

Cross-border accessibility and local development in Portugal and Spain

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Abstract

One of the EU major concerns is cohesion and cross-border regional development. Usually cross-border regions are less dynamic, acting as bottlenecks mainly in peripheral territories. This paper is focused on the Portuguese-Spanish border using socio-economic and accessibility data. It considers Spatial Econometrics to produce statistical evidence on the relationship between accessibility and development at a local scale. A pilot study is conducted on North and Center region using variables such as population age, graduation characteristics, migrations, unemployment and daily accessibility to main towns. In the future this evaluation will be applied to the entire cross-border area between Portugal and Spain.

Keywords: cross-border regions; accessibility and development; spatial analysis; spatial autocorrelation

AMS Classification: C31, O18, R58

Accesibilidad transfronteriza y desarrollo local en Portugal y España

Resumen

Una de las preocupaciones más importantes de la UE, es la cohesión y el desarrollo transfronterizo regional. Por regla general, las regiones transfronterizas son menos dinámicas, actuando como cuellos de botella, sobretodo en territorios periféricos. Este trabajo se centra en la frontera entre Portugal y España utilizando datos socio-económicos y de accesibilidad. Se utilizan técnicas de econometría espacial para producir datos estadísticos sobre la relación entre la accesibilidad y el desarrollo a escala local. Se llevó a cabo un estudio piloto en la región Norte y Centro utilizando variables como la edad de la población, las características de graduación, las migraciones, el desempleo y el acceso diario a las ciudades principales. En el futuro esta evaluación se aplicará a toda la zona transfronteriza entre Portugal y España.

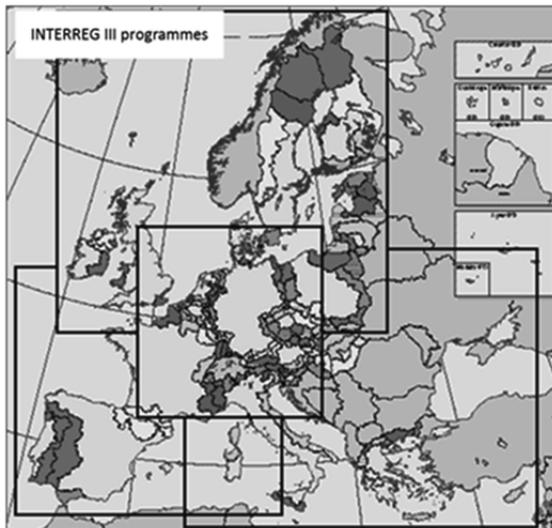
Palabras clave: Regiones fronterizas; accesibilidad y desarrollo; análisis espacial, autocorrelación espacial

Clasificación AMS: C31, O18, R58

1. Introduction

The implementation of the main road transport infrastructures in Europe is based on the EU Trans-European Transport Networks (TEN-T). As mentioned in the EU site for Transport and Mobility, transport infrastructure is essential for several reasons: the smooth operation of the internal market, the mobility of persons and goods, and the economic, social and territorial cohesion of the EU. The implementation of this infrastructure in Portugal followed the European guidelines, and some regional development improvements were not as expected, namely in those regions close to Spain and traditionally less developed. This development did not happen with the expected magnitude and extension, and those regions had been losing competitiveness and population. In border areas between Portugal and Spain, a new (road) infrastructure was built in the last decades, changing completely the accessibility panorama, but the development variables seem to get worst in most of the cross border regions. Some road links are still missing, but some already exist and are not having the expected development impact. Specific programs like INTERREG are focused on solving development issues in border areas. In Figure 1 it is possible to see the above mentioned cross-border area between Portugal and Spain. This is one of the key areas in the European Union that needs specific policies, in general materialized in cooperation projects between both countries. So that in future the development of these regions can be promoted, it is essential to realize how the investment in transport infrastructure may help these regions.

Figure 1

INTERREG III main action areas

Therefore, accessibility is a concept related with transport and communications that may have a facilitating role and act as catalyst for development. The main objective in this work is to understand road infrastructure's impact in the development, through the effects of accessibility on cross-border areas between Portugal and Spain, using spatial analysis methods, such as autocorrelation studies and spatial regression. Therefore, this initial exploratory study uses some accessibility variables and some variables that might reflect development and explores its tendency for autocorrelation. This step it is essential to analyse, at a municipal level, the spatial behaviour with statistical significance of relevant variables, including accessibility.

