** | 1,052 | 66 | 773 | 250 | 84 | 5,288 | 1,017 | 104 | 234 | 2,913 | **15,152** | **33,658** |
| **C-León** | **6** | 790 | 628 | 1,057 | 1,267 | 1,202 | **34,734** | 933 | 485 | 2,260 | 472 | 2,378 | 194 | 704 | 2,364 | 799 | **15,533** | **50,267** |
| **Cantab.** | **7** | 147 | 165 | 610 | 353 | 40 | 1,326 | **6,422** | 40 | 152 | 99 | 336 | 11 | 101 | 1,841 | 72 | **5,293** | **11,715** |
| **Extrem.** | **8** | 828 | 42 | 17 | 114 | 146 | 406 | 19 | **6,042** | 75 | 9 | 260 | 30 | 23 | 52 | 109 | **2,130** | **8,172** |
| **Galicia** | **9** | 543 | 216 | 1,316 | 658 | 244 | 1,397 | 109 | 76 | **39,791** | 24 | 821 | 82 | 45 | 648 | 530 | **6,709** | **46,500** |
| **La Rioja** | **10** | 90 | 469 | 112 | 309 | 76 | 802 | 34 | , | 81 | **2,689** | 183 | 17 | 804 | 927 | 117 | **4,021** | **6,710** |
| **Madrid** | **11** | 1,631 | 571 | 291 | 1,037 | 3,434 | 1,650 | 149 | 397 | 852 | 119 | **18,862** | 345 | 170 | 777 | 1,185 | **12,608** | **31,470** |
| **Murcia** | **12** | 1,402 | 125 | 38 | 450 | 940 | 94 | 18 | 109 | 116 | 45 | 445 | **9,477** | 51 | 80 | 2,990 | **6,903** | **16,380** |
| **Navarra** | **13** | 193 | 870 | 170 | 815 | 74 | 678 | 116 | 24 | 111 | 513 | 425 | 44 | **7,380** | 1,934 | 304 | **6,271** | **13,651** |
| **P. Vasco** | **14** | 603 | 1,157 | 419 | 1,523 | 217 | 3,231 | 1,066 | 44 | 487 | 810 | 1,186 | 133 | 3,070 | **24,475** | 686 | **14,632** | **39,107** |
| **Valencia** | **15** | 1,485 | 1,527 | 120 | 3,339 | 2,918 | 611 | 65 | 183 | 410 | 164 | 1,921 | 3,090 | 257 | 533 | **50,174** | **16,623** | **66,797** |
| **Import.** | | **12.058** | **10,888** | **4,782** | **15,653** | **11,813** | **15,795** | **3,252** | **4,425** | **7,002** | **3,007** | **18,218** | **6,756** | **7,153** | **12,728** | **17,139** | **150,669** | |
| **Total** | | **75,056** | **25,505** | **18,192** | **104,328** | **30,319** | **50,529** | **9,674** | **10,467** | **46,793** | **5,696** | **37,080** | **16,233** | **14,533** | **37,203** | **67,313** | | **548,921** |

Source: Encuesta Permanente del Transporte. Department of Transport.

**Table 3.2**
**Coverage and openness ratios in the Spanish *Autonomías*. 1996**
**(thousand tons except otherwise stated)**

| | Intra-regional (1) | Exports (2) | Imports (3) | Coverage (2)/(3) | Openness [(2)+(3)]/[(1)+(2)] |
|---|---|---|---|---|---|
| **Andalucía** | 62,998 | 10,072 | 12,058 | 83.5% | 30.3% |
| **Aragón** | 14,617 | 10,717 | 10,888 | 98.4% | 85.3% |
| **Asturias** | 13,410 | 5,490 | 4,782 | 114.8% | 54.3% |
| **Cataluña** | 88,675 | 18,515 | 15,653 | 118.3% | 31.9% |
| **C-LM** | 18,506 | 15,152 | 11,813 | 128.3% | 80.1% |
| **Castilla y León** | 34,734 | 15,533 | 15,795 | 98.3% | 62.3% |
| **Cantabria** | 6,422 | 5,293 | 3,252 | 162.8% | 72.9% |
| **Extremadura** | 6,042 | 2,130 | 4,425 | 48.1% | 80.2% |
| **Galicia** | 39,791 | 6,709 | 7,002 | 95.8% | 29.5% |
| **La Rioja** | 2,689 | 4,021 | 3,007 | 133.7% | 104.7% |
| **Madrid** | 18,862 | 12,608 | 18,218 | 69.2% | 98.0% |
| **Murcia** | 9,477 | 6,903 | 6,756 | 102.2% | 83.4% |
| **Navarra** | 7,380 | 6,271 | 7,153 | 87.7% | 98.3% |
| **País Vasco** | 24,475 | 14,632 | 12,728 | 115.0% | 70.0% |
| **Valencia** | 50,174 | 16,623 | 17,139 | 97.0% | 50.5% |
| **Total** | 398,252 | 150,669 | 150,669 | | |

Source: Encuesta Permanente del Transporte. Department of Transport.

Table 3.2 shows also that the balance of exports to imports is far from being equilibrated with *Cantabria* and *La Rioja* showing important surpluses relative to their respective total flows and *Extremadura* and *Madrid* displaying important relative deficits. No evident pattern emerges between the coverage and the openness ratios as defined in the table, but it is apparent that the degree of openness of a region has a strong and negative correlation with their own total flows.

Tables 3.3 and 3.4 offer the data in Table 3.1 expressed as a percentage of total flows and export/import flows, respectively. Three regions out of fifteen, *Andalucía*, *Cataluña* and *Valencia*, cope with 45 percent of total flows although these same regions cope with about 30 per cent of either exports or imports. Their respective intra-regional flows are by far the biggest representing 50 per cent of total intra-regional flows.

**Flows intensity**

In order to analyse the nature of the inter-regional flows in every region and/or between any two regions we define the following indexes:

Openness: $$O_i = \frac{\sum_{\forall j \neq i} x_{ij} + \sum_{\forall j \neq i} x_{ji}}{\sum_{\forall j} x_{ij}} \qquad (1)$$

Note that contrary to the definition of the standard openness index for foreign trade flows for a given country, the index $O_{ij}$ is exclusively based on tonnage transported within and between a certain number of regions disregarding flows to the rest of the world.

