# Spatial Effects on Rural Commerce

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## Abstract:

Commerce in rural territories should not be considered as a needed service, but as a basic infrastructure, that impact not only existent population, but also tourism, and rural industrialization. So, the rural areas need not only agriculture but industry and services, to have a global and balanced development, including for the countryside and the population.

In the work presented in this paper, we are considering the formulation of the direct relation between population and the endowment of commerce sites within a geographical territory, the "area of commercial interactions". These are the closer set of towns that can gravitate to each other to cover the required needs for the populations within the area. The products retailed, range from basic products for the daily lives, to all other products for industry, agriculture, and services.

The econometric spatial model developed to evaluate the interactions and estimate the parameters, is based on the Spatial Error Model, which allows for other spatial hidden effects to be considered without direct interference to the commercial disposition.

The data and territory used to test the model correspond to a rural area in the Spanish Palencia territory (NUTS-3 level). The parameters have dependence from population levels, local rent per head, local and regional government budgets, and particular spatial restrictions.

Interesting results are emerging form the model. The more significant is that the spatial effects can replace some number of commerce sites in towns, given the right spatial distribution of the sites and the towns. This is equivalent to consider the area of commercial interactions as the unit of measurement for the basic infrastructure and not only the towns.

## Key words:

Rural development, rural commerce, spatial econometric models

## Introduction

The importance of rural commerce in the economy of rural development has been amply discussed by many publications (Rowley, Sears and Nelson, 1996). However the problem of population retention in the rural territories is one of the mayor issues in countries were the migration form rural to urban an industrial areas has resulted in the depopulation of the rural countryside and the settlement of restrained poorer and older populations in place.

Rural development has frequently being approached in many Countries as part of agriculture policy and environmental sustainbility, were the population retention problem is addressed by public subsidies related to the land utilization (Buckwell, 2006). But it is not working as planned. One main reason has been that when the infrastructure falls behind

certain level no retention is possible. And the way the retail commerce is available over a rural area, plays a key role in maintaining those living standards.

The structural economic models of rural development, reflecting population, employment and income (Hoogstra, Florax, and Van Dick, 2005), don´t give but a lateral consideration to the role of commerce, embedding its effects and roles within other explanatory variables. Notwithstanding that there is a strong correlation between population and commerce retailers.

In this work, which is part of my doctoral thesis research, we are considering the formulation of the direct relation between population and the endowment of commerce elements within a geographical territory, the "area of commercial interactions". These are the set of villages and towns closer enough to travel to each other to cover the required needs of the population within the area.

The formulation of the direct relations in the territory is based in a spatial econometric model. These relations are included in two ways. Within the explanatory variables, including a spatial gravitationally weighted term applied to the retail units of commerce belonging to the towns in the area (commerce spatial spill over). And a disturbance term that follows the spatial autoregressive process, spatially related to the distribution of the population in the territory.

The function derived for the resulting model is a Cobb-Douglas with spatial components. For one town with population P presents the following expression:

(1) $$P_i = M_i S_{Li}^{\alpha} (W_G S)_{Pi}^{\beta}$$

Where M is the equivalent population needed in the town for one unit of commerce, which is dependent of the average rent per person in the town. The larger the rent effect the lower is M. The number of commerce sites in each town is given by the vector S. And W is the gravitational matrix weight.

The calculation of the parameters in the spatial econometric model is done using the Spatial Error Model (Anselin, 1988) (LeSage and Kelley, 2009) that includes the spatial autoregressive disturbance term, as follows:

(2) $$lnP = lnM + \alpha lnS + \beta ln(W_G S) + (I - \lambda W_{Territory})^{-1}\varepsilon$$

So far, with the cases evaluated, interesting results are emerging form it. For its relevance it is important to mention that the hypothesis test for the parameters neutrality has proved positive. That means in practical terms that the spatial effects can replace some number of commerce sites in some towns, given the right spatial distribution of the commerce sites and towns.

**Structural econometric commerce model**

From the dual economy model (Ghatar, 2003) and the commerce economic gravitation model (Sheppard, 1997) has been derived a formulation for the interaction between population and commerce, for a close area of towns. The formulation is as follows:

(3) $$P_i = (\beta_1 S_i + \beta_2 \sum_{j \in Area} w_{g,ij} S_j)Y_i$$

Where the components have the same significance as in (1), being Y the rent per capita in the town, and the term *Area* refers to all the different towns in the "commercial area of interaction".

