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Accessibility and Industrial Location. Some Evidence from Spain*

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Abstract

During the 1990s an intense programme of high capacity road construction was carried out in the Spanish road network. This considerably improved accessibility to municipalities. The aim of this paper is to determine whether this greater accessibility has had positive effects on the creation of industrial establishments. We analyze the location decisions of firms at a municipality level and in 2-digit manufacturing industries (11 industries). The main contributions of this paper are the variables and econometric techniques we use. As well as the usual variables, such as specialization or the diversification of the labour force, we use more innovative variables such as local added value, road accessibility, and the characteristics of firms in neighbouring municipalities. Our econometric techniques are space models with discrete dependent variables.

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1. Introduction

Traditionally, the location of economic activity has received little interest from scholars. This lack of interest is not due to certain characteristics of the subject but to fact that authors have preferred to analyse the temporal dimension of economics rather than the spatial dimension. Since the 1990s, however, several interesting papers on the interaction between space and economy have been published. Some of these are in the field of New Economic Geography (Fujita et al., 1999). Others are in the field of Spatial Econometrics (Anselin, 1988). By taking space into account, these studies have been better able to analyze spatial interactions in econometric models.

This paper analyzes the territorial effects of extending the highway network. Specifically, we analyze how improvements in accessibility designed for the *Plan General de Infraestructuras* (General Infrastructure Plan (GIP)) of 1984-1991 have affected the location of manufacturing establishments in Spain.

This paper is organised as follows. In section 2 we review the literature on industrial location and road accessibility, discuss the teritorial unit used in the analysis and the econometric methods used. In section 3 we present our preliminary results on the effects of improvements in road accessibility on firm location. In section 4 we provide our data and econometric specification and in section 5 we provide a short conclusion. Section 5 is followed by appendices.

2. Determinants of the Location of Manufacturing Establishments

In this section we first review the most important recent contributions on accessibility and industrial location. We then discuss the territorial units we used (municipalities) and explain the econometric methodology. Finally, we show the locational determinants that will be tested.

2.1 Review of the literature

The consequences of the General Infrastructure Plan (1984–1991), which brought about a considerable improvement in the Spanish road system, are analogous to a decrease in transport costs, since the accessibility of many municipalities to the highway network increased. In this paper we measure accessibility as the amount of time (in minutes) needed to access the highway network (HN) from each municipality. However, we recognise that other accessibility measures may produce different results.

We assume it is logical to consider that a municipality that is better connected to the HN is more attractive for the location of new firms and for the endogenous growth of local firms. Based on this assumption, several contributions have discussed the effects of these road infrastructures (García-Milà and McGuire, 1992; Carlino and Mills, 1987; Carlino and Voith, 1992) or the effect of all infrastructure (Aschauer, 1989) on job creation or production, since improvements in infrastructure can improve the productivity levels of the private sector that uses them. Also, since the services made available by infrastructures linked to their geographical position, the territories in which the infrastructures are located will enjoy several comparative advantages. Some contributions, however, show that the consequences of improved accessibility are not the same for all industries and that it is necessary to analyse the specific characteristics and specific location requirements of each industry (Chandra and Thompson, 2000). It is possible, therefore, that spillovers generated by HN will be both positive and negative (Boarnet, 1998).

Besides these industry-specific components, we should point out that, although theoretical contributions emphasize the role of investment in infrastructure on economic growth, the empirical evidence, based on the characteristics of the territorial areas analyzed, provides contradictory results. Less favourable effects are observed, for example, in the non-metropolitan areas—mainly for transport infrastructure such as HN. Specifically, a better HN may drive firms out to the (now) nearer metropolitan areas as a result of the lower transportation costs. Unfortunately, the effects of improved HN on firm relocation has been paid little attention in the literature (Boarnet, 1998).

Another way to analyze the impact of these infrastructures is from an agglomeration economies point of view. The existence of agglomeration economies has traditionally been considered an important locational determinant, but at the same time improvements in HN can erode these agglomeration economies (Haughwout, 1999). For example, these improvements make it easier to move merchandise and people between the centre and the periphery, making it less necessary to locate in the centre and decreasing the positive effects of the agglomeration.

With regard to the industrial aspects, we can assume that different industries have different requirements in terms of transportation demand heavy inputs and outputs. This explain why proximity to HN will not be the same for all industries (also note that closer proximity implies higher land prices). In any case, as well as considering the positive effects incurred by being closer to the HN, these positive effects need to be clarified especially if transportation costs fall and non-material flows rise (Holl, 2004a). Because of such considerations, some scholars nowadays doubt whether transportation costs can be considered a locational factor. This is a very different position from that of mainstream economics since Weber's work (1929).

In this context, Holl (2004b) shows that the construction of the HN in Portugal (1986-1997) has modified the spatial distribution of firm location, since municipalities whose accessibility to the HN has improved have become more attractive to new firms. This process has led to a deconcentration of economic activity as peripheral municipalities have increased their accessibility and more new firms have located there.

There is also empirical evidence for Spain on the impact of HN on the location decision of firms (Holl, 2004a)[1]. The main results agree with those of other countries: municipalities located near the HN increase their locational attractiveness in comparison with other municipalities and this effect differs according to the manufacturing industry.

[1] Also from a territorial point of view, Mas et al. (1996) show the positive effects of infrastructures on the Spanish economy.

The effect of HN improvements can also be analysed by considering the balance between centrifugal and centripetal forces. Summarising the arguments of the previous sections, we can assume that there is a set of centrifugal forces that expel the activity from the centre (higher land prices, demographic pressure, traffic jams, pollution, etc.) and a set of centripetal forces that act in the opposite way (the location of the main infrastructures, the supply of advanced services, the existence of skilled labour, proximity to main markets, etc.). However, improvements in the HN cut travelling time from small municipalities to the larger metropolitan areas. This causes some changes in spatial balance: centrifugal forces gain weight at the same time as centripetal forces lose weight.

Some contributions have analyzed how transportation costs (i.e. accessibility) affect the spatial configuration of economic activity[2]. If we consider two situations, one in which the transportation costs are high and one in which they are low, the spatial configuration of economic activity in these situations is completely different. In the first situation, firms will disseminate their activities in an attempt to locate near their consumers and final markets and thus cut transportation costs[3]. However, in the second situation, firms will prefer to concentrate their activities in few locations from where they will distribute their products to the markets in which they operate. The second situation seems to contradict the rational expectations of improved accessibility, which is usually consistent with a greater dispersion of economic activities.