Coverage: $$C_i = \frac{\sum_{\forall j \neq i} x_{ij}}{\sum_{\forall i \neq j} x_{ji}} \qquad (2)$$

that is, the ratio between tons transported from region *i* to any other region over tons transported to the former from the latter. For both $O_i$ and $C_i$ indexes we have commented in the preceding section. Data are shown in Table 3.2

**Table 3.3**

**Goods transported by origin and destination region (as percentage of total . 1996**

| | Dest. | Andal. | Aragón | Asturias | Cataluña | C-LM | C-León | Cantab. | Extrem. | Galicia | La Rioja | Madrid | Murcia | Navarra | P. Vasco | Valencia | Exp. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Orig. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | |
| **Andal.** | **1** | **11,5** | 0,1 | 0,0 | 0,2 | 0,2 | 0,1 | 0,0 | 0,4 | 0,1 | 0,0 | 0,2 | 0,2 | 0,0 | 0,1 | 0,3 | **1,8** | **13,3** |
| **Aragón** | **2** | 0,1 | **2,7** | 0,0 | 0,7 | 0,1 | 0,2 | 0,0 | 0,0 | 0,0 | 0,1 | 0,2 | 0,0 | 0,1 | 0,2 | 0,3 | **2,0** | **4,6** |
| **Asturias** | **3** | 0,0 | 0,0 | **2,4** | 0,0 | 0,0 | 0,3 | 0,1 | 0,0 | 0,2 | 0,0 | 0,1 | 0,0 | 0,0 | 0,1 | 0,0 | **1,0** | **3,4** |
| **Cataluña** | **4** | 0,3 | 0,8 | 0,0 | **16,2** | 0,1 | 0,2 | 0,0 | 0,0 | 0,1 | 0,0 | 0,4 | 0,1 | 0,1 | 0,2 | 0,8 | **3,4** | **19,5** |
| **C-LM** | **5** | 0,3 | 0,1 | 0,0 | 0,2 | **3,4** | 0,2 | 0,0 | 0,1 | 0,0 | 0,0 | 1,0 | 0,2 | 0,0 | 0,0 | 0,5 | **2,8** | **6,1** |
| **C-León** | **6** | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | **6,3** | 0,2 | 0,1 | 0,4 | 0,1 | 0,4 | 0,0 | 0,1 | 0,4 | 0,1 | **2,8** | **9,2** |
| **Cantab.** | **7** | 0,0 | 0,0 | 0,1 | 0,1 | 0,0 | 0,2 | **1,2** | 0,0 | 0,0 | 0,0 | 0,1 | 0,0 | 0,0 | 0,3 | 0,0 | **1,0** | **2,1** |
| **Extrem.** | **8** | 0,2 | 0,0 | 0,0 | 0,0 | 0,0 | 0,1 | 0,0 | **1,1** | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | **0,4** | **1,5** |
| **Galicia** | **9** | 0,1 | 0,0 | 0,2 | 0,1 | 0,0 | 0,3 | 0,0 | 0,0 | **7,2** | 0,0 | 0,1 | 0,0 | 0,0 | 0,1 | 0,1 | **1,2** | **8,5** |
| **La Rioja** | **10** | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,0 | 0,0 | **0,5** | 0,0 | 0,0 | 0,1 | 0,2 | 0,0 | **0,7** | **1,2** |
| **Madrid** | **11** | 0,3 | 0,1 | 0,1 | 0,2 | 0,6 | 0,3 | 0,0 | 0,1 | 0,2 | 0,0 | **3,4** | 0,1 | 0,0 | 0,1 | 0,2 | **2,3** | **5,7** |
| **Murcia** | **12** | 0,3 | 0,0 | 0,0 | 0,1 | 0,2 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,1 | **1,7** | 0,0 | 0,0 | 0,5 | **1,3** | **3,0** |
| **Navarra** | **13** | 0,0 | 0,2 | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,0 | 0,0 | 0,1 | 0,1 | 0,0 | **1,3** | 0,4 | 0,1 | **1,1** | **2,5** |
| **P. Vasco** | **14** | 0,1 | 0,2 | 0,1 | 0,3 | 0,0 | 0,6 | 0,2 | 0,0 | 0,1 | 0,1 | 0,2 | 0,0 | 0,6 | **4,5** | 0,1 | **2,7** | **7,1** |
| **Valencia** | **15** | 0,3 | 0,3 | 0,0 | 0,6 | 0,5 | 0,1 | 0,0 | 0,0 | 0,1 | 0,0 | 0,3 | 0,6 | 0,0 | 0,1 | **9,1** | **3,0** | **12,2** |
| **Import.** | | **2,2** | **2,0** | **0,9** | **2,9** | **2,2** | **2,9** | **0,6** | **0,8** | **1,3** | **0,5** | **3,3** | **1,2** | **1,3** | **2,3** | **3,1** | **27,4** | |
| **Total** | | **13,7** | **4,6** | **3,3** | **19,0** | **5,5** | **9,2** | **1,8** | **1,9** | **8,5** | **1,0** | **6,8** | **3,0** | **2,6** | **6,8** | **12,3** | | **100,0** |

Source: Encuesta Permanente del Transporte. Department of Transport.