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. Rietveld and

Bruinsma (1998) and Banister and 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 works of Vickerman (1995), Button (1995), Forslund and Johansson (1995) and Gutiérrez and Urbano (1996). More recently, Lopez et al (2008) related to important new European transport infrastructures consolidating the concept of «potential accessibility». However, the calculation of accessibility is not enough to measure the way it acts as a development factor. Páez (2004) makes some important advances by using the same type of accessibility indicators as variables in a spatial regression analysis framework, supported by the spatial econometrics work of Anselin (1988). Besides Paez (2004), the work of Anselin (1988) has inspired great number of contributions since the beginning of the millennium, e.g. Mur et al (2009). The same methodology is now used in recent Portuguese work (Ribeiro, 2009).

The number of kilometres 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 accessibility achieved by the new roads has affected population growth at municipality level (Ribeiro et al, 2010).

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 databases contain 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, some articles have examined the same type of issues: Silva (2005) and Cavaleiro et al (2009). But again, these important studies have considered the availability of transport infrastructure as a factor for development and do not analyse the significance of that potential impact and its local differences. Globally, there seems to be a lack of scientific research on transport infrastructure impact as a spatial development factor for cross-border regions.

3. Methodology

3.1 Case study

The analysis proposed in this study represents a first step on the spatial regression for evaluating the relation between accessibility and development. This step it is essential to analyse, at a municipal level, the spatial behaviour with statistical significance of relevant variables, including accessibility. The municipality level is fundamental in order to evaluate the regional development differences at a local scale within the cross border area, which is not possible at a higher level such as NUTIII. A central constraint in this study is the fact that it is difficult to compare municipalities from Portugal and Spain (Spanish municipalities are much smaller than Portuguese municipalities and census data from each country do not always match). Therefore the first important step already developed is the construction of a Cross-Border Data Base, with comparable geographical units. The geographical area of analysis of this work is formed by NUTIII of Portugal and Spain, which are identified as areas for action in the INTERREG program: eighteen NUT III from Portugal and seven NUT III from Spain (Figure 2).

Figure 2

Study area



This cross border map is entailing some of the ongoing projects which are divided into zones. The zones are: Norte/Galicia, Centro/Castilla y Leon, Alentejo/Extremadura, and Algarve/Andalucia, and can imply more than one of these regions each time.

As mentioned, for the local level, it is important to have the same type of geographical units in both sides of the border, forming the cross-border region under analysis. The geographical unit of analysis is primarily the municipality. But since municipalities have different sizes within each country and between countries (Figure 3) some

aggregations of municipalities are being performed. These aggregations are done using the “Comarcas” criteria for aggregation in the Spanish side.

Figure 3

Differentiation between Portuguese and Spanish municipalities



Using this scale as the starting point for analysis, a new database with the municipalities must be built, using Geographic Information Systems (GIS).

Therefore, this data base will have a geographical expression and can be coordinated with programs such as GeoDa, to perform spatial analysis. This is the case of this study, using GeoDa for autocorrelation studies, and further on for regression analysis.

Based on variables needed for the ongoing analysis and available at the municipal level, new geographic areas on both sides of the border were built, comparable in size and characteristics, easily related to the road network.

Table 1 presents the correspondence between NUT III and NUT II between both countries on the cross border area selected.

Table 1

NUT II and NUT III in the cross-border between Portugal and Spain

Portugal		Spain	
NUTII	NUTIII	NUTIII	NUTII
Norte	Minho Lima		Galicia
	Cávado	Pontevedra	
	Alto Trás os Montes	Ourense	
	Douro		
Centro	Beira Interior Norte	Zamora	Castilla y León
	Beira Interior Sul	Salamanca	
Alentejo	Alto Alentejo	Cáceres	Extremadura
	Alentejo Central	Badajoz	
	Baixo Alentejo		
Algarve	Algarve	Huelva	Andalucia

This way, we obtained an expected database of 183 Portuguese municipalities plus 63 Spanish comarcas, a total of 246 units.

3.2 Data Collection

The first phase of this study, data collection, was of great importance. Thus, for both Portugal and Spain, the necessary variables were obtained from the National Statistical Offices of both countries. The study considered data from 1991, 2001 and 2011, in terms of population census. In addition, data on road maps, for the calculation of accessibility variables, were also collected in both countries (Spain through Centro Nacional de Información Geográfica - www.cnig.es, and Portugal through Instituto de Infra-Estruturas Rodoviárias IP – www.inir.pt).