These arguments have shown that the effect of transportation costs (accessibility) on the spatial distribution of economic activity is neither clear nor obvious, since greater accessibility can lead to opposite effects on firm location. In any case, it is important to conclude that investments in transport infrastructure influence the spatial distribution of economic activity such that some areas benefit (due to a greater capacity to attract firms) and others are

[2] See Fujita et al. (1999) for a review of these contributions.

harmed (due to the expulsion of firms towards those areas whose accessibility has increased) (Haughwout, 1999). If we consider these opposite effects, it is important to determine the net effect for all the areas. This net effect could be analysed from firm relocations within Spain but, unfortunately, existing Spanish data bases do not provide this kind of information.

2.2 Methodology

To study the effects of improvements in accessibility we conducted an exploratory spatial analysis and a confirmatory spatial analysis using municipalities as the territorial unit.

The choice of municipalities as the spatial unit is not trivial. Most authors think that location and spatial effects should be analysed at a local level, so European NUTs II and NUTs III are rejected (Audretsch y Feldman, 1996; Ciccone y Hall, 1996; Viladecans, 2004). Theoretically, we cannot defend the superiority of municipalities over other territorial areas below European NUTs III, such as the Spanish *comarcas* or metropolitan areas. However, since there is no standard classification of Spanish municipalities either in *comarcas* or metropolitan areas, municipalities seem to be the best practical choice.

For the exploratory analysis we studied whether the creation of new manufacturing units follows spatial patterns. To do so we applied Spatial Statistics Techniques and analyzed the period of time over which the General Infrastructure Plan was carried out and the previous one. We are not only interested in the existence of these spatial patterns—we also want to find out whether they have been affected by the improvements in accessibility.

[3] In fact, the spatial distribution of economic activities does not depend only on transportation costs: there is a trade-off between transportation costs and economies of scale, but we will focus our analysis on the first of these.

As well as testing whether accessibility plays a role in location decisions, the target of confirmatory analysis is to test whether local value added and spatial externalities, both inside and outside the municipalities, are relevant factors. To do so we applied spatial econometric techniques.

2.3 Industrial location determinants

Since we focused on the role of accessibility we did not analyse location determinants comprehensively[4]. Location determinants are usually grouped into categories such as supply factors, demand factors and external economies and diseconomies (Guimaraes *et al*, 2004). The location factors we took into consideration were: human capital (supply side), local value added (demand side) and specialization and diversification (externalities sources).

We think, *ceteris paribus,* decision makers prefer locations with a more qualified labour market to locations with a less qualified labour market, even if this implies higher wages. Human capital is therefore positively related to location decisions. Local value added should be also taken into consideration since it reflects both local economic activity and the internal potential market of the municipality. Local specialisation generates Marshallian externalities—economic advantages derived from a local skilled-labour poor, local information spillovers and non-trade local inputs—and related concepts such us location economies (Richardson, 1986)—or, following Glaeser *et al* (1992), MAR external economies (named after Marshall, Arrow and Romer), such as industry specific externalities in non-competitive environments.

Manufacturing diversity, usually linked to large urban agglomerations, produces the so-called urbanization economies (Richardson, 1986) and related concepts such as Jacobs external economies (Glaeser *et al,* 1992). That is, firms in diverse cities benefit from a more competitive environment and other advantages such us non-industry-specific and non-trade local inputs etc. According to Duranton and Puga (2000), not only is the creation of new plants biased towards larger and more diverse cities, but the location of innovative activities that lead to new products is also biased.

Interterritorial externalities are usually restricted to interregional contexts. However, some authors have applied this concept to a less aggregated spatial scale both implicitly, as in Ellison and Glaeser (1997), and explicitly, as in Alañón (2004) and in Alañón and Myro (2005). As tested in Alañón and Myro (2005), interurban agglomeration forces played an important role in the location of manufacturing establishments in Spanish peninsular municipalities over the period 1991-1995. Broadly speaking, these externalities are the interurban effects of the location determinants described above. It is therefore reasonable that decision makers take into consideration not only the internal characteristics of a given location but also the characteristics of its neighbouring area. *Ceteris paribus*, decision makers prefer locations with good accessibility, i.e. ones that are surrounded by municipalities that provide a qualified labour force and public goods and services, are a good market for their products and generate spatial externalities, rather than more isolated locations or locations without such good neighbours.

3. Exploratory analysis of the creation of manufacturing establishments

In this section we conduct an exploratory analysis to test whether the creation of new manufacturing establishments followed a spatial pattern over the period of influence of the General Infrastructure Plan (GIP) and whether this pattern changed due to the greater accessibility derived from the GIP. Since the GIP lasted from 1984 to 1991, we will analyse two periods: 1985–1990 and 1991–1995. As far as improvements in accessibility are concerned, there should be no substantive differences between these periods. Although there were

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[4] For more information about location determinants, see Guimarães *et al* (2000), Figueiredo *et al* (2000) or Guimarães *et al* (2004).

improvements during the second period, decision makers could anticipate the effects of these improvements.

Spatial patters can be detected through the BB Joint Count test for spatial autocorrelation or spatial dependence. The BB Joint Count test shows whether binary variables are clustered or randomly distributed in space. This test is defined as follows[5]:

(1) $$BB = (1/2)\sum_i \sum_j w_{ij} LOC_i LOC_j$$

where w_{ij} is the *i-jth* element of a spatial weights matrix *W* which reflects the potential interaction between the observation pair i and j, *LOC* is set to 1 for municipality i or j if new units of a given manufacturing activity have been created over a period of time, and *LOC* is set to 0 otherwise. A positive and significant z-value for this statistic indicates positive autocorrelation, i.e. similar values, whether high ones or low ones, are more spatially clustered than could be caused purely by chance (Anselin, 1992). Significant and positive z-values therefore show agglomerative behaviour, while significant and negative z-values reflect dispersion or centripetal forces in the creation of new manufacturing establishments.