**Table 3.4**

**Goods transported by origin and destination region (as percentage of exports/imports). 1996**

| **Orig.** | **Dest.** | **Andal.** | **Aragón** | **Asturias** | **Cataluña** | **C-LM** | **C-León** | **Cantab.** | **Extrem.** | **Galicia** | **La Rioja** | **Madrid** | **Murcia** | **Navarra** | **P. Vasco** | **Valencia** | **Exp.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | |
| **Andal.** | **1** | | 0,2 | 0,1 | 0,7 | 0,8 | 0,4 | 0,0 | 1,4 | 0,2 | 0,0 | 0,9 | 0,7 | 0,1 | 0,2 | 0,9 | **6,7** |
| **Aragón** | **2** | 0,3 | | 0,1 | 2,4 | 0,3 | 0,6 | 0,0 | 0,0 | 0,1 | 0,2 | 0,7 | 0,1 | 0,5 | 0,6 | 1,1 | **7,1** |
| **Asturias** | **3** | 0,2 | 0,1 | | 0,2 | 0,1 | 1,2 | 0,2 | 0,0 | 0,7 | 0,0 | 0,3 | 0,0 | 0,1 | 0,5 | 0,1 | **3,6** |
| **Cataluña** | **4** | 1,2 | 2,8 | 0,1 | | 0,4 | 0,9 | 0,2 | 0,1 | 0,5 | 0,2 | 1,4 | 0,4 | 0,5 | 0,9 | 2,8 | **12,3** |
| **C-LM** | **5** | 1,3 | 0,3 | 0,1 | 0,6 | | 0,7 | 0,0 | 0,5 | 0,2 | 0,1 | 3,5 | 0,7 | 0,1 | 0,2 | 1,9 | **10,1** |
| **C-León** | **6** | 0,5 | 0,4 | 0,7 | 0,8 | 0,8 | | 0,6 | 0,3 | 1,5 | 0,3 | 1,6 | 0,1 | 0,5 | 1,6 | 0,5 | **10,3** |
| **Cantab.** | **7** | 0,1 | 0,1 | 0,4 | 0,2 | 0,0 | 0,9 | | 0,0 | 0,1 | 0,1 | 0,2 | 0,0 | 0,1 | 1,2 | 0,0 | **3,5** |
| **Extrem.** | **8** | 0,5 | 0,0 | 0,0 | 0,1 | 0,1 | 0,3 | 0,0 | | 0,0 | 0,0 | 0,2 | 0,0 | 0,0 | 0,0 | 0,1 | **1,4** |
| **Galicia** | **9** | 0,4 | 0,1 | 0,9 | 0,4 | 0,2 | 0,9 | 0,1 | 0,1 | | 0,0 | 0,5 | 0,1 | 0,0 | 0,4 | 0,4 | **4,5** |
| **La Rioja** | **10** | 0,1 | 0,3 | 0,1 | 0,2 | 0,1 | 0,5 | 0,0 | 0,0 | 0,1 | | 0,1 | 0,0 | 0,5 | 0,6 | 0,1 | **2,7** |
| **Madrid** | **11** | 1,1 | 0,4 | 0,2 | 0,7 | 2,3 | 1,1 | 0,1 | 0,3 | 0,6 | 0,1 | | 0,2 | 0,1 | 0,5 | 0,8 | **8,4** |
| **Murcia** | **12** | 0,9 | 0,1 | 0,0 | 0,3 | 0,6 | 0,1 | 0,0 | 0,1 | 0,1 | 0,0 | 0,3 | | 0,0 | 0,1 | 2,0 | **4,6** |
| **Navarra** | **13** | 0,1 | 0,6 | 0,1 | 0,5 | 0,0 | 0,4 | 0,1 | 0,0 | 0,1 | 0,3 | 0,3 | 0,0 | | 1,3 | 0,2 | **4,2** |
| **P. Vasco** | **14** | 0,4 | 0,8 | 0,3 | 1,0 | 0,1 | 2,1 | 0,7 | 0,0 | 0,3 | 0,5 | 0,8 | 0,1 | 2,0 | | 0,5 | **9,7** |
| **Valencia** | **15** | 1,0 | 1,0 | 0,1 | 2,2 | 1,9 | 0,4 | 0,0 | 0,1 | 0,3 | 0,1 | 1,3 | 2,1 | 0,2 | 0,4 | | **11,0** |
| **Import.** | | **8,0** | **7,2** | **3,2** | **10,4** | **7,8** | **10,5** | **2,2** | **2,9** | **4,6** | **2,0** | **12,1** | **4,5** | **4,7** | **8,4** | **11,4** | **100,0** |

Source: Encuesta Permanente del Transporte. Department of Transport.

Flow intensity:
$$I_{ij} = \frac{1}{4}\left[ \frac{x_{ij}}{\sum_{\forall i \neq j} x_{ij}} + \frac{x_{ij}}{\sum_{\forall j \neq i} x_{ij}} + \frac{x_{ji}}{\sum_{\forall i \neq j} x_{ji}} + \frac{x_{ji}}{\sum_{\forall j \neq i} x_{ji}} \right] = I_{ji} \qquad (3)$$

that is, the average of flows between any two regions relative to both total exports from the first region and total imports to the second.[2] This index is symmetric for any two regions and its value goes from 0 (no flows between regions *i* and *j*) to 1 (only flows between regions *i* and *j*). Table 3.5 shows the computed values of this index in percentage terms. Out of 105 possible relationships between any two regions,[3] only seven cases show flows intensities over 20 per cent of all joint flows, while for a limit of 15 per cent we have one in every four cases. The couples that have the higher flow intensity are: *Valencia-Murcia* (31.3%), *Madrid-Castilla La Mancha* (30.1%), *Cataluña-Aragón* (29.6%), *Andalucía-Extremadura* (28.9%) and *País Vasco-Navarra* (27.5%). The lowest intensities are found in *Murcia-Cantabria* (0.3%), *Extremadura-La Rioja* (0.3%) and *Extremadura-Asturias* (0.5%).

Everywhere, in the above definitions, figures computed show sharply the implications of geographical proximity. Thus, flows intensity is higher the nearer the involved territories. This issue is explored in the following section.

[2] See Arcarons, Perellada and Soy (19??) from which index (3) is borrowed
[3] Data for 1996

**Table 3.5**

**Flow intensity between any two regions 1996**

| Orig. | Dest. | Andal. 1 | Aragón 2 | Asturias 3 | Cataluña 4 | C-LM 5 | C-León 6 | Cantab. 7 | Extrem. 8 | Galicia 9 | La Rioja 10 | Madrid 11 | Murcia 12 | Navarra 13 | P. Vasco 14 | Valencia 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Andal.** | **1** | | 3,3% | 3,0% | 10,2% | 12,7% | 5,1% | 1,6% | 28,9% | 5,1% | 1,5% | 11,8% | 14,3% | 1,9% | 3,8% | 10,7% |
| **Aragón** | **2** | 3,3% | | 2,3% | 29,6% | 3,7% | 5,9% | 1,9% | 0,7% | 2,6% | 7,0% | 6,5% | 1,7% | 10,2% | 8,6% | 12,0% |
| **Asturias** | **3** | 3,0% | 2,3% | | 2,7% | 1,8% | 18,4% | 9,8% | 0,5% | 19,8% | 2,2% | 4,6% | 0,6% | 2,4% | 7,5% | 2,1% |
| **Cataluña** | **4** | 10,2% | 29,6% | 2,7% | | 5,4% | 7,9% | 4,4% | 2,2% | 6,9% | 4,8% | 9,5% | 5,3% | 8,3% | 9,6% | 22,2% |
| **C-LM** | **5** | 12,7% | 3,7% | 1,8% | 5,4% | | 7,9% | 0,9% | 7,7% | 2,7% | 1,5% | 30,1% | 10,8% | 1,0% | 1,7% | 19,6% |
| **C-León** | **6** | 5,1% | 5,9% | 18,4% | 7,9% | 7,9% | | 17,0% | 8,9% | 19,1% | 10,9% | 13,0% | 1,5% | 7,4% | 19,1% | 4,3% |
| **Cantab.** | **7** | 1,6% | 1,9% | 9,8% | 4,4% | 0,9% | 17,0% | | 0,8% | 2,5% | 1,8% | 3,5% | 0,3% | 2,2% | 22,3% | 1,0% |
| **Extrem.** | **8** | 28,9% | 0,7% | 0,5% | 2,2% | 7,7% | 8,9% | 0,8% | | 1,9% | 0,3% | 6,4% | 1,5% | 0,6% | 1,0% | 2,7% |
| **Galicia** | **9** | 5,1% | 2,6% | 19,8% | 6,9% | 2,7% | 19,1% | 2,5% | 1,9% | | 1,1% | 8,9% | 1,4% | 1,2% | 6,3% | 4,8% |
| **La Rioja** | **10** | 1,5% | 7,0% | 2,2% | 4,8% | 1,5% | 10,9% | 1,8% | 0,3% | 1,1% | | 2,6% | 0,7% | 14,1% | 15,7% | 2,5% |
| **Madrid** | **11** | 11,8% | 6,5% | 4,6% | 9,5% | 30,1% | 13,0% | 3,5% | 6,4% | 8,9% | 2,6% | | 4,2% | 3,2% | 6,7% | 9,6% |
| **Murcia** | **12** | 14,3% | 1,7% | 0,6% | 5,3% | 10,8% | 1,5% | 0,3% | 1,5% | 1,4% | 0,7% | 4,2% | | 0,7% | 1,2% | 31,3% |
| **Navarra** | **13** | 1,9% | 10,2% | 2,4% | 8,3% | 1,0% | 7,4% | 2,2% | 0,6% | 1,2% | 14,1% | 3,2% | 0,7% | | 27,5% | 2,9% |
| **P. Vasco** | **14** | 3,8% | 8,6% | 7,5% | 9,6% | 1,7% | 19,1% | 22,3% | 1,0% | 6,3% | 15,7% | 6,7% | 1,2% | 27,5% | | 4,0% |
| **Valencia** | **15** | 10,7% | 12,0% | 2,1% | 22,2% | 19,6% | 4,3% | 1,0% | 2,7% | 4,8% | 2,5% | 9,6% | 31,3% | 2,9% | 4,0% | |