As previously stated, the analysis proposed in this study represents a first step on the spatial regression for evaluating the relation between accessibility and development. This step is called autocorrelation study or exploratory analysis, and is essential to identify, at a municipal level, the spatial behaviour of relevant variables, including accessibility.

For this set of 246 Cross-Border geographical units, 46 variables were choose and submitted to several filters in order to avoid future problems.

Taken from the initial 46 variables, a group of nine variables was finally used for the exploratory analysis. These studies are related with the evaluation of spatial autocorrelation for each variable.

The accessibility variables considered, for each municipality/comarca are:

1. Relative accessibility (time by road) at the National level (NUTI): ARIL, ARIM - meaning, respectively, relative accessibility (time) to Lisbon and Madrid.

2. Relative accessibility at the regional level (NUTII): ARIIa, ARIIb - meaning, respectively, relative accessibility (time) to the regional capital (a) and to the closest (by road) regional capital of the neighbour country (b).
3. Relative accessibility at the sub-regional level (NUTIII): ARIIIa, ARIIIb - meaning respectively, relative accessibility (time) to the sub-regional capital (a) and to the closest (by road) sub-regional capital of the neighbour country (b).

These accessibility variables were measured using time distances by road. Besides these six variables, another three variables were also tested for autocorrelation, since they will be used in regression analysis as dependent variables.

1. VPOP9111 – Population variation between 1991 and 2011.
2. VIE9101 – Ageing index variation between 1991 and 2001
3. VTXD9101 – Unemployment rate variation rate between 1991 and 2001 (there is no data for 2011 yet).

This group of nine variables will be considered for the autocorrelation studies described in the next section. From the initial group of 246 geographical units some of them were choose as the map of this pilot study area includes only the Centre and the North (South is out for now), (Figure 4).

Figure 4

Areas under analysis



3.3 Methods

Autocorrelation analysis for the selected variables in the area of interest is fundamental for a better understanding of further spatial regression studies results. This Section focuses on the macro-region defined above, trying to identify the spatial structure corresponding for the three variables that will be used as dependents, and for the six accessibility indices.

Autocorrelation analysis

There are two types of autocorrelation: global autocorrelation (degree of autocorrelation of a variable, considering all the territory under study) and local autocorrelation (autocorrelation of a variable for each local unit). In case of global autocorrelation the most widely index in use is the Moran I. Graphically, the global Moran's I indicates the slope of the regression line when a variable is correlated with an average of the values at its neighbours (spatial lag) – that is, with the average score for this variable in neighbouring territorial units from a territorial structure defined at the outset (neighbourhood structure). Four different types of clusters may appear when we move to the second category of local indicators of spatial autocorrelation. They are known as:

High - High - Units with high values of the variable combined with high values for neighbouring units.

Low - Low - Units with low values of the variable combined with low values for neighbouring units

Low - High - Units with low values of the variable combined with high values for neighbouring units

High - Low - Units with high values of the variable combined with low values for neighbouring units.

4. Results and Discussion

4.1 Autocorrelation for accessibility indices

The autocorrelation exploratory analysis, in this case the Local Indexes for Spatial Analysis (LISA) maps and correspondent significance maps, were performed for various accessibility indices. The relation between the municipalities with each NUTII, and the capitals of the corresponding NUTI, II and III units are shown.