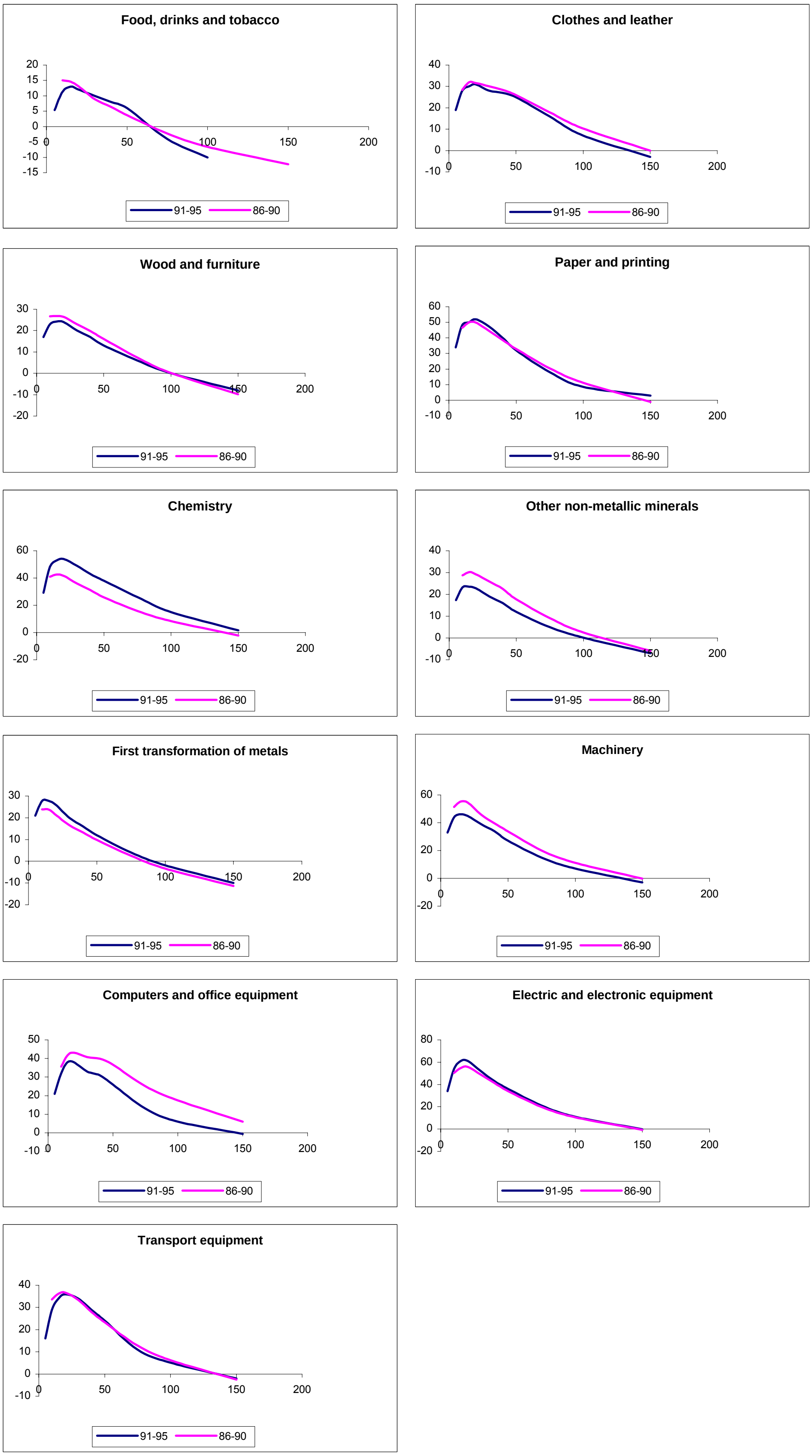
We applied the BB Joint Count test to 11 manufacturing industries. w_{ij}, the *i-jth* elements of spatial weight matrices were set to 1 if the distance between municipality i and municipality j was not far from a given kilometric threshold *k* and to 0 otherwise. The minimum kilometric threshold was set to 5 kilometres and the maximum was set to 15.

The results in figure 3.1 show a significant and positive decreasing spatial pattern for all manufacturing sectors. That means that the creation of establishments of a given industry in every municipality is related to the creation of new establishments in neighbouring municipalities, which may reflect the existence of interurban externalities and should be taken into account in the confirmatory analysis. The BB Joint Count statistics reach their maximum statistical significance at around 20 km. Both Viladecans (2001, 2003 and 2004) and Roshenthal and Strange (2003) obtain similar results using other approaches for Spanish and American municipalities of over 15,000 inhabitants, respectively. Spatial autocorrelation seems to vanish beyond 100 and 150 kilometres for most manufacturing industries.

As we pointed out at the beginning of this section, there are no significant differences in the spatial patterns between the two periods. Decision makers anticipated future improvements in accessibility due to the GIP when choosing the best location for their firms.

[5] For more information, see Anselin (1992) or Cliff and Ord (1980).

Figure 3.1 Test BB Joint Count Statistics



4. Data, model and results

The relationship between improvements in accessibility and firm location must be analysed with extreme caution, since there may be a problem of endogeneity. Usually, investments in the road network are greater in areas with a greater concentration of economic activity and a greater capacity to attract new firms[6]. It is necessary, therefore, to control these non-observable locational characteristics that also influence the extension of the road network and the location of firms. It is therefore also important to analyse whether the construction of new transport infrastructure is an exogenous variable and so not related to previous economic growth in this area. In this context, Chandra and Thompson (2000) show that the location decisions for this infrastructure are endogenous for the larger, metropolitan areas (in fact, construction is motivated by their economic growth and the level of congestion on existing roads), and exogenous for the smaller, non-metropolitan areas. In particular, Chandra and Thompson (2000) show that total income increases in non-metropolitan municipalities that are adjacent to freeways but decreases in non-adjacent municipalities due to activity relocation caused by a preference for greater accessibility to this infrastructure.