Source: Encuesta Permanente del Transporte. Department of Transport.

**Distance versus contiguity**

Our data allows us to distinguish between these two concepts given that they refer to tons of goods moved between regions and tons-kilometre. Contiguity between any two regions is simply defined as geographical contiguity and the corresponding variable, $cont_{ij}$, given the value 1 if this is the case and 0 in their absence. For distance we use an “effective distance” measure computed as follows:

Average effective distance: $$dist_{ij} = \left( \frac{(xk_{ij}/x_{ij}) + (xk_{ji}/x_{ji})}{2} \right) = dist_{ji} \qquad (6)$$

where $xk_{ij}$ are tons-kilometre covered by goods going from region *i* to region *j*. Of course, the reverse flows do not need to cover the same distance as they link different locations. In both directions we find thus goods linking activity centres located sparsely across the territory and what we are actually measuring is a sort of average distance between “economic gravity centres” of any two regions. Tables 3.6 and 3.7 contain the results of the corresponding calculations.

It can be seen that average effective distance covered by intra-regional flows is rather short, 53 kilometres, relatively small even in large regions like *Andalucía* (71 km.) or the two *Castillas* (62 and 57 km.). As for the distances covered by exports or imports, we see that the range goes from 74 km. (*La Rioja-Navarra*) to 1103 km. (*Cataluña-Galicia*). The average distance covered by all flows between regions is 361 km. These figures beg an explanation that can only be given if one descends to the close economic structure of exchanges between activity centres in or out the different regions. Geographical segmentation of exchanges within certain corridors or areas must be common although combinations of flows must also be possible. This would extend the reach and penetration of economic relationships. This is not however the aim of this paper.

**Table 3.6**

**Effective distance between any two regions 1996**

| Dest. / Orig. | | Andal. 1 | Aragón 2 | Asturias 3 | Cataluña 4 | C-LM 5 | C-León 6 | Cantab. 7 | Extrem. 8 | Galicia 9 | La Rioja 10 | Madrid 11 | Murcia 12 | Navarra 13 | P. Vasco 14 | Valencia 15 | Exp. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Andal.** | **1** | 71 | 786 | 851 | 981 | 366 | 670 | 902 | 224 | 1.003 | 909 | 497 | 317 | 952 | 980 | 506 | 522 | 133 |
| **Aragón** | **2** | 783 | 49 | 635 | 243 | 255 | 310 | 479 | 611 | 870 | 185 | 331 | 583 | 152 | 317 | 295 | 309 | 159 |
| **Asturias** | **3** | 911 | 601 | 40 | 883 | 617 | 206 | 196 | 579 | 199 | 453 | 478 | 861 | 455 | 357 | 807 | 368 | 135 |
| **Cataluña** | **4** | 981 | 215 | 938 | 53 | 601 | 575 | 684 | 1.000 | 1.103 | 451 | 607 | 598 | 427 | 580 | 341 | 503 | 131 |
| **C-LM** | **5** | 377 | 297 | 610 | 593 | 62 | 269 | 515 | 277 | 704 | 524 | 98 | 238 | 548 | 564 | 221 | 252 | 147 |
| **C-León** | **6** | 706 | 288 | 245 | 583 | 329 | 57 | 170 | 299 | 288 | 97 | 220 | 649 | 236 | 174 | 559 | 309 | 135 |
| **Cantab.** | **7** | 844 | 412 | 205 | 697 | 550 | 219 | 30 | 650 | 546 | 242 | 408 | 818 | 277 | 120 | 722 | 275 | 141 |
| **Extrem.** | **8** | 286 | 690 | 529 | 1.035 | 329 | 337 | 684 | 52 | 747 | 556 | 331 | 667 | 826 | 654 | 688 | 416 | 147 |
| **Galicia** | **9** | 989 | 815 | 195 | 1.099 | 738 | 336 | 495 | 684 | 56 | 667 | 596 | 915 | 733 | 660 | 966 | 596 | 134 |
| **La Rioja** | **10** | 767 | 164 | 473 | 456 | 474 | 145 | 235 | 571 | 630 | 30 | 344 | 706 | 62 | 145 | 615 | 220 | 144 |
| **Madrid** | **11** | 516 | 329 | 481 | 620 | 100 | 212 | 403 | 325 | 614 | 353 | 34 | 412 | 435 | 430 | 388 | 339 | 156 |
| **Murcia** | **12** | 287 | 584 | 974 | 636 | 218 | 628 | 833 | 688 | 922 | 711 | 425 | 47 | 745 | 813 | 123 | 283 | 147 |
| **Navarra** | **13** | 876 | 177 | 488 | 444 | 473 | 245 | 250 | 792 | 721 | 74 | 407 | 614 | 32 | 120 | 546 | 277 | 144 |
| **P. Vasco** | **14** | 907 | 303 | 363 | 590 | 539 | 219 | 129 | 636 | 678 | 116 | 432 | 797 | 97 | 40 | 647 | 323 | 146 |
| **Valencia** | **15** | 564 | 291 | 858 | 366 | 232 | 591 | 723 | 656 | 980 | 604 | 391 | 136 | 514 | 647 | 48 | 359 | 125 |
| **Import.** | | 609 | 287 | 356 | 512 | 264 | 298 | 268 | 320 | 560 | 232 | 327 | 292 | 212 | 315 | 352 | | |
| **Total** | | 158 | 150 | 123 | 122 | 141 | 133 | 110 | 166 | 131 | 136 | 178 | 149 | 121 | 134 | 125 | | |

Source: Encuesta Permanente del Transporte. Department of Transport.