It is customary to express these production type models with a Cobb-Douglas formulation, then (3) can be put such as:

(4) $$P_i = A S_{Li}^{\alpha} S_{Si}^{\beta} J_i^{\gamma}$$

Where A is a constant related to the population in the area. $S_L$ is the local commercial offer in the town, including permanent (shops o retail outlets) and non permanent such as street markets, selling from vans or direct sale from the producer. $S_S$ is the commerce spill over in the area resulting from the permanent commerce present in the other towns in the area that is available to the town in consideration. J is an index collecting all sources of rent that can contribute to the income rent per capita of the town.

As already mentioned in (1) and reflected in (3), the commerce spill over term is a spatially generated term that results from applying the commerce gravitation matrix $W^G$, to the permanent commerce vector attached to the towns in the area.

The full spatial econometric model used for the estimation of the parameters is based on the Spatial Error Model (SEM). As we can see this model introduces a spatial term in the disturbance, including a new spatial proximity matrix W. The reason for including this spatial autoregressive term is to allow for possible variations due to other economic effects of spatial nature, like main roads proximity, amenities like National Parks, and others. Following the expression in (4), we can put the estimation model as:

(5)
$$\underline{y} = a\iota_n + \alpha \underline{x}_1 + \beta W_G \underline{x}_2 + \gamma \underline{x}_3 + (I_n - \lambda W)^{-1} \underline{\varepsilon}$$

Were we are considering $\underline{\varepsilon} \approx N(0, \sigma^2 I_n)$, normal and homoscedastic.

The Spatial Error Model parameters (a, α, β, γ, λ, $\sigma^2$) are estimated by Maximum Likelihood (ML), using the algorithm in (LeSage & Kelley, 2009) and computed with Octave. The Likelihood function is as:

(6)
$$lnL = -(n/2)\ln(\pi\sigma^2) + \ln|I_n - \lambda W| - \frac{e^T e}{2\sigma^2},$$

$$\underline{e} = (I_n - \lambda W)(\underline{y} - a\iota_n - \alpha \underline{x}_1 - \beta W_G \underline{x}_2 - \gamma \underline{x}_3)$$

**Commerce spill over, gravitation matrix**

The spatial gravitation matrix weights the attraction for people in town (i) to go into town (j) commerce's to satisfy their needs. The gravitation attraction uses the inverse power of the distance between (i) and (j) as weighting factor. Two approaches are used, the power of two, gravitational attraction, and the power of one, normally described as the potential attraction function.

One problem arises when an important commercial town (number and quality of retailers) is outside the geographic area but near enough to project its influence over the "commercial area of interest". That influence distorts the gravitation within the area. To deal with this issue, as it will described below, the potential attraction function will be used.

Consider the area represented in figure 1, where the interactions between the different towns are marked with lines. No external towns to the area are present.

*Fig. 1 . Example, area of commercial interactions*
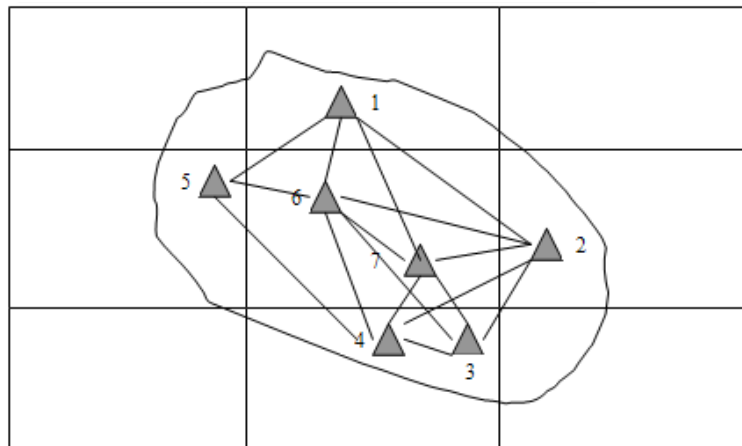
So, the elements of the gravitation matrix will be in the following form, given town (i) as origin and (j) as destination:

(7)
$$w_{G,ij} = d_{ij}^{-1}$$

With the following rules: if i=j, or there is no direct path between them, like towns 1 and 3 or 5 and 2 in figure 1, then the element takes the value cero.

