SPATIAL DEVELOPMENT OF CROSS-BORDER AREAS AND THE IMPORTANCE OF ACCESSIBILITY

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ABSTRACT

Cross-border Regional development is one of the EU current major concerns. These regions are usually less dynamic socio-economically and tend to be peripheral areas in each country. Some of these regions have recently benefited from new roads, which have mainly been funded through the European financial program of Transnational Transport Networks, TEN-T. Almost twenty years after implementation started and after initial observations on the impacts, some development problems are unexpectedly getting worse. Using socioeconomic data from the Portugal/Spain cross-border area a model able to measure the relation between accessibility and development in this region is being calibrated. This paper is an initial study on the calibration process for some Portuguese municipalities in the border area for the period 1991-2001. This initial study also prepares the setting for a more complete study covering both sides of the border, therefore including Spanish data.

1 INTRODUCTION

The spatial distribution of activities is the result of opportunities and localization strategies outlined in terms of specific objectives. If we take into account that most human activities involve using and sharing limited resources it is easy to see that the decision processes are complex and involve an important economic component. The acceleration of regional development, particularly in peripheral and border regions - as in our case – seems generally to be associated with substantial capital investment, the allocation of sophisticated technical and scientific resources to production systems, and a thorough renovation of the economy. Building new infrastructure in these areas also leads to significant public investment to make private capital more productive, and it is hoped, therefore, that the expansion of networks and systems will, in the first place, enable firms to operate at lower costs and achieve better performance and, second, mean that the resulting productivity gains will increase the range of regional economic activity. Our geographical working area is considered a peripheral region; it is facing a sharp population decline, weak business dynamics, and its transport infrastructure is referred to as *being little in line with the local development needs*.

Two characteristics of this type of territory can help us better understand these local needs. First, based on census data, there is a significant trend for the number of young people to fall and the elderly population to increase, with particularly disturbing future implications. In fact, although this is *only* a reduction in the younger population, it necessarily implies a

future reduction in workforce; this trend means that an increasingly small active population will have *to* support a growing number of elderly people. The region can realistically only establish a trend towards population stabilization if people come from outside, that is, if the territories are attractive, because there is no credible prospect of a change in the sign (negative) of natural increase. And a young potentially active population is essential for regional development.

Second, the topography and water courses (as well as political decisions) have always conditioned the structure of the main road network of the area. This situation has changed very little in recent years. Apart from the delay that has been systematically observed in improving some of the main roads crossing the region - essential to both the permeation of the national territory and to penetrating either side of the border - the capillary network has not been properly addressed by the authorities. These networks are doubly important for the integrated development of the region. From an inside point of view it represents more direct links between Portuguese towns. From a wider strategic point of view, it represents links to neighboring Spanish settlements. This latter issue is fundamental to a cross-border cooperation (CBC) pattern which age-old tradition needs to preserve and enhance in order to improve local economic dynamics.

Accessibility in general and the transport infrastructure in particular are fundamental to the integrated development of any region. To achieve this target it is necessary they exist and act as such. However, although some components have not yet gone beyond the virtual planning stage, the region - on both sides of the border - is already endowed with an interesting range of transport infrastructure. One issue here is that not all of these new or improved roads operate at full use of their capacity (or else they do not do so in network).
While infrastructure construction and the implementation of transport systems in these regions, which are simultaneously remote and border areas, may be guided by the principle of territorial equity, we are also aware that logic should prevail in local claims; any requests for investment of generic utility should be replaced by more selective interests that are easier to support technically and economically.

Whilst it is not possible to eliminate the effects of the past it is nonetheless legitimate to balance any development opportunities in this region with scenarios of more and/or improved accessibility at national, interregional and cross border levels.

These background considerations demonstrate the importance of this subject, although it has not been treated in any depth in the literature.

In fact, recent examination of the most prestigious science databases shows that specific papers devoted to this issue are quite rare, and even fewer have focused on cross-border accessibility, and most of these are qualitative in nature. This paper thus aims to provide some new scientific knowledge about the impact of accessibility on sustainable development. A specific cross-border region between Portugal and Spain has been chosen as a case study, and previous results in similar studies are also used.