**Table 3.7**
**Effective distance covered by goods moved between and within regions. 1996**

| | Average effective distance covered by ... | | | | |
|---|---|---|---|---|---|
| | Goods moved intra-region (1) | Goods exported (2) | Total goods moved (1)+(2) | Goods imported (3) | Total goods moved (1)+(3) |
| **Andalucía** | 71 | 522 | 133 | 609 | 158 |
| **Aragón** | 49 | 309 | 159 | 287 | 150 |
| **Asturias** | 40 | 368 | 135 | 356 | 123 |
| **Cataluña** | 53 | 503 | 131 | 512 | 122 |
| **C. - La Mancha** | 62 | 252 | 147 | 264 | 141 |
| **C. - León** | 57 | 309 | 135 | 298 | 133 |
| **Cantabria** | 30 | 275 | 141 | 268 | 110 |
| **Extremadura** | 52 | 416 | 147 | 320 | 166 |
| **Galicia** | 56 | 596 | 134 | 560 | 131 |
| **La Rioja** | 30 | 220 | 144 | 232 | 136 |
| **Madrid** | 34 | 339 | 156 | 327 | 178 |
| **Murcia** | 47 | 283 | 147 | 292 | 149 |
| **Navarra** | 32 | 277 | 144 | 212 | 121 |
| **P. Vasco** | 40 | 323 | 146 | 315 | 134 |
| **Valencia** | 48 | 359 | 125 | 352 | 125 |
| **Total** | 53 | 361 | 138 | 361 | 138 |

Source: Encuesta Permanente del Transporte. Department of Transport.

**Table 4.1**
**The determinants of interregional flows (Dependent variable: $\ln(x_{ij} + x_{ji})$)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Intercept | -6.73<br>(-8.45) | -6.56<br>(-8.24) | -6.91<br>(-8.76) | -12.77<br>(-12.69) | -14.05<br>(-16.14) | -12.98<br>(-15.43) |
| Population: $\ln(pop_i + pop_j)$ | 1.54<br>(28.60) | | 0.84<br>(3.48) | 1.23<br>(18.70) | | -1.49<br>(-6.19) |
| Value added: $\ln(va_i + va_j)$ | | 1.47<br>(28.40) | 0.69<br>(2.97) | | 1.31<br>(23.08) | 2.73<br>(11.6) |
| Distance: $\ln((dist_{ij} + dist_{ji})/2)$ | -1.68<br>(-29.23) | -1.54<br>(-27.24) | -1.62<br>(-26.95) | | | |
| Contiguity: $cont_{ij}$ | | | | 1.94<br>(20.62) | 1.94<br>(23.39) | 1.93<br>(24.57) |
| Adj. $R^2$ | 0.807 | 0.805 | 0.812 | 0.696 | 0.762 | 0.788 |

The idea of effective distance makes sense as tonnage exchanged between any two territories should be greater the shorter the distance separating them. Chart 3.1 shows a non linear relationship between these two variables where we see that flows intensity falls rapidly as distance covered approaches about 300 kilometres. Beyond that distance, flows intensity becomes negligible, except for a handful of cases. The fact, however that the fit is not perfect leaves room for a deeper investigation about the determinants of exchanges between regions.

## 4. The determinants of interregional flows

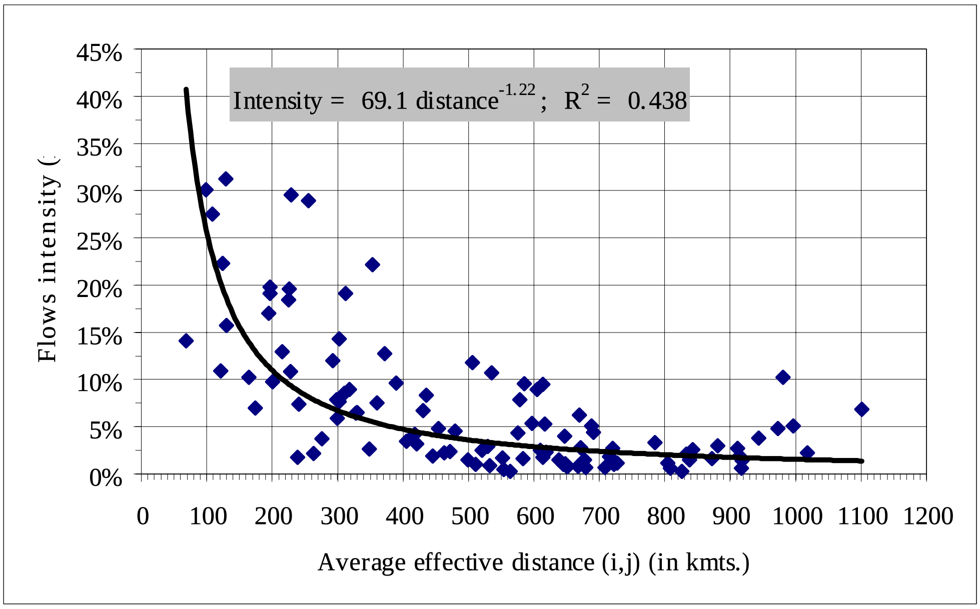
Regions exchange goods with each other that are presumably larger the larger is their size, both in population or in value added terms, and the smaller is the distance that separates them. This is basically the prediction of gravitational models much used in the international trade and investment literature. Empirical gravity models, in turn, can be naturally derived from standard theories of international trade, like the H-O theory.[4] Les us thus consider a gravity equation of the type:

[4] See Deardorff (1995) and Evenett and Keller (1998) for a review of the theoretical foundations of the gravity

$$\ln\left(x_{ijt} + x_{jit}\right) = \alpha_0 + \beta_1 \ln\left(pop_{it} + pop_{jt}\right) + \beta_2 \ln\left(va_{it} + va_{jt}\right) + \beta_3 \ln\left(dist_{ijt}\right) \qquad (7)$$

**Chart 3.1**

**The flows-distance relationship between any two regions**




where $pop_i$ is population, $va_i$ is value added and $dist_{ij}$ is effective distance computed as indicated in the previous section. Again, this distance is very much affected by the precise economic relationships between providers and customers at each location. Presumably total population and value added are strongly correlated and just one of these variables would be sufficient to test the size (of the regions) effect on the volume of goods exchanged amongst them.[5] We would also expect the sign of $\beta_1$ and $\beta_2$ to be positive and the sign of $\beta_3$ to be negative. The estimation of (7) by OLS gives the results offered in the three fist columns of table 4.1.