4.1 Variables and data

As dependent variable, we use LOC_{ij}, which reflects the creation of manufacturing establishments in municipality i and in manufacturing industry j over the period 1991-1995. As we will show in sections 4.2 and 4.3, LOC_{ij} will account for the number of new manufacturing establishments in Poisson and binomial negative models. However, LOC_{ij} will be set to 1 if at least one establishment of manufacturing industry j has been located in municipality i over the period and to 0 otherwise in spatial Probit lag and error models. The data are taken from Spanish Registry of Industrial Establishments (REI).

[6] See Holl (2004a) for a more extensive discussion on this issue. In any case, the endogeneity problem will occur, basically, if the construction programs of transport infrastructure are intended to improve connection between the larger urban metropolitan areas. The problem will

As independent variables, we use human capital, location quotient, manufacturing diversity, local value added, accessibility indicator and the potential role of interurban agglomeration forces.

The human capital index, CH_i, is defined as the percentage of the population over ten years old with at least a secondary school degree in municipality $_i$ in 1991. The expected sign is positive since it reflects the quality of the labour market. The CH_i data are taken from the 1991 Spanish Population Census (*Censo de Población*).

Cl_{ij} represents the advantages of geographical specialization, traditional location economies, Marshallian externalities or MAR's type. It is defined as a location quotient:

(2) $$Cl_{i,j} = (E_{ij} / E_I)/(E_J / E_T)$$

where E_{ij} represents total employment in manufacturing activity $_j$ in municipality $_i$, E_i represents total employment in municipality $_i$, E_J represents national employment in manufacturing activity $_j$, and E_T represents total national employment in all manufacturing activities. Its sign is expected to be positive. Since higher Cl_{ij} may be caused by a large number of small firms or by a small number of large firms, besides location externalities it may also reflect the effects of concentration or internal returns of scale. Our employment data are taken from the last Spanish Establishments Census (*Censo de Locales* 1990).

DI_i is a manufacturing diversification index for municipality $_i$ and reflects spatial external economies due to diversity: urbanization economies (Richardson, 1986) and Jacobs type (Glaeser *et al*, 1992). This index is based on the correction for differences in sectoral employment shares at the national level of

be smaller if they are intended to improve the accessibility of small municipalities to the road the inverse of a Hirschman-Herfindahl index proposed in Duranton and Puga (2000):

(3) $$Di_i = 1/\sum_j / s_{ij} - s_j /$$

where s_{ij} is the share of manufacturing activity $_j$ in manufacturing employment in municipality $_i$, and s_j is the share of manufacturing activity $_j$ in total national manufacturing employment. The sign is expected to be positive and the statistical source is the 1990Spanish Establishments Census.

Vab_i is the local value added of municipality $_i$ taken from Alañón (2002). Its sign is expected to be positive.

Acc_i is the accessibility indicator for municipality $_i$ and reflects the time needed to access the highway network from municipality $_i$. It is constructed from the Geographical Information Systems[7] and, since better accessibility means less travelling time, its sign is expected to be negative.

Finally, we considered the potential role of interurban agglomeration forces $Fai_{i.}$ As we show in the next section it can be measured by both the spatially lagged independent variables in Poisson and negative binomial models model (WCH_i, WCL_i, WDI_i and $WVab_i$, where W is a spatial weights matrix) and by the spatially lagged dependent variable in spatial Probit models (*WLOC*). For the spatial Probit models as spatial weights matrix we used a binary contiguity matrix whose elements w_{ij} were set to 1 if municipalities $_i$ and $_j$ share a common border and 0 otherwise. To be consistent with the results of exploratory analysis for the negative binomial and the Poisson models, we also used a binary matrix whose elements w_{ij}, were set to 1 if the distance between municipalities $_i$ and $_j$ is 15 kilometres or less and to 0 otherwise. Since the diameter of the average

network.

[7] Accessibility data have been produced and provided by Federico Pablo and Carlos Muñoz.

Spanish municipality is around 10 km (Holl, 2004a), both spatial weights matrices should be very similar.

To sum up, the creation of new manufacturing establishments can be expressed by the following expression (4):

$$LOC_{ij} = f(Ch_i, Cl_{ij}, Di_i, Vab_i, Acc_i, Fai_i) \quad (4)$$

4.2 Econometric specification

Location models are usually constructed by considering the location decision problem as one of random profit maximization (Figueiredo *et al*, 2002). Following McFadden (1974) and Carlton (1983), it is assumed that if an entrepreneur who has decided to open a new establishment in manufacturing industry $_j$, locates in municipality $_i$, it will produce a potential profit π_{ij}. Formally

$$\pi_{ij} = \omega_i + \varepsilon_{ij} \quad (5)$$

where ω_i reflects the internal characteristics of municipality $_i$ and ε_{ij} is a random variable that is expected to be distributed independently. This entrepreneur will locate in municipality $_i$ if the potential profit is greater than in other municipalities, say $_m$, i.e.

$$\pi_{ij} > \pi_{mj} \quad (6)$$

where $_{i \neq m}$. This profit depends on a set of local characteristics and is usually expressed as a linear combination of these characteristics (Figueiredo *et al,* 2002). In our case this profit would therefore also depend on the characteristics of the neighbouring area

$$\pi_{ij} \;\; f(X_n, WX_n) \quad (7)$$

where the explanatory variables X_n and WX_n represent the local characteristics that impact on profits and the relevant characteristics of the neighbouring municipalities, respectively. Then, WX could be substituted by $W\pi_{ij}$

(8) $$\pi_{ij}\ f(X_n, W\pi_{ij})$$

As it is not possible to observe π_{ij} (Ellison and Glaeser, 1997), the dependent variable of location models is usually the number of new establishments or new firms created over a period of time —our *LOC* variable in the previous section. Then, expressing *LOC* as a linear combination of independent variables from equation (4):

(9) $$LOC_{ij} = \Sigma_n \beta_n X_n + \Sigma_n \rho_n WX_n + \varepsilon_{ij}.$$

In this paper, the number of firm locations in each municipality is modelled as a Poisson-distributed random variable. Specifically, we consider that the probability that a municipality attracts a firm depends on the specific attributes, both internal and external, of the site (municipality):

(10) $$\text{Prob}\ (y_i) = f(x_i)$$

where y_i denotes the number of new industrial establishments created in site (municipality) *i* between 1991 and 1995, and x_i denotes municipality attributes that affect profit functions of firms and act as a location determinant irms.