To include the potential situations of important commercial towns outside the area considered, the formulation for the commercial spill over is slightly modified. A second gravitation matrix is introduced, covering only the direct relation between these towns and the direct linked towns within the area. The commercial spatial spill over term is now formulated as:

(8)
$$\underline{S}_S = W_G(\underline{S}_{towns.area} + W_{G1}\underline{S}_{towns.outside})$$

The elements belonging to $W_G$ and $W_{G1}$ will follow the same formulation as in (7). The expression for one element of $S_S$ will have the structure presented below, with towns (*l1, l2*) outside the area and in direct link to town (j):

(9)
$$S_{Sij} = s_j d_{ij}^{-1} + s_{l1,j} d_{l1,j}^{-1} d_{ij}^{-1} + s_{l2,j} d_{l2,j}^{-1} d_{ij}^{-1}$$

The gravitational effect of these towns outside the "area of commercial interactions" follows a power of two attraction function.


**Index of rent generation**

This index J, resumes the increment of incoming rent that by different reasons takes place in the town. Either because people come from outside to work in it, or on holidays, or the weight of the public subsidies allocated are significant with respect to the rent per head, or the industry and services, including tourism, associated to the town, are noticeable. The expression for the index is:

(10)
$$J_i = \frac{Y_i^*}{Y_i}$$

Where Y represents the average rent (wages and capital rent) per person associated to the town. The term $Y^*$ summarizes all the incoming rent available. To calculate $Y^*$ a weighted summation of different indexes related to each source of rent is use according to the Data Envelopment Analysis model (DEA) (OECD, 2008). Thus the expression for $Y^*$ is:

(11)
$$Y_i^* = \sum \delta_m i_{mi}$$

The indexes to be used more frequently are the following:

$$ira_i = Y_i \frac{Pop.Census_i + Pop.Floating_i}{Pop.Census_i}$$

(12)
$$igl_i = \frac{Budget.investments_i + Rural.Subsidies_i}{Pop.Census_i}$$

$$itur_i = Y_{tur.area} \frac{lodgings_i + amenities_i}{\sum_{Area}(lodgings_j + amenities_j)}$$


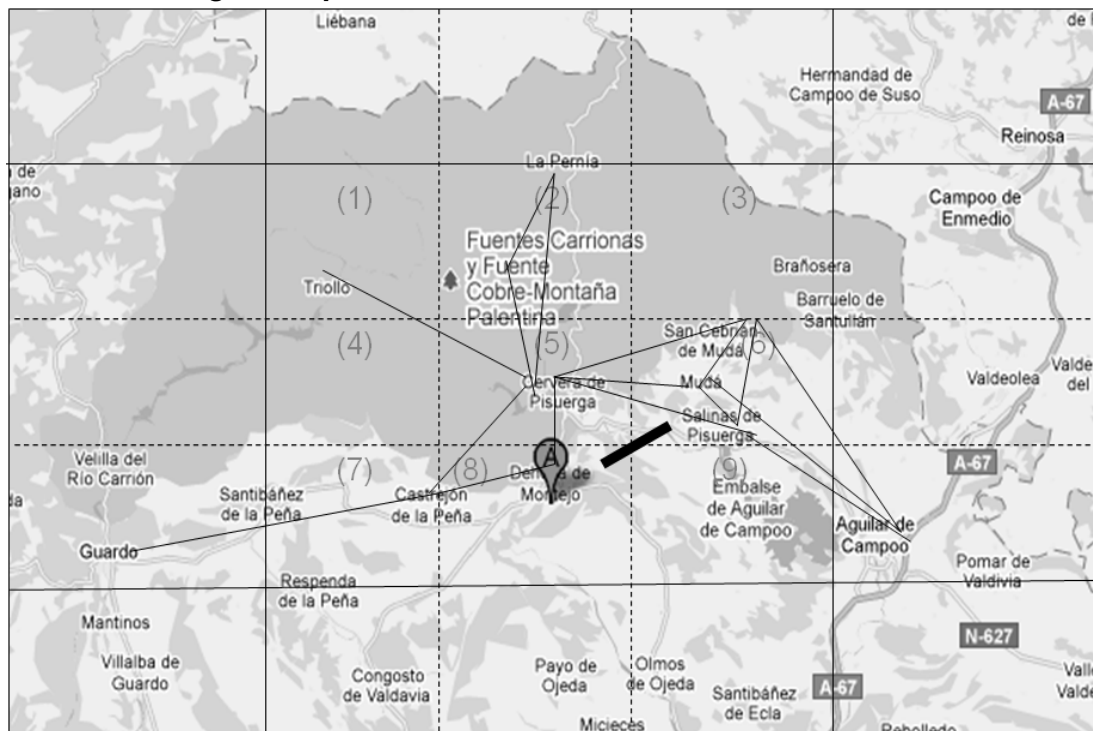**Commerce econometric model evaluation**