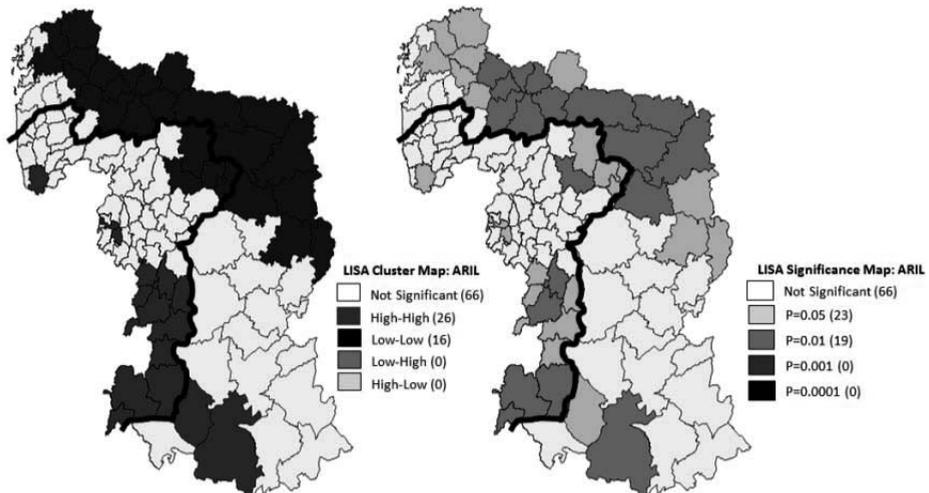
Table 2

Relations between the municipalities/comarcas with each NUT

Country	NUTIII	ARI	ARIIa	ARIIf	ARIIIa	ARIIIb
E	Pontevedra	L/M	Santiago de Compostela	Porto	Vigo	Viana do Castelo
E	Ourense	L/M	Santiago de Compostela	Porto	Ourense	Vila Real
E	Zamora	L/M	Valladolid	Porto	Zamora	Bragança
E	Salamanca	L/M	Valladolid	Coimbra	Salamanca	Guarda
E	Cáceres	L/M	Merida	Coimbra	Caceres	Castelo Branco
P	Minho Lima	L/M	Porto	Santiago de Compostela	Viana do Castelo	Vigo
P	Cavado	L/M	Porto	Santiago de Compostela	Braga	Vigo
P	Alto T. os Montes	Lx/M	Porto	Santiago de Compostela	Bragança	Zamora
P	Douro	L/M	Porto	Santiago de Compostela	Vila Real	Ourense
P	Beira I. Norte	L/M	Coimbra	Valladolid	Guarda	Salamanca
P	Beira I. Sul	L/M	Coimbra	Valladolid	Castelo Branco	Caceres

The first case (Figure 5) is the relative accessibility to both capitals, Lisbon and Madrid (ARIL and ARIM, respectively).

Figure 5

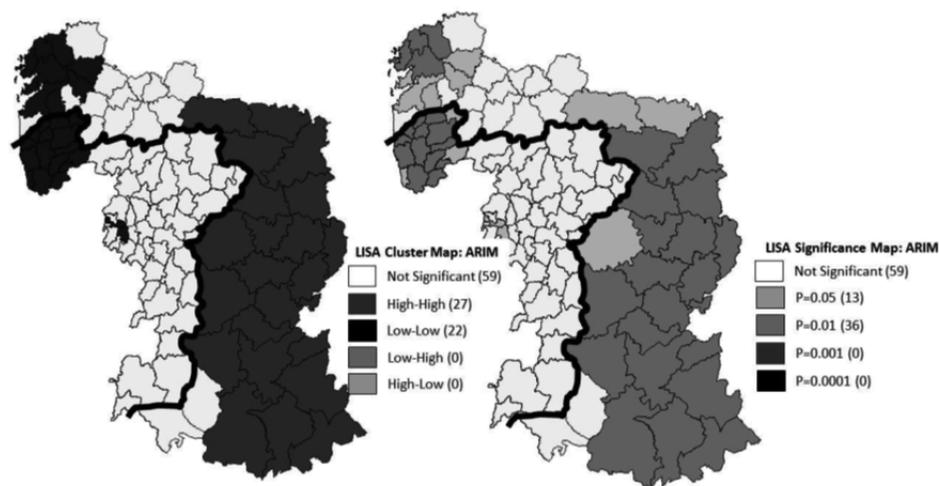
Lisa and significance maps for relative accessibility to capital of NUT I – Portugal (Lisbon)

In the case of time-distance of all municipalities to the city of Lisbon, it is possible to observe that the border effect is not very important especially for the two clusters, high-high and low-low. In fact the existence of good connection with Lisbon, influences positively a group of municipalities from both sides of the border, near Castelo Branco and Cáceres. This connection has the opposite effect for a group of cross-border municipalities, up in the North because of the bad connection North-South directly in the direction of Lisbon (note that ‘high’ means a bigger time-distance and therefore less accessibility). Among the highlighted spatial units, it is clear that some municipalities have a higher level of significance. Taking this significance level into account, the cross-border effect appears clearly significant.

Considering the time-distance of all municipalities to Madrid (Figure 6), the border effect also appears very clear on the cross border Portugal-Spain.