As we know (Greene, 1998), each Y_i is a random variable with a Poisson distribution and with a λ_i parameter (related to regressors x_i):

(11) $$\Pr ob(Y = y_i) = \frac{e^{-\lambda_i}\lambda_i^{y_i}}{y_i!} \qquad y_i = 0, 1, 2, \ldots$$

in which the most common representation of λ_i is:

(12) $$\ln \lambda_i = \beta' x_i$$

where β is the parameter vector to be estimated and x_i is a vector municipality with attributes that affect profit functions of firms.

The main advantage of Poisson models is that they deal with the "zero" problem, but Poisson models have two important assumptions that need to be taken into account. The first assumption is that the mean and the variance should be equal, but this restriction is often violated when the Poisson model is used to model industrial location phenomena, given the concentration of industrial establishments in specific areas (this causes the variance to be greater than the mean, which is known as the "overdispersion problem"). This problem can be solved using a negative binomial model, which allows the variance to exceed the mean. The probability distribution of the Negative Binomial model is:

(13) $$\Pr ob(Y = y_i | u) = \frac{\exp((-\lambda_i \exp(u_i))\lambda_i^{y_i}}{y_i!}$$

where $\exp(u)$ has a gamma distribution with a mean of 1 and a variance of α.

The second assumption is the excess zero problems, i.e. there is a large number of observations that take the value zero: for the industrial location phenomenon these are the municipalities in which no industrial establishments are located. The Poisson model can deal with observations with values of zero, but not when their number is excessive[9]. In these cases, the Negative Binomial model is very suitable. The Negative Binomial model assumes that there is some non-observed heterogeneity among the sites.

However, neither negative binomial models nor Poisson models account for the existence of spatial autocorrelation. Although the existence of univariate spatial dependence in LOC_{ij}, as shown in the exploratory analysis, does not

[9] The situation in which a large number of territories (municipalities) receive no industrial establishments is reasonable if we work at a very disaggregated geographical level, which the municipality level is.

necessarily mean that the residuals of our estimation they will probably be autocorrelated as we are making LOC_{ij} depend on on what happen in neighbouring municipalities. Therefore, the assumption of an independently distributed ε_{ij} is too strong. Since the existence of spatial autocorrelation makes it invalid to use most of the usual statistics and econometrics techniques, and despite the strengths of the random profit maximization framework, we estimated spatial Probit models with both spatially lagged dependant variables and spatially autocorrelated error terms[10]. As well as spatial Probit models, we estimated negative binomial models and Poisson models with spatially lagged explanatory variables.

4.3 Results

Our estimations results are summarized in tables 4.1a, 4.1b and 4.1c[11]. First of all, we should stress that the accessibility coefficient is significant and shows the expected sign in most of the econometric specifications. Only the spatial Probit model for food, drinks and tobacco, and computers and office equipments, and the negative binomial model for food, drinks and tobacco, and other non-metallic minerals do not show a significant accessibility coefficient. Internal explicative variables—potential market, human capital, specialization and diversification—are always significant and show the expected sign.

Interurban agglomeration forces or interurban externalities measured as the spatial coefficient of the spatial Probit model are significant and present the expected sign in most industries. Neither the spatial coefficients of the spatial Probit autoregressive model nor those of the spatial Probit error model are significant in the computers and office equipment industry.

[10] For more information about spatial autocorrelation in limited dependant variable models, see Anselin (2001), Fleming (2004), LeSage (1997,2000), McMillen (1995), Pinkse and Slade (1988), or Smith and LeSage (2002).

[11] See appendix I for extended results.

Negative binomial and Poisson results may shed light on the source of interurban agglomeration forces or interurban externalities. Neither potential market nor human capital seem to cause interurban externalities since their spatially lagged variables are either non-significant or show an unexpected sign. However, the spatially lagged diversity index is always significant. The spatially lagged specialization indicator coefficient is also significant and shows the right sign in most industries and econometric specifications, but in negative binomial models for food, drinks and tobacco, wood and furniture, and machinery.

4.1a Determinants of manufacturing location 1991-95 (1/3) (significant coefficients)																
	Food, drinks and tobacco				**Clothes and leather**				**Wood and furniture**				**Paper and printing**			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Ac	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ch	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vab	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Di	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cl	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+
Error (λ)				+				+				+				+
Lag (ρ)			+				+				+				+	
WVab	+	+				+			+				+	+		
WCh	-	-			-	-			-	-			-	-		
WDi	+	+			+	+			+	+			+	+		
WCl	+				+	+			-				+	+		
I Poisson; II Negative binomial; III Spatial Probit lag; IV Spatial Probit error																

4.1b Determinants of manufacturing location 1991-95 (2/3) (significant coefficients)																
	Chemistry				**Other non-metallic minerals**				**First transform. of minerals**				**Machinery**			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Ac	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
Ch	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vab	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Di	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cl	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Error (λ)				+				+				+				+
Lag (ρ)			+				+				+				+	
WVab	-				+									+		
WCh		-			-	-			+	-				-		
WDi	+	+			+	+			+	+			+	+		
WCl	+	+			+	+			+	+			+			
I Poisson; II Negative binomial; III Spatial Probit lag; IV Spatial Probit error																

4.1c Determinants of manufacturing location 1991-95 (3/3) (significant coefficients)												
	Computers and office equipment				Electric and electronic equip.				Transport Equipment			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Ac	-	-		-	-	-	-	-	-	-	-	-
Ch	+	+	+	+	+	+	+	+	+	+	+	+
Vab	+	+	+	+	+	+	+	+	+	+	+	+
Di	+	+	+	+	+	+	+	+	+	+	+	+
Cl	+	+	+	+	+	+	+	+	+	+	+	+
Error (λ)				+				+				+
Lag (ρ)							+				+	
WVab												
WCh	-								-	-		
WDi	+	+			+	+			+	+		
WCl	+	+			+	+			+	+		
I Poisson; II Negative binomial; III Spatial Probit lag; IV Spatial Probit error												

5. Conclusions

The aim of this article was to evaluate the effects of improvements in accessibility due to the General Infrastructure Plan (GIP) on the creation of new manufacturing establishments. Our econometric results show that there was a positive effect. Exploratory analysis suggests that decision makers anticipate these improvements in accessibility. It also reflects the existence of interurban externalities, which seem to be strongest between 15 and 20 kilometres and to vanish beyond 100 or 150 kilometres, depending on the industry. Confirmatory analysis, carried out by means of spatial Probit models and non-spatial models (negative binomial models and Poisson models) with spatially lagged explanatory variables, shows that the source of these interurban externalities may be manufacturing specialisation and manufacturing diversity.