First we selected a group of 15 cross-border municipalities and through a classical regression analysis we evaluated the above relationship, considering only these municipalities' access connections within Portugal. Then we repeated the process but added information concerning access connections with Spain for those 15 municipalities. These two stages are the focus of this paper.

In the third stage we intend to aggregate data on the Spanish municipalities directly connected to the other side of the border, next to the Portuguese municipalities. In a fourth stage this work will be extended to all municipalities on both sides of the entire Portugal/Spain border. The two later stages will be developed within a spatial regression framework, with the addition of the 'location' variable as an explanatory variable for development.

2 LITERATURE REVIEW

Considerable investment has been made in new road infrastructure in recent decades. This investment has mainly been supported by the argument that road links are important tools in improving social and economic cohesion. In Europe the related policies and actions aim to consolidate the Trans-European Transport Networks (TEN-T) and provide closer links between core and peripheral countries (European Commission, 2007). The positive influence of transport infrastructure (through improved accessibility) in development is a widely accepted concept. But the full validity of this concept has not yet been established. The great majority of studies about how accessibility impacts on development apply on a spatially aggregated basis and use methodologies and models such as cost benefit analysis with production functions (Aschauer, 1989), among others. Piet Rietveld and Frank Bruinsma (1998) and David Banister and Joseph Berechman (2000) report a wide range of approaches. Research in Portugal uses the same aggregated approaches to show that new transport infrastructure positively affects the global Portuguese economic performance (Pereira and Andraz, 2005). The growing complexity of spatial socio-economic interactions has recently called for the use of more disaggregated spatial units and the inclusion of the 'location' factor, arguing that the positive effects are weaker when looking at it on a local basis (Mas *et al*, 1996; Guild, 2000). The use of accessibility indicators is an important step forward, as seen in the work of Roger Vickerman (1995), Kenneth Button (1995), Ulla Forslund and Bjorn Johansson (1995) and Javier Gutiérrez and J. Urbano (1996) and, more recently, of Lopez and Javier Gutierrez (2008) related to important new European transport infrastructures and consolidating the concept of 'potential accessibility'. However, the calculation of accessibility is not enough to measure the way it acts as a development factor. Antonio Páez makes some important advances by using the same type of accessibility indicators as variables in a spatial regression analysis framework (Páez, 2004), supported by the spatial econometrics work of Luc Anselin (1988). Besides Paez, the work of Anselin has inspired great number of contributions since the beginning of the millennium, e.g. Jesus Mur (2009).The same methodology is now used in recent Portuguese work (Ribeiro, 2009). The number of kilometers of Portugal's network of major roads has increased substantially in the last twenty years (through the TEN-T program), as has happened in many European countries (Santos *et al*, 2009). Consequently, most of the country felt a huge increase in accessibility but the corresponding improvement in development has not matched expectations, since in many areas population continues to decline (Gaspar *et al*, 2002). These negative effects are more pronounced in cross-border areas, where a spatial regression analysis is used to explain to what extent the new accessibility achieved by the new roads has affected population growth at municipality level (Ribeiro *et al*, 2010). Overall, cross-border areas have become increasingly important in the context of European integration, particularly since the recent enlargement. Usually, but not always, peripheral to the main city centers within their country's spatial structure, these regions suffer from chronic development problems (many of them related to centuries of history and changing boundaries). Among other similar programs, the

European Commission approved recently (2007) a European program for cross-border cooperation between Spain and Portugal for the period 2007-2013 (http://www.poctep.eu). The efforts are now concentrating on improving connectivity and basic infrastructures in the border areas in a new approach aimed at improving competitiveness, promoting employment and enhancing socio-economic and institutional integration in the border regions. Therefore, it is fundamental to analyze how the existing transport infrastructures can do better to meet those objectives. The scientific background (to the relation between accessibility and development) does not go much further than the literature mentioned above, and on cross-border issues it is extremely recent, largely resulting from recent European funded projects (and mainly qualitative). And there is no article on the application of spatial regression analysis to this subject. In fact, the most prestigious relevant database contains very few articles about cross-border regions, development and accessibility (or transport), (Mesarec and Lep, 2009; Johnson, 2009; Lopez *et al*, 2009). As Portuguese examples, several articles have examined the same type of issues. For example, Jorge Silva (2005) and Cavaleiro *et al* (2009). But again, these important studies consider the availability of direct transport infrastructure as the indicator for development and do not analyze the significance of that potential impact. Globally, there seems to be a lack of scientific research on transport infrastructure impact as a spatial development factor for cross border regions.