Figure 6

Lisa and significance maps for relative accessibility to capital of NUT I – Spain (Madrid)

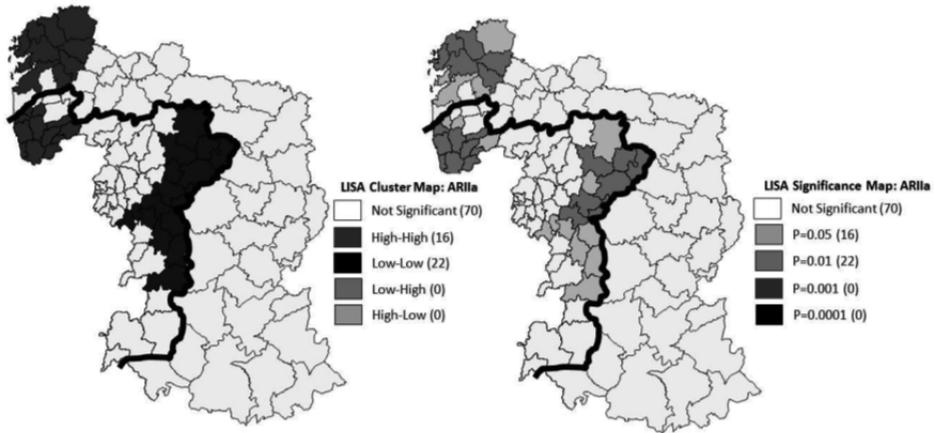


The Spanish municipalities are better connected with Lisbon than the Portuguese municipalities are with Madrid. Of course distances are different, and that implies that on further research this should be taken into account. Besides that the cross-border bottleneck on the Raia area is evident and it has statistical significance.

Considering the accessibility to the ‘own capital at a regional scale’ (ARI_{IIa}), (Figure 7), which means the time-distance from each municipality to its regional capital within its own country, it is interesting to observe that the ones ‘best connected’, form a ‘high-high’ cluster in Minho-Galicia and in terms of ‘low-low’ we have the north-east zone of Portugal. The remaining area is not significant.

Figure 7

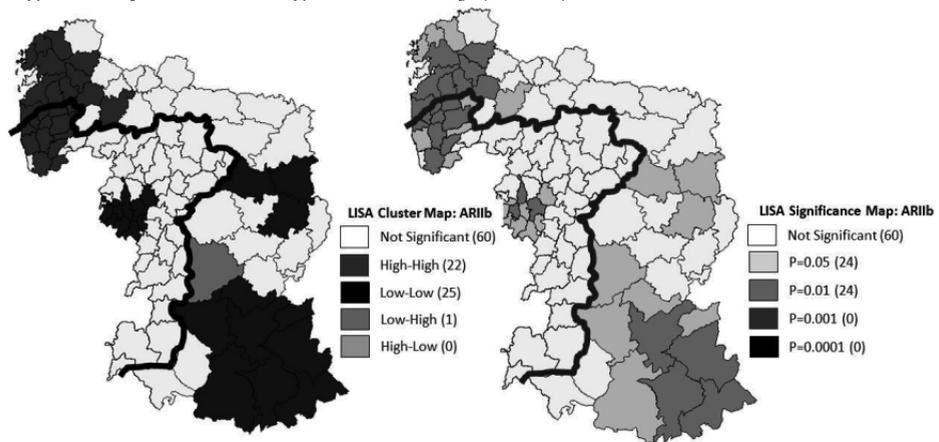
Lisa and significance maps for relative accessibility to the regional capital of NUTII (ARIIa)



When we consider for each municipality the distance to the closest Portuguese/Spanish neighbour (Figure 8), other interesting observations emerge (please note that the neighbourhood is the municipality/comarca in the foreign country that it is closer to each comarca/municipality).

Figure 8

Lisa and significance maps for relative accessibility to the closest (by road) regional capital of the neighbour country (ARIIb)