Despite these positive effects, we must bear in mind that infrastructure investment can have opposite territorial effects. On one hand, extending the highway network (HN) may increase the accessibility of municipalities close to HN and make these municipalities more attractive potential locations. On the other hand, firms may leave their former locations and move to municipalities whose accessibility has significantly increased. However, the direction of these migrations is not obvious. Some firms may leave rural locations that are far from HN. Others may leave well-located large agglomerations in order to avoid negative externalities such us congestion or higher land prices. The negative effects on distant municipalities may be even worse. Paradoxically, assuming that a substantive proportion of HN extension is funded by the Government, as in the Spanish case, this would mean that distant municipalities were funding infrastructures that encourage firms to migrate from these municipalities (Boarnet, 1998) or make them a less attractive potential location for new firms. Any empirical approach to the causal relationship between accessibility and firm location should therefore also considerer these negative effects. Unfortunately, Spanish databases on manufacturing establishments do not collect information on firm relocations, so we can only focus on the overall effects on firm creation.

Appendix I: Extended econometric results

FOOD, DRINKS AND TOBACCO														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-3,11928	0,090	-34,48	0,000	-4,20349	0,176	-23,88	0,000	-2,45233	0,078	0,000	-2,11714	0,095	0,000
Ac	-0,00012	0,000	-10,88	0,000	-0,00003	0,000	-1,63	0,103	-0,00004	0,000	0,000	-0,00001	0,000	0,188
Ch	5,49610	0,144	38,25	0,000	5,22839	0,412	12,68	0,000	1,84283	0,208	0,000	1,25482	0,245	0,000
Vab	0,00062	0,000	50,31	0,000	0,00891	0,001	9,53	0,000	0,00435	0,001	0,000	0,00743	0,002	0,000
Di	0,97795	0,019	52,06	0,000	1,58610	0,086	18,52	0,000	1,53336	0,058	0,000	1,50986	0,072	0,000
Cl	0,00293	0,001	4,69	0,000	0,02556	0,006	3,97	0,000	0,00302	0,001	0,015	0,00256	0,002	0,097
Error (λ)									0,32620	0,023	0,000			
Lag (ρ)												0,32959	0,021	0,000
WCh	-4,38319	0,282	-15,54	0,000	-4,91820	0,572	-8,6	0,000						
WDi	2,15574	0,069	31,15	0,000	2,55770	0,147	17,36	0,000						
WVab	0,00315	0,000	12,74	0,000	0,00377	0,001	3,1	0,002						
WCl	,00248	0,001	2,79	0,005	-0,00064	0,004	-0,17	0,865						

CLOTHES AND LEATHER														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	Coef	D.St.	Prob.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-3,62330	0,108	-33,55	0,000	-5,43554	0,269	-20,19	0,000	-2,71823	0,099	0,000	-2,38752	0,113	0,000
Ac	-0,00030	0,000	-18,23	0,000	-0,00017	0,000	-6,03	0,000	-0,00011	0,000	0,000	-0,00007	0,000	0,000
Ch	4,82020	0,191	25,29	0,000	5,76233	0,610	9,44	0,000	1,16085	0,240	0,000	0,79432	0,281	0,003
Vab	0,00065	0,000	41,87	0,000	0,00774	0,001	7,1	0,000	0,00480	0,001	0,000	0,00814	0,002	0,000
Di	1,06554	0,023	47,32	0,000	1,88540	0,117	16,1	0,000	1,50690	0,074	0,000	1,24829	0,077	0,000
Cl	0,09545	0,002	51,44	0,000	0,41685	0,020	21,37	0,000	0,21613	0,012	0,000	0,20960	0,014	0,000
Error (λ)									0,09406	0,029	0,003			
Lag (ρ)												0,15446	0,023	0,000
WCh	-3,72809	0,334	-11,16	0,000	-5,38602	0,851	-6,33	0,000						
WDi	1,83912	0,089	20,57	0,000	2,11164	0,221	9,53	0,000						
WVab	0,00044	0,000	1,06	0,289	0,00308	0,002	1,92	0,055						
WCl	0,45313	0,011	39,7	0,000	0,32956	0,047	7,07	0,000						

WOOD AND FURNITURE														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-2,76777	0,085	-32,64	0,000	-5,38773	0,186	-28,96	0,000	-2,92866	0,090	0,000	-2,69174	0,103	0,000
Ac	-0,00024	0,000	-19,44	0,000	-0,00010	0,000	-5,41	0,000	-0,00007	0,000	0,000	-0,00004	0,000	0,000
Ch	5,53271	0,137	40,43	0,000	6,06190	0,431	14,05	0,000	2,47649	0,221	0,000	2,21566	0,256	0,000
Vab	0,00041	0,000	24,92	0,000	0,00527	0,001	7,77	0,000	0,00432	0,001	0,000	0,00472	0,003	0,000
Di	1,26162	0,020	63,16	0,000	1,91357	0,083	22,99	0,000	1,90047	0,068	0,000	1,76354	0,077	0,000
Cl	0,07373	0,002	38,67	0,000	0,17191	0,011	15,87	0,000	0,06902	0,007	0,000	0,06407	0,009	0,000
Error (λ)									0,12931	0,027	0,000			
Lag (ρ)												0,19755	0,022	0,000
WCh	-4,58989	0,269	-17,08	0,000	-2,55603	0,586	-4,36	0,000						
WDi	1,92926	0,066	29,33	0,000	2,33023	0,147	15,85	0,000						
WVab	0,00071	0,000	2,38	0,017	0,00160	0,001	1,26	0,208						
WCl	-0,14396	0,013	-11,21	0,000	0,03219	0,025	1,3	0,192						