This paper broaches a process of spatial regression analysis, starting to build up a model to be applied to the entire Portugal/Spain cross-border region that is able to quantify this impact. In fact, the spatial nature of this impact suggests that the use of regression techniques can include the space factor, which is particularly important in the analysis of cross-border territories. Spatial regression analysis (SRA) is included in the larger field of spatial econometrics (SE), using space as an explicative factor in models built to explain economic phenomena. For this research, the selected methods refer to the spatial regression analysis (SRA) (Florax and Nijkamp, 2004; Arbia, 2006; Bailey and Gatrell, 1995).

The selected area for the first approach described in this paper is limited to the application of spatial regression techniques (only 15 units) and does not consider Spanish data. Therefore and for now we will focus only on the application of classical regression.Finally, we hope this research approach will contribute quite significantly to the scientific information available about the important connection between transport infrastructure and development in cross-border regions. As currently seen by the European Commission these regions represent strategic factors for the future strengthening of European integration, since cooperation is now one of the three main European Union objectives.

3 STUDY AREA, DATA AND METHODOLOGY

At this stage we selected a group of 15 Portuguese cross-border municipalities (Figure 1) and evaluated the above relationship, considering these municipalities' accessibility connections within the Portuguese territory, using a classical regression analysis. In future stages we will include data from both sides of the border, always taking the municipality as the unit.

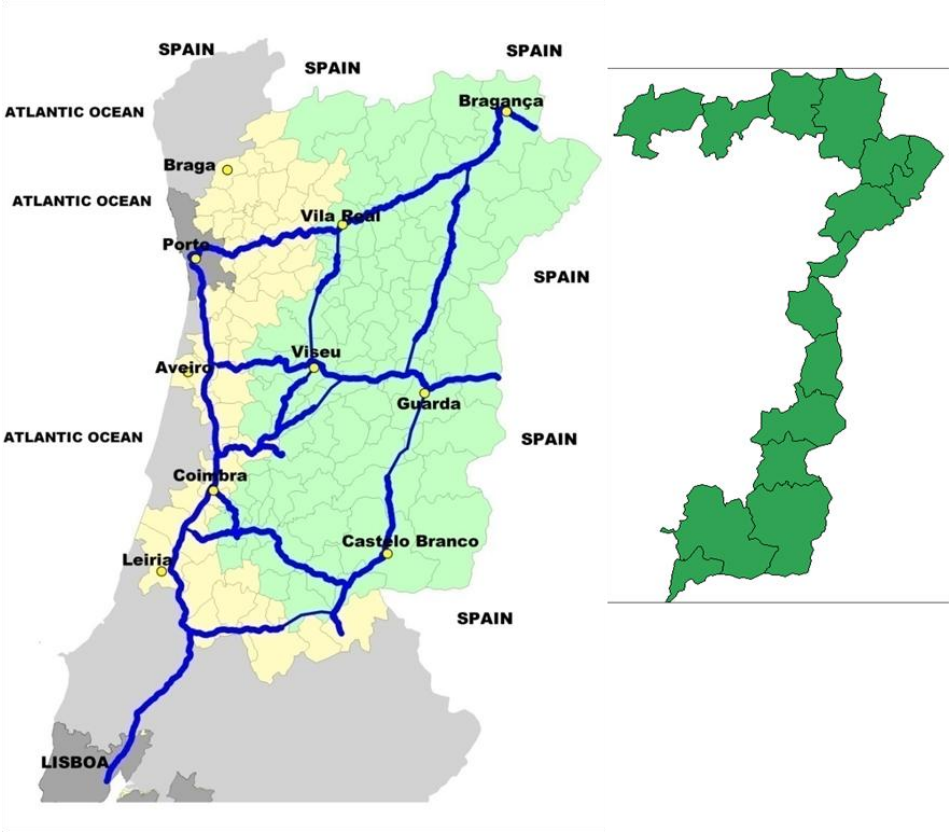

Figure 1 The selected 15 Portuguese municipalities

Two sets of variables are needed for the regression: those that could reflect development and those that could induce development. The variables that could reflect spatial development are socio-economic, (e.g. population variation, if taken as a good proxy for product data[1]). The variables that could induce development (or not) include population literacy and/or accessibility levels; the latter potentially inducing development and closer to transport infrastructure investment. The socio-economic variables (population literacy) will be collected from current Census data and/or correlated databases[2]. Some of the accessibility variables consider not only these socioeconomic variables, but also the time/distance calculated from digitalized transport networks[3]. These transport networks are those appropriate to serve the spatial structure formed by the spatial units selected.