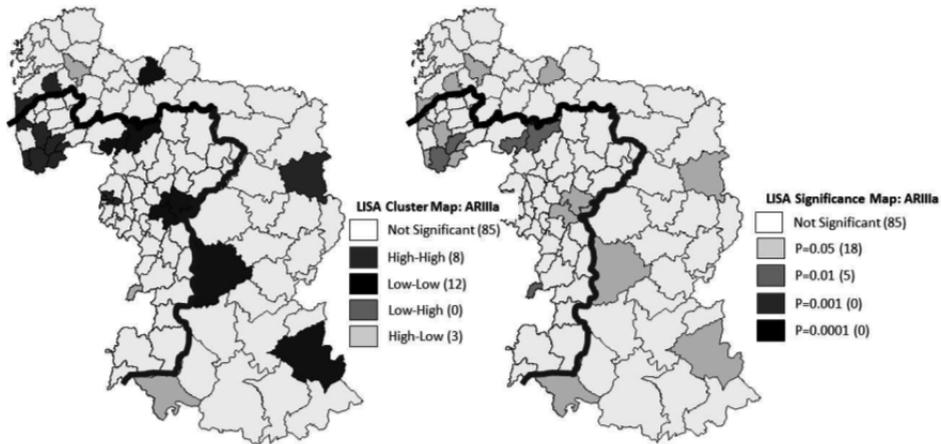


Again, the cross-border region Minho-Galicia is well connected, and several areas in Spain are badly connected with Portugal. However, a group of small municipalities in Portugal, near Serra da Estrela also formed a cluster badly connected with Spain.

Considering the accessibility to the ‘own sub-regional capital’ (ARIIIa), (Figure 9), which means the time distance from each municipality to its sub-regional capital within its own country, it is interesting to observe that now smaller clusters appear, both well/bad connected with its own sub-regional capital.

Figure 9

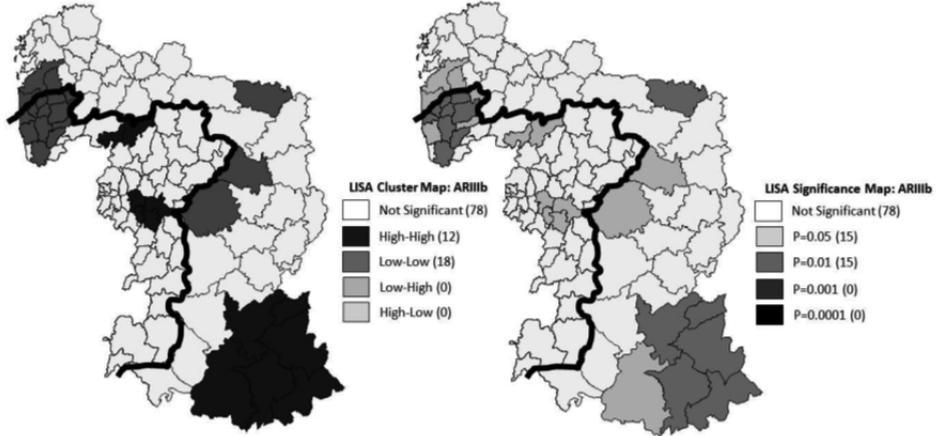
Lisa and significance maps for relative accessibility to the sub-regional capital of NUTIII (ARIIIa)



When we take for each municipality the distance to the Portuguese/Spanish sub-regional neighbour (Figure 10) the clusters are not dispersed over space and tend to create aggregated areas with good/bad connections with its neighbours.

Figure 10

Lisa and significance maps for relative accessibility to the closest (by road) sub-regional capital of the neighbour country (ARIIIb)



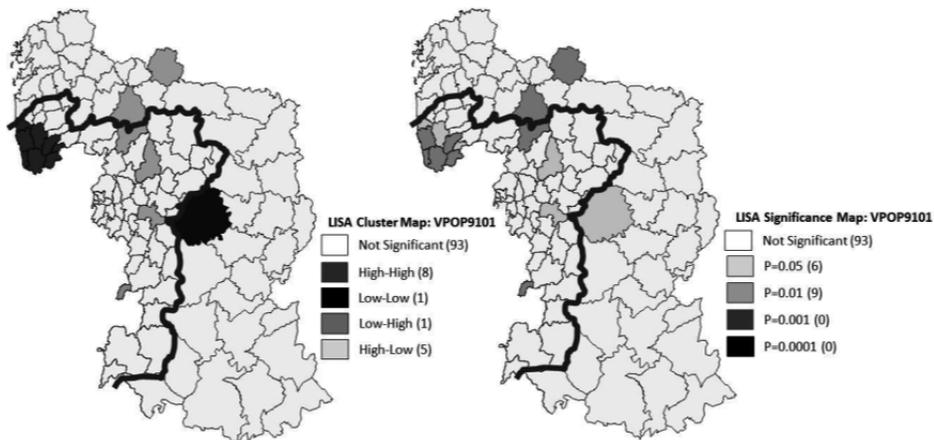
However, it is possible to observe, again, the good connections in the transborder area Minho-Galizia.