PAPER AND PRINTING														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-5,21904	0,173	-30,14	0,000	-7,09921	0,329	-21,56	0,000	-3,44090	0,116	0,000	-2,80642	0,130	0,000
Ac	-0,00034	0,000	-11,3	0,000	-0,00016	0,000	-4,27	0,000	-0,00011	0,000	0,000	-0,00006	0,000	0,000
Ch	5,30810	0,251	21,14	0,000	6,92339	0,655	10,58	0,000	3,02218	0,263	0,000	2,03305	0,304	0,000
Vab	0,00048	0,000	24,74	0,000	0,00467	0,001	6,39	0,000	0,00517	0,001	0,000	0,01233	0,002	0,000
Di	1,15381	0,026	43,66	0,000	1,84428	0,118	15,57	0,000	1,46206	0,080	0,000	1,00794	0,077	0,000
CI	0,15007	0,006	26,07	0,000	0,22782	0,020	11,17	0,000	0,12503	0,012	0,000	0,11634	0,018	0,000
Error (λ)									0,05145	0,027	0,037			
Lag (ρ)												0,09866	0,025	0,000
WCh	-2,54235	0,508	-5	0,000	-2,92148	0,981	-2,98	0,003						
WDi	2,39148	0,120	20,01	0,000	2,58088	0,237	10,87	0,000						
WVab	0,00157	0,000	4,41	0,000	0,00290	0,001	2,13	0,033						
WCI	0,29645	0,037	7,92	0,000	0,27324	0,099	2,75	0,006						

CHEMISTRY														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-5,37410	0,175	-30,79	0,000	-6,89745	0,312	-22,13	0,000	-3,08225	0,111	0,000	-2,68885	0,125	0,000
Ac	-0,00026	0,000	-9,82	0,000	-0,00018	0,000	-5,23	0,000	-0,00012	0,000	0,000	-0,00007	0,000	0,000
Ch	3,58751	0,263	13,66	0,000	5,39448	0,632	8,54	0,000	2,41789	0,259	0,000	1,89742	0,294	0,000
Vab	0,00025	0,000	9,27	0,000	0,00442	0,001	5,2	0,000	0,00471	0,001	0,000	0,00762	0,002	0,000
Di	1,16495	0,031	38,19	0,000	1,66082	0,113	14,64	0,000	1,42814	0,070	0,000	1,11276	0,081	0,000
CI	0,08972	0,004	25,45	0,000	0,21904	0,025	8,72	0,000	0,14273	0,016	0,000	0,14934	0,021	0,000
Error (λ)									0,07164	0,028	0,002			
Lag (ρ)												0,13275	0,025	0,000
WCh	0,68771	0,501	1,37	0,170	-0,60269	0,957	-0,63	0,529						
WDi	2,21034	0,129	17,16	0,000	2,78357	0,234	11,91	0,000						
WVab	-0,00129	0,000	-2,67	0,007	-0,00106	0,001	-0,72	0,472						
WCI	0,29776	0,038	7,84	0,000	0,26328	0,094	2,79	0,005						

OTHER NON-METALIC MINERALS														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-3,79979	0,148	-25,67	0,000	-5,42839	0,239	-22,75	0,000	-2,89166	0,102	0,000	-2,64463	0,126	0,000
Ac	-0,00012	1,8E-05	-6,67	0,000	-0,00003	0,000	-1,4	0,163	-0,00005	0,000	0,000	-0,00003	0,000	0,008
Ch	4,27895	0,261	16,39	0,000	5,01379	0,513	9,77	0,000	1,81966	0,259	0,000	1,45199	0,308	0,000
Vab	0,00042	3,2E-05	12,95	0,000	0,00302	0,001	4,43	0,000	0,00451	0,001	0,000	0,00792	0,002	0,000
Di	1,01862	0,034	29,57	0,000	1,85894	0,104	17,9	0,000	1,53765	0,070	0,000	1,33883	0,082	0,000
CI	0,0416	0,001	22,99	0,000	0,18381	0,010	17,81	0,000	0,07086	0,007	0,000	0,08951	0,009	0,000
Error (λ)									0,07593	0,026	0,000			
Lag (ρ)												0,13281	0,025	0,000
WCh	-4,42378	0,476	-9,28	0,000	-4,25322	0,748	-5,69	0,000						
WDi	2,12967	0,115	18,45	0,000	2,15292	0,184	11,69	0,000						
WVab	0,00192	0,000	3,75	0,000	0,00220	0,001	1,67	0,094						
WCI	0,10181	0,007	13,67	0,000	0,12194	0,028	4,41	0,000						

FIRST TRANSFORMATION OF METALS													
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-4,02633	0,084	-48,12	0,000	-5,47998	0,177	-30,88	0,000	-2,80164	0,090	0,000	-2,56378	0,101	0,000
Ac	-0,00022	0,000	-17,7	0,000	-0,00012	0,000	-6,6	0,000	-0,00009	0,000	0,000	-0,00006	0,000	0,000
Ch	3,87444	0,143	27,16	0,000	5,85891	0,404	14,5	0,000	2,34249	0,223	0,000	2,07555	0,248	0,000
Vab	0,00025	0,000	15,87	0,000	0,00519	0,001	7,19	0,000	0,00445	0,001	0,000	0,00461	0,002	0,000
Di	1,16072	0,017	66,75	0,000	1,89959	0,078	24,31	0,000	1,98022	0,068	0,000	1,85045	0,081	0,000
Cl	0,01986	0,001	19,3	0,000	0,12314	0,010	12,22	0,000	0,05055	0,008	0,000	0,04147	0,010	0,000
Error (λ)									0,14582	0,028	0,000			
Lag (ρ)												0,22635	0,021	0,000
WCh	0,94680	0,250	3,79	0,000	-1,34277	0,548	-2,45	0,014						
WDi	2,07966	0,064	32,69	0,000	2,37292	0,137	17,3	0,000						
WVab	0,00004	0,000	0,18	0,861	0,00161	0,001	1,38	0,168						
WCl	0,01712	0,002	9,15	0,000	0,05244	0,019	2,73	0,006	r					