Then we repeated the process but added information on access connections with Spain for those 15 municipalities. For this a new variable was included to add a specific classification to each of the 15 municipalities, according to the number and type of its connections with the Spanish side of the border. Table 1 describes the number and type of all those connections. It also shows a classification we imposed on each type of connection, i.e., from Motorway (T=7) – on the left, to Railway[4] (T=1) – on the right.

[1] There is no reliable information on product at municipality level.
[2] Of interest is the Census Data Collection expected within Portuguese territory for 2011, which means an excellent opportunity to enhance the accuracy of our results.
[3] Potential accessibility of a municipality is the total activity (population, product) reachable within a certain time distance from that municipality to the others that are part of a certain study area.
[4] Although a railway is not a road access it still exists and *adds* real connection between on opposite sides of the border.

Table 1 Number and type of cross-border connections of each municipality

Municipalities (from North to South)	Motorway (T=7)	International Road (T=6)	Interregional Road (T=5)	Surfaced Road (T=4)	Unsurfaced Road (T=3)	Road Subject to Restrictions (T=2)	Railway (T=1)
Montalegre				**3**			
Chaves		**1**					
Vinhais				**1**			
Bragança		**1**	**1**	**1**			
Vimioso				**1**			
Miranda do Douro			**1**	**2**	**1**		
Mogadouro			**1**				
Freixo de Espada à Cinta				**1**			
Figueira de Castelo Rodrigo			**1**				
Almeida	**1**			**1**			**1**
Sabugal							
Penamacor			**1**				
Idanha-a-Nova			**1**	**2**			
Castelo Branco							
Vila Velha de Rodão						**1**	

Using all these data a new variable might then be built, arranging the municipalities in order of their importance in terms of the number and type of cross-border connections with Spain, as in Equation 1:

$$\text{Connection 2010}_i = (\text{nº of Motorways}_i * 7) + (\ldots) + (\text{nº of Railways}_i * 1) \quad (1)$$

This variable, called *Connection 2010*, led to the following classification (Table 2):

Table 2 Municipalities in *Connection 2010* order

Municipalities	Connection 2010 (classification)
Sabugal	**0**
Castelo Branco	**0**
Vila Velha de Rodão	**2**
Vinhais	**4**
Vimioso	**4**
Freixo de Espada à Cinta	**4**
Mogadouro	**5**
Figueira de Castelo Rodrigo	**5**
Penamacor	**5**
Chaves	**6**
Montalegre	**12**
Almeida	**12**

Idanha-a-Nova	**13**
Bragança	**15**
Miranda do Douro	**16**

This variable represents 'actual' connections and a special note must be made on that. How can we compare present connections with population evolution between 1991 and 2010. The answer relies on the fact that all the new connections are part of a National Road Plan known since 1985 and therefore able to produce changes associated with the expectations of the local development it generates.

There will be two more stages in the near future, as mentioned earlier: the first of these will aggregate the data of the Spanish municipalities directly connected to the other side of the border, right next to the Portuguese municipalities, and the second will extend this work to all municipalities located in both sides along the entire Portugal/Spain border. The work will thus be completed in four stages.

4 DATA ANALISYS

Within the framework of regression analysis and using all data selected for the Portuguese cross-border municipalities under analysis, the modeled relations (between the variables that reflect development and the ones with the potential to induce development) will hopefully add scientific weight to knowledge on significant spatial development tendencies for the region. Accessibility variables enter in the regression as independent ones, therefore as variables potentially able to induce development.