That population and value added are strongly correlated is apparent in the coefficients shown in column (3) as compared with the two previous columns. Both coefficients are lower and far less significant. We retain equation (2) where the

equation.

[5] The partial correlation coefficient between the log of the joint population of any two regions and their log of joint value added is 0.97 in our sample.

value added elasticity of bilateral flows is 1.5 and about the same size, but negative, the distance elasticity. Both signs are as expected and the coefficients are highly significative, as it is also standard when gravitational models are used. The fit of the model is also very good given that the spatial dimension of our data is larger than its time dimension.

In order to test whether the standard contiguity measure is a good proxy for distance, we have performed the estimations shown in columns (4) to (6) of Table 4.1. Although we cannot discard such use for this variable, results are clearly worst when it is used. The value added elasticity of bilateral flows, in equation (5), diminishes, as well as t ratios, while their distance elasticity increases. The fit is poorer and, in equation (6), we obtain the bizarre negative sign for the population coefficient. This in turn, implies that the contiguity variable cannot prevent collinearity from showing up in the equation. Effective distance or other distance measure based on kilometres should always be preferred to contiguity dummies (see Moreno and Trehan, (1997)

**Integration and growth in the Spanish regions**

More flows, trade or investment, mean more integration and, as we have seen, distance and size are key variables in explaining exchanges between Spanish regions. But, do more flows mean more growth or common growth? If this is so, distance and location play a role on growth. Integration means however many more things than trade flows. Even separate regions in a given country, peripheral to each other in terms of bilateral flows, as can be the case of the pair *Murcia-Cantabria* (see Table 3.5) with a 0.3% flow intensity measure between them and effective average distance of 826 kilometres, share a common language, central government, macroeconomic policy or judiciary system. Integration thus will be restricted here to the narrower definition of exchanges and our aim in this section will be to explore the relationships between integration and growth in the Spanish regions. Integration, also, would expand the market that every region can reach creating the "thick markets" type of externality discussed in section 2 above.

Recent studies have reported that linkages across economies are important explaining growth. Chua (1993) finds that a region's production is affected not only by its own inputs, but also by bordering region's inputs. Barro and Sala-i-Martin (1995) show that the initial income of neighbouring countries is significant in explaining growth rates. Vayá, López-Bazo and Artís (1998), using data for European regions, show that both the initial productivity and growth of neighbouring regions affect the growth of a region and argue that the omission of these effects in a convergence equation may bias downward the estimated rate of converge parameter. In a more recent paper, López-Bazo et al (1998) test for the presence of externalities using a growth model for Spanish regions. They find that the growth rate of a region is a function of the stock of capital (human and physical) of its neighbours. Moreno and Trehan (1998), using distance as well as other alternative measures of proximity, show how a country's growth is affected by growth of neighbours.

Spatial econometrics techniques, which most of the previous studies use, are particularly adequate for trying to answer our original question of whether integration enhances mutual growth. Spatial econometrics is based on the concept of "spatial dependence" that refers to the lack of independence which is present among spatial units. Spatial dependence is generally determined by the effect of geographical distance but the notion of space can be extended to other dimensions (economic, cultural, organisational,...)

Since our focus is on spatial economic relationships we will use data on goods flows among Spanish regions, already presented in section 3 above, as an indicator of interdependence. Previous work has mostly employed geographical distance or contiguity among regions as a measure of distance. In some cases trade flows have also been applied, specially when the spatial units are countries for goods flows between units are then better measured (Moreno et al.,1998).

Our work is constrained by the short time period for which there are available data on goods flows among Spanish regions. The period 1993 to 1995 for which we have data is certainly too short to observe substantial changes in the level of integration, i. e. a sustained increase in the size of these flows. Consequently, it is not strange if we don't observe significant differences using goods flows vs. Proximity measures as indicators of integration.

We will start by asking whether a region's growth is influenced by growth of its neighbour's, particularly when they are linked by trade goods. The key variable explaining growth in a region is obtained by multiplying a weighting matrix by the vector of growth rates of output per capita in the rest of the regions. Usually the weighting equation represents one time period (R). However we will use several periods and we will suppose that there is not spatial dependence between periods. The weight matrix has a dimension nxnxT, being T the number of years.

$$W = \begin{bmatrix} R & 0 & \vdots & 0 \\ 0 & R & \vdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \vdots & R \end{bmatrix} \qquad (8)$$

where 0 is a nxn matrix of zeros and *R* is a nxn matrix of weights whose elements $r_{ij}$ are defined as:

$$r_{ijt} = \frac{x_{ijt}}{\sum_j x_{ijt}} \qquad (9)$$
$$r_{ijt} = 0 \quad if \; i = j$$

being $x_{ij}$ the goods flow from region $i$ to region $j$. Alternatively, if we consider distance instead of goods flows:

$$r_{ijt} = \frac{1/d_{i\,jt}}{\sum_j 1/d_{ijt}} \qquad (10)$$

The weighting matrix $W$, links all the regions with each other except with itself. The relative importance of each region varies depending on the volume of goods exchanged or, alternatively, on the inverse of the distance to the region considered.

Table 5.1 shows growth of income per capita for each region and year and the explanatory variable, growth in other regions, using as a weight matrix effective distance, goods flows and contiguity.