4.2 Autocorrelation for development variables

It is rather curious to verify that there is no significant tendency for population to form either a high or a low cluster. Exception made of the high-high group in the region of Braga (on the Portuguese side), and a group of low-low near Vilar Formoso (but on the Spanish side), (Figure 11).

Figure 11

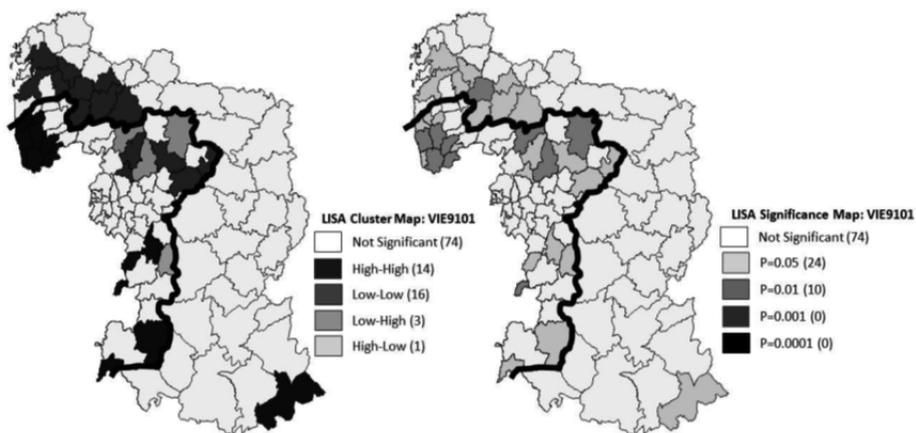
VPOP9101



In the case of the ageing index, in most of the municipalities in the Spanish side there is no significant evolution in spatial terms, exception for a cluster located in the North of the region, between Orense and Vigo (Figure 12).

Figure 12

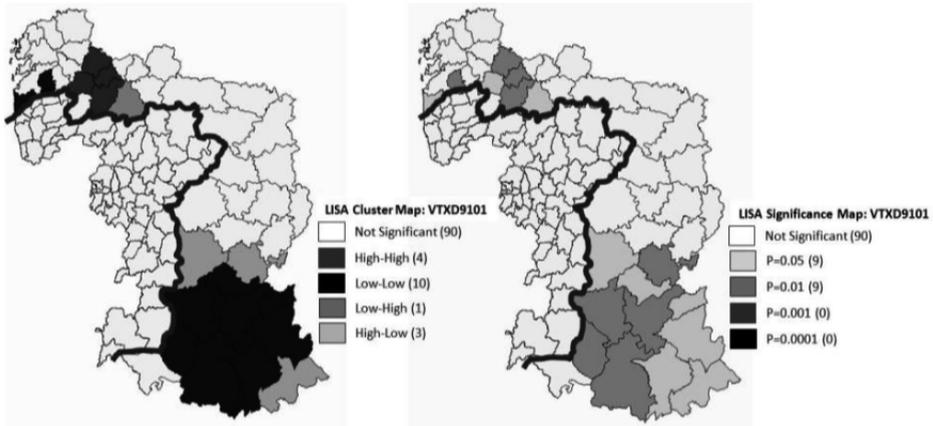
VIE9101



The unemployment rate (Figure 13) shows a curious behaviour around a big cluster of the high-high type, partly coincident with the ageing index (as somehow expected).

Figure 13

VTXD9101



5. Conclusions

This study constitutes a first step on a broader spatial regression analysis for evaluating the relation between accessibility and development. Therefore, we first concentrate on six accessibility indices and three other variables that might reflect economic development. Their spatial structure is the purpose of this paper. The analysis carried out indicates that there exist significant regional differences in the relation between transports and development. In fact, the identification of specific spatial autocorrelation features for each variable will be quite helpful in the following spatial regression analysis that must extend this research.

To accomplish our first objective, a pilot area was chosen, with six accessibility indices, and three variables reflecting economic development. The analysis shows very interesting results. In fact, for the accessibility variables it is possible to identify better and worst connection clusters, both inside the country and with the neighbours from the other country. Therefore, next step will be, through regression analysis, the identification of the differences in the relations between accessibility and development, across the border area. This has obvious interest for the development of future investments projects on road infrastructures that can help to promote connection between the two countries in the places needed, and therefore improving cohesion.

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