MACHINERY													
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-5,29349	0,159	-33,28	0,000	-7,07905	0,308	-22,97	0,000	-3,27763	0,117	0,000	-2,76699	0,119	0,000
Ac	-0,00033	0,000	-12,24	0,000	-0,00015	0,000	-4,53	0,000	-0,00011	0,000	0,000	-0,00006	0,000	0,000
Ch	5,58302	0,236	23,62	0,000	7,39911	0,673	11	0,000	2,90865	0,273	0,000	2,15674	0,294	0,000
Vab	0,00038	0,000	17,04	0,000	0,00706	0,001	6,7	0,000	0,00520	0,001	0,000	0,01162	0,002	0,000
Di	1,16260	0,028	41,24	0,000	1,60048	0,114	14,01	0,000	1,41780	0,073	0,000	1,04510	0,078	0,000
Cl	0,00678	0,000	13,67	0,000	0,06925	0,016	4,46	0,000	0,03779	0,014	0,000	0,01752	0,009	0,000
Error (λ)									0,06792	0,028	0,006			
Lag (ρ)												0,12073	0,024	0,000
WCh	-0,79655	0,464	-1,72	0,086	-1,85624	0,925	-2,01	0,045						
WDi	2,11913	0,118	17,89	0,000	2,62538	0,239	10,98	0,000						
WVab	0,00035	0,000	0,85	0,396	0,00407	0,002	2,42	0,016						
WCl	0,03482	0,005	7,07	0,000	0,02234	0,014	1,63	0,104						

COMPUTERS AND OFFICE EQUIPMENT														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-6,89775	0,421	-16,38	0,000	-8,23490	0,683	-12,06	0,000	-3,23440	0,172	0,000	-2,59832	0,144	0,000
Ac	-0,00044	0,000	-5,45	0,000	-0,00033	0,000	-3,6	0,000	-0,00009	0,000	0,000	-0,00003	0,000	0,069
Ch	7,48773	0,505	14,84	0,000	7,94248	1,167	6,8	0,000	2,47817	0,393	0,000	1,10026	0,366	0,002
Vab	0,00064	0,000	17,05	0,000	0,00678	0,001	5,07	0,000	0,00506	0,001	0,000	0,00903	0,001	0,000
Di	1,14929	0,062	18,62	0,000	1,16839	0,213	5,49	0,000	0,62637	0,092	0,000	0,23968	0,089	0,001
CI	0,04871	0,009	5,51	0,000	0,06981	0,024	2,89	0,004	0,03617	0,009	0,000	0,03268	0,012	0,002
Error (λ)									0,01373	0,029	0,346			
Lag (ρ)												0,03020	0,027	0,132
WCh	-3,76187	1,157	-3,25	0,001	-3,16493	1,899	-1,67	0,096						
WDi	1,95396	0,292	6,7	0,000	2,45206	0,470	5,22	0,000						
WVab	0,00126	0,001	1,47	0,141	0,00190	0,002	0,94	0,349						
WCI	0,27670	0,046	5,98	0,000	0,26350	0,098	2,7	0,007						

ELECTRIC AND ELECTRONIC EQUIPMENT														
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
	Coef	Std.Er. z		P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-6,63533	0,283	-23,48	0,000	-8,07512	0,451	-17,92	0,000	-3,32593	0,128	0,000	-2,73140	0,130	0,000
Ac	-0,00046	0,000	-8,19	0,000	-0,00029	0,000	-4,61	0,000	-0,00012	0,000	0,000	-0,00005	0,000	0,008
Ch	5,31138	0,412	12,9	0,000	5,40140	0,840	6,43	0,000	2,75009	0,314	0,000	1,49339	0,354	0,000
Vab	0,00043	0,000	13,16	0,000	0,00491	0,001	5,5	0,000	0,00507	0,001	0,000	0,00990	0,002	0,000
Di	1,25015	0,046	27,31	0,000	1,59708	0,147	10,89	0,000	1,04403	0,081	0,000	0,63346	0,078	0,000
CI	0,02294	0,003	7,87	0,000	0,10015	0,021	4,78	0,000	0,03213	0,006	0,000	0,07747	0,019	0,000
Error (λ)									0,02853	0,026	0,129			
Lag (ρ)												0,05943	0,025	0,006
WCh	0,90867	0,797	1,14	0,254	1,47231	1,252	1,18	0,240						
WDi	1,80287	0,205	8,79	0,000	2,19458	0,332	6,61	0,000						
WVab	0,00000	0,001	0	1,000	0,00122	0,002	0,73	0,465						
WCI	0,09433	0,028	3,31	0,001	0,09844	0,055	1,78	0,076						

TRANSPORT EQUIPMENT															
	Poisson				Negative binomial				Spatial Error			Spatial Lag		
u	Coef	Std.Er.	z	P>|z|	Coef	Std.Er.	z	P>|z|	Coef	D.St.	Prob.	Coef	D.St.	Prob.
Const	-5,90093	0,267	-22,14	0,000	-6,87463	0,395	-17,38	0,000	-3,19807	0,128	0,000	-2,70894	0,128	0,000
Ac	-0,00031	0,000	-7,04	0,000	-0,00019	0,000	-4,09	0,000	-0,00010	0,000	0,000	-0,00005	0,000	0,000
Ch	5,56207	0,392	14,19	0,000	7,53163	0,777	9,7	0,000	2,59351	0,324	0,000	1,67960	0,315	0,000
Vab	0,00030	0,000	7	0,000	0,00297	0,001	3,17	0,002	0,00463	0,001	0,000	0,00806	0,002	0,000
Di	1,09410	0,049	22,23	0,000	1,50754	0,136	11,13	0,000	1,01686	0,070	0,000	0,67159	0,081	0,000
Cl	0,29015	0,017	17,4	0,000	0,38542	0,043	8,99	0,000	0,21277	0,022	0,000	0,22575	0,030	0,000
Error (λ)									0,04531	0,026	0,043			
Lag (ρ)												0,07716	0,026	0,002
WCh	-1,62846	0,739	-2,2	0,028	-3,52699	1,191	-2,96	0,003						
WDi	1,83444	0,194	9,45	0,000	1,96763	0,293	6,72	0,000						
WVab	-0,00078	0,001	-0,95	0,343	-0,00137	0,002	-0,84	0,402						
WCl	0,38928	0,071	5,49	0,000	0,79345	0,197	4,03	0,000						

6. References

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