So, for this set of municipalities two different regression analyses were considered.

a) One assuming a relationship in which *nothing* exists beyond the border:

$$Population_{1991\text{-}2001} = f\,(Acessibility_{1991\text{-}2001};\ School\ Background_{1991}) \quad (2)$$

Where: $Population_{1991\text{-}2001}$ and $Acessibility_{1991\text{-}2001}$ respectively represent population variation and the variation of potential accessibility between 1991 and 2001; and the $School\ Background_{1991}$ represents the highest education level achieved by the population in 1991. In a) the following results were obtained (Table 3):

Table 3 Relationship in which *nothing* exists beyond the border

Variable	Coefficient	Std. Error	t-Statistic	Probability
CONSTANT	**-22.482880**	**2.001134**	**11.235070**	**0.000000**
School Background$_{1991}$	**06.023493**	**0.848747**	**07.096922**	**0.000013**
Acessibility$_{1991\text{-}2001}$	**-00.179037**	**0.083831**	**02.135682**	**0.054005**

$R^2 = 0{,}81$

Table 3 shows that when high education level increase 1%, population increases too by around 6.02%; but when potential accessibility level increases 1%, the population decreases 0.18%. Which means that besides the fact that all variables are significant, population with higher education in 1991 seems to have more impact on population increase than variations in potential accessibility between 1991 and 2001. Of course a figure of 0.18% is too low, but even so it has a negative sign which it is not a good prognosis for this group of municipalities. In addition, taking into account its socio-economic characteristics, this result was expected: if the territory does not have enough infrastructures to ensure welfare the population will try to leave the territory as soon as appears accessibility increases and/or improves.

b) Another adding data concerning the above mentioned cross-border connections:

$Population_{1991\text{-}2001} = f\ (Acessibility_{1991\text{-}2001};\ School\ Background_{1991};\ Connection_{2010})$ (3)

Where the new variable, $Connection_{2010}$ represents the importance of cross-border connections with Spain, in 2010, as mentioned in Table 2. In b) the following results were obtained (Table 4):

Table 4 Relationship including cross-border connections

Variable	Coefficient	Std. Error	t-Statistic	Probability
CONSTANT	**-21.226460**	**2.224796**	**-9.540857**	**0.000001**
School Background$_{1991}$	**06.337008**	**0.873064**	**7.258352**	**0.000016**
Acessibility$_{1991\text{-}2001}$	**-00.208267**	**0.085814**	**-2.426962**	**0.033590**
Connection$_{2010}$	**-00.251796**	**0.209189**	**-1.203675**	**0.253979**

$R^2 = 0{,}84$

The results from Table 4 are similar to the previous case. But, besides the fact that the new variable ($Connection_{2010}$) is not significant, we may add to the general conclusion that when the cross-border connections are improved by 1%, the population decreases 0.25%. Anyway, we can again see that enhanced accessibility within the Portuguese territory and more cross-border connections will combine to contribute to a decrease of population.

5 CONCLUSIONS

This work's main objective is to build a model able to measure the relation between accessibility and development for all the municipalities in the Portugal/Spain cross-border area. This scientific opportunity stems from the observation of huge road infrastructure investment, often indicated as being little in line with the local development needs in

peripheral regions that are currently facing sharp population decline and weak business dynamics.

At the same time, and since this subject is of so much importance, it is surprising that very few studies have focused on quantitatively measuring the complex relationship between accessibility and development.

This study has selected the particular case of cross-border regions, since these are usually the most depressed areas in both countries. It will be developed in four main stages and this paper deals with the first two:

First we selected a group of 15 cross-border municipalities and through a classical regression analysis we evaluated the above relationship, considering only these municipalities' access connections within Portugal. Then we repeated the process but added information concerning access connections with Spain for those 15 municipalities.

In the third stage we intend to aggregate data on the Spanish municipalities directly connected to the other side of the border, next to the Portuguese municipalities. In a fourth stage this work will be extended to all municipalities on both sides of the entire Portugal/Spain border.

The results from both the first and the second stages suggest that increased accessibility within the country and good connections with Spain, respectively, are less relevant for local development than school background, or are insignificant. Moreover, an increase in national potential accessibility or in connection seems to have a negative influence on population increase.

These results show that locally, and particularly for cross-border municipalities, accessibility seems to be an irrelevant factor in development. The third and fourth stages of this analysis (see above) will help to consolidate the conclusions that have been drawn in this paper as the launching pad for this important analysis.

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