**TABLE 5.1.**
**GROWTH RATES OF OUTPUT PER CAPITA OF REGIONS AND THEIR "NEIGHBOURS"**

| REGION | Gy | W-Gy W=kms | W-Gy W=Flows | W-Gy W=contiguity |
|---|---|---|---|---|
| 1993 | | | | |
| Andalucia | -4.06% | -2.91% | -3.02% | -3.87% |
| Aragón | -2.37% | -2.48% | -2.44% | -2.54% |
| Asturias | -4.10% | -2.29% | -1.83% | -1.37% |
| Cantabria | -2.72% | -2.56% | -2.15% | -1.87% |
| Castilla la Mancha | -6.10% | -2.57% | -2.92% | -2.55% |
| Castilla y León | 0.84% | -2.81% | -2.92% | -2.98% |
| Cataluña | -2.29% | -2.71% | -2.84% | -3.05% |
| Extremadura | -2.66% | -2.91% | -2.98% | -3.11% |
| Galicia | -2.23% | -2.74% | -2.57% | -1.63% |
| La Rioja | -1.26% | -2.54% | -2.26% | -1.65% |
| Madrid | -3.04% | -3.23% | -3.66% | -2.63% |
| Murcia | -2.84% | -3.24% | -3.79% | -4.63% |
| Navarra | -2.71% | -2.15% | -2.23% | -1.99% |
| País Vasco | -2.35% | -2.37% | -2.11% | -1.46% |
| Valencia | -3.74% | -2.90% | -3.05% | -3.40% |
| 1994 | | | | |
| Andalucia | 0.70% | 0.93% | 0.86% | 0.55% |
| Aragón | 0.77% | 1.21% | 1.28% | 1.29% |
| Asturias | 0.92% | 1.21% | 1.25% | 1.58% |
| Cantabria | 1.70% | 1.02% | 1.13% | 1.15% |
| Castilla la Mancha | 0.36% | 1.00% | 0.89% | 0.86% |
| Castilla y León | 1.82% | 1.07% | 1.02% | 0.93% |
| Cataluña | 1.88% | 0.99% | 0.85% | 0.68% |
| Extremadura | 0.52% | 1.02% | 0.97% | 0.96% |
| Galicia | 1.23% | 1.12% | 1.09% | 1.37% |
| La Rioja | 1.29% | 1.28% | 1.23% | 1.27% |
| Madrid | 0.85% | 0.96% | 0.89% | 1.09% |
| Murcia | 0.76% | 0.90% | 0.77% | 0.55% |
| Navarra | 1.79% | 1.08% | 1.05% | 0.92% |
| País Vasco | 0.71% | 1.36% | 1.43% | 1.65% |
| Valencia | 0.58% | 1.01% | 1.08% | 0.94% |
| 1995 | | | | |
| Andalucia | 1.86% | 1.70% | 1.75% | 0.95% |
| Aragón | 3.47% | 2.02% | 2.36% | 2.06% |
| Asturias | 1.75% | 1.88% | 1.98% | 1.44% |
| Cantabria | 1.24% | 2.21% | 2.36% | 2.19% |
| Castilla la Mancha | 1.08% | 2.01% | 2.11% | 1.95% |
| Castilla y León | 1.60% | 2.05% | 2.24% | 1.95% |
| Cataluña | 2.86% | 2.18% | 2.56% | 3.06% |
| Extremadura | 0.96% | 1.89% | 1.83% | 1.51% |
| Galicia | 1.47% | 1.91% | 2.16% | 1.68% |
| La Rioja | 2.06% | 2.24% | 2.46% | 2.60% |
| Madrid | 2.31% | 1.79% | 1.84% | 1.34% |
| Murcia | 0.80% | 2.10% | 2.19% | 1.86% |
| Navarra | 2.11% | 2.25% | 2.70% | 2.91% |
| País Vasco | 3.21% | 1.88% | 2.06% | 1.75% |
| Valencia | 2.65% | 1.84% | 1.99% | 2.05% |

In order to test for the effects of integration on growth we start by estimating a simple equation where growth of output per capita depends on growth of interdependent regions, without controlling for any other determinant of growth. A simple model of spatial dependence is then given by:

$$g_y = a + \rho W g_y + \varepsilon_i \qquad (11)$$

where $g_y$ is growth of income per capita in a region between period t-1 and t, $\varepsilon_i$ is distributed as a $N(0,\delta^2)$, and $W$ is the weighting matrix.

The errors in equation (11) are not independent of the right hand side variables and thus ordinary least squares will be inconsistent. To avoid the simultaneity problem we estimate using maximum likelihood. In Table 5.2 we present estimates of this equation using different weighting matrixes. The first column shows the regression coefficients and its probabilities using a goods flows weighting matrix with rows normalised to 1. The estimated coefficient indicates that an increase of 1 percent in the growth rates of the integrated regions is associated with a 0.85 percent growth of the region under consideration. The corresponding coefficient is commonly interpreted as that of a growth externality going from neighbouring regions to any region due, among other influences, to the expansion of the market at the reach of any region, our so called “thick markets” externality. This relation is very significant showing evidence about the existence of this type of externalities.

**TABLE 5.2**
**SPATIAL LAG MODEL – MAXIMUM LIKELIHOOD ESTIMATION**
**Dependent variable: growth rate of output per capita**
**Period: 1993-95**

| | Goods flows (normalised) | Inverse of distance (normalised) | Contiguity (normalised) | Distance adjusted for region size (normalised) | Goods flows adjusted for regional size |
|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** |
| ρ | 0.852<br>(0.000) | 0.869<br>(0.000) | 0.808<br>(0.000) | 0.852<br>(0.000) | 10.751<br>(0.000) |
| **CONSTANT** | -0.00062<br>(0.693) | -0.00028<br>(0.859) | -0.00031<br>(0.859) | -0.00021<br>(0.889) | -0.00075<br>(0.725) |
| **LIK** | 136.838 | 136.578 | 130.698 | 137.432 | 126.047 |
| **AIC** | -269.676 | -269.155 | -257.396 | -270.864 | -248.093 |
| **LM-ERR** | (0.204) | (0.895) | (0.028) | (0.961) | (0.274) |
| **LR-LAG** | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |

(P) values are in parentheses
AIC-Akaike information criterion
LIK-Logarithm of the likelihood
LM-ERR -Lagrange multiplier test on spatial error dependence (Burridge, 1980)
LR-LAG is the likelihood ratio test for the significance of the spatial lag of the endogenous variable

Columns 2 and 3 show results with row normalised distances and contiguity matrices respectively. Results are quite similar to those obtained using goods flows although the use of effective distance to weight the influence of other regions seems to perform better, in particular with respect to contiguity. The externalities coefficient is above 0.8 and it is in all cases very significant. Note that, as established in section 4, there is a strong correlation between flows intensity and distance. Thus it is not estrange that results are very similar as for these two alternative weighting procedures. Plainly stated, the closer the regions are, either in trade or in geographical terms, the more interdependent are their growth proceses.

Alternative weighting matrices have been used to test how sensitive the externality coefficient is to these changes. The first modification intends to take into account regional size. We expect that the greater the size of the nearby regions, the more it will affect the other regions. Following this logic, López-Bazo et al (1998) rescale the distance matrix the following way:

$$r_{ijt} = \frac{POB_{jt}\left(1/d_{ij}\right)}{\sum_j POB_{jt}\left(1/d_{ij}\right)} \tag{12}$$

where $POB_{jt}$ is equal to the population in region $j$ in period $t$.

Results are similar, but slightly better, to those obtained not considering regional size. The externalities coefficient is around 0.85 and it is also significant.

The last transformation considered is presented in column 5 of Table 5.2. Using the goods flows matrix we have transformed each element the following way:

$$r_{ijt} = \frac{\left(x_{ijt} / GVA_{it}\right)}{\sum_i \sum_j \left(x_{ijt0} / GVA_{ijt0}\right)} \tag{13}$$

where $GVA$ is gross value added.

This modification intends to take into account variations in the degree of integration across time. If we row normalise the matrix, all regions will have a similar degree of integration, although the regions with which each other region is integrated may change. In order to take into account the differences in the level of integration between the different regions and in time, we divide each element by the sum of the rows and columns of the goods flows matrix for the first year. We must also divide each element by the value added of the region considered, in order to control for regional size. Doing this transformation, what matters is, not only the relative level of integration, but also the absolute integration.

The results using this new weighing matrix are presented in column (5) in Table 5.2. The externality variable is very significant. However, the model performs slightly worse than the other specifications, and it is hard to interpret the coefficient.

Summarising, results show that goods flows acts as a channel for interdependent regional growth. Proximity and contiguity, due to their high correlation with goods flows, are also a channel for linking regional growth patterns.

Now we would like to examine whether the interdependency in the growth rates between regions is still present once we control for other factors affecting growth in the same region. We thus introduce the externalities variable in a convergence equation to test if its effect is still present once we take into account the initial income of the region. The equation to estimate has the following form:

$$g_y = a + \rho W g_y + \beta \ln y + \varepsilon_i \qquad (14)$$

where $g_y$ is the growth of output per capita and ln*y* is the output per capita at period t-1.

Before estimating this equation, we start estimating equation (14) without the externality parameter, that is a simple convergence equation. We estimate this equation by ordinary least squares without and with regional dummies. Column 1 in Table 5.3 present these results without fixed effects and column 2 considers regional fixed effects. The inclusion of regional dummies improves the specification, and consequently the specification model with fixed effects is preferred.

| TABLE 5.3<br>Dependent variable: growth rate of output per capita<br>Period: 1993-95 | | | |
|---|---|---|---|
| | **OLS** | **OLS *** | **ML-LAG*** |
| | **(1)** | **(2)** | **(3)** |
| ρ | | | 0.694<br>(0.000) |
| **CONSTANT** | -0.092<br>(0.469) | 8.752<br>(0.000) | 3.939<br>(0.000) |
| **B** | 0.0135<br>(0.465) | -1.268<br>(0.000) | -0.571<br>(0.000) |
| **LIK** | 106.503 | 132.433 | 165.690 |
| **AIC** | 209.006 | 232.865 | -297.379 |
| **LM-LAG** | | (0.000) | |
| **LM-ERR** | | (0.000) | (0.001) |
| **LR-LAG** | | | (0.000) |

(P) values are in parentheses
AIC-Akaike information criterion
LIK-Logarithm of the likelihood
LM-ERR -Lagrange multiplier test on spatial error dependence (Burridge, 1980)
LM-LAG --Lagrange multiplier test on spatial lag dependence (Anselin, 1988)
LR-LAG is the likelihood ratio test for the significance of the spatial lag of the endogenous variable

To determine whether there is spatial autocorrelation we compute the Lagrange multiplier tests. The LM-err and LM-lag indicate respectively the presence of substantial residual and spatial autocorrelation.

Given the evidence of spatial autocorrelation we estimate by maximum likelihood the convergence equation introducing a spatial lag of the growth rate. As displayed in column 3, the spatial lag is very significant and the coefficient is lower than the one obtained in the first specification. The inclusion of the spatial lags has also caused a relevant decrease in the speed of convergence. This regression intends to correct the spatial autocorrelation, but this does not entirely disappear as evidenced by the significance of the Lagrange multiplier test on spatial error dependence.

Finally we want to examine whether the spatial correlation is only present in the error term. In this case the equation should include a spatial autoregressive structure in the error term similar to the one used earlier for growth rates.

$$\begin{aligned} g_y &= a + B\ln y + u \\ u &= \lambda W u + e \quad e \approx N(0,\sigma^2) \end{aligned} \tag{15}$$

If this was the preferred model it would mean that the spatial autocorrelation in the growth rates would be the result of common shocks that are common to geographic interdependent regions rather than the effect of externalities.

Table 5.4 presents results for regression (15). Although the spatial parameter is highly significant, the common factor test[6] is significant at 10 percent level indicating the internal inconsistency of the model. The implication is that the spatial error model is inappropriate and consequently we choose the spatial lag model as the correct one.

6 An equation with a spatial autorregressive structure can be written: $y = \lambda Wy + X\beta - \lambda WX\beta + \varepsilon$ or $y = \lambda Wy + X\beta - WX\gamma + \varepsilon$, in an unconstrained form. The Common Factor tests the hypothesis H0:$\lambda\beta=\gamma$, where $\gamma$ is the coefficient for the spatial lag of the exogenous variable in an unconstrained form. *X* is the exogenous variable.

| TABLE 5.4<br>SPATIAL ERROR MODEL –MAXIMUM LIKELIHOOD ESTIMATION<br>Period: 1993-1995<br>Dependent variable: growth rate of output per capita | |
|---|---|
| **CONSTANT** | 6.070<br>(0.000) |
| **B** | -0.879<br>(0.000) |
| **LAMBDA** | 0.889<br>(0.000) |
| **LIK** | 179.373 |
| **AIC** | -326.745 |
| **COMFAC** | (0.010) |
| **LM-LAG** | (0.410) |
| **LR-ERR** | (0.000) |

(P) values are in parentheses
AIC-Akaike information criterion
LIK-Logarithm of the likelihood
LM-ERR -Lagrange multiplier test on spatial error dependence (Burridge, 1980)
LM-LAG --Lagrange multiplier test on spatial lag dependence (Anselin, 1988)
COMFAC –Common factor test.
LR.-ERR is the likelihood ratio test for the significance of the spatial autoregressive structure in the error term

## 6. Concluding comments

Close territories tend to certain share growth features. Closeness can be interpreted in many terms, including active economic relationships despite distance although geographical proximity is strongly correlated with intense economic relationships. In this paper we have tried to supply further evidence on these issues drawing on data recently made available by the Spanish Department of Transport about goods exchanges between regions by road transports. First, after a detailed description of the data, we have shown how these data allows to construct a measure of effective distance between territories. Then, it has been shown that intensity of flows is strongly correlated, apparently in a non linear way, with this measure of effective distance in a gravity relationship. Goods exchanges or “trade” between regions and distance are thus good substitutes in any exploration of the relationships between growth and integration. As for this relationship, we find evidence of interdependent growth between Spanish regions being affected by the intensity of exchanges and/or distance amongst them. In other words, the larger the exchanges or the shorter the distances between territories, more interdependent their growth patterns are likely to be.

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