To evaluate the model with a real rural commercial area, the province of Palencia in Spain (NUTS-3 level), and the rural zone of Cervera de Pisuerga, with 8 towns, have been selected. Also there are present outside the area two large towns nearby, Aguilar de Campo and Guardo, with important commercial infrastructure. The towns in the commercial area are:

Cervera de Pisuerga, Castrejon de la Peña, Dehesa de Montejo, Muda, La Pernia, Polentinos, San Cebrian de Muda, and Triollo.

The next image, figure 2, of the rural zone, shows the situation of the towns and the connections between them, considering the geographical limitations because of the mountains and lakes in the area.

***Fig. 2 . Map with the rural zone situation and connections***



It can be notice that there is a natural gravitation towards Cervera, due to the way the towns are connected by road.

The spatial econometric model to estimate is the one described in (4) and (5). For the local commerce in the town $S_L$ the following approach was taken, considering that non permanent commerce in this rural setup is quite important:

(13) $$S_L = 1 + S$$

Normally the non permanent commerce contribution is less than or equal to one, but in this case we make equal to one. S is the local permanent commerce as reflected by the official records.

**Data collection process**

The basic data about the towns in the zone are taken from the Spanish National Statistical Office (INE) last official census, 2001. Although this data is not up to date, for the purpose of the model estimation will be sufficient. Next official census, due in 2011 will provide up to date information to evaluate and estimate the model with actual information about what is happening with the economy of the different areas to compare the predictions from the model. This basic data is presented in table 1.

### Tab. 1 . Rural zone basic data

| Towns | Population | Floating Pop. | Commerce (S) | Year Budget | Rent per capita |
|---|---|---|---|---|---|
| La Pernia | 447 | 900 | 7 | 162,747.00€ | 11.953,98€ |
| Triollo | 85 | 230 | 1 | 65,307.00€ | 13,890.23€ |
| San Cebrian de Muda | 197 | 297 | 1 | 118,612.00€ | 13,094.00€ |
| Polentinos | 81 | 146 | 0 | 63,523.00€ | 13,966.00€ |
| Muda | 130 | 216 | 0 | 63,547.00€ | 12,551.46€ |
| Dehesa de Montejo | 201 | 302 | 0 | 162,747.00€ | 14,088.40€ |
| Cervera de Pisuerga | 2586 | 4186 | 72 | 1,616,804.00€ | 13,204.78€ |
| Castrejon de la Peña | 601 | 912 | 7 | 162,747.00€ | 11,507.00€ |

The gravitation weight matrix is derived from the distance matrix between the towns. As per formula (7) the weight is the inverse of the distance. The distance matrix, showing the barriers that limit the connections between towns, is presented below in table 2. Numbers represent distance between towns in Kms.

### Tab. 2 .Towns distance matrix (Kms)

| Towns | C.Peña | C.Pisuerga | D.Mont. | Muda | Pernia | Polentinos | S.C.Muda. | Triollo |
|---|---|---|---|---|---|---|---|---|
| Castrejon Peña | 0 | 13 | 10 | 0 | 0 | 0 | 0 | 0 |
| Cervera Pisuerga | 13 | 0 | 6 | 10 | 16 | 14 | 12 | 22 |
| Dehesa Montejo | 10 | 6 | 0 | 15 | 0 | 0 | 19 | 0 |
| Muda | 0 | 10 | 15 | 0 | 0 | 0 | 2 | 0 |
| La Pernia | 0 | 16 | 0 | 0 | 0 | 10 | 0 | 0 |
| Polentinos | 0 | 14 | 0 | 0 | 10 | 0 | 0 | 0 |
| San Cebrian Muda | 0 | 12 | 19 | 2 | 0 | 0 | 0 | 0 |
| Triollo | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 |

The proximity matrix reflects the next-to situation of the towns, and that can be chosen in different ways, as movements on a chess board. The weights of the proximity matrix are used normalized, but in the matrix presented in table 3, they are not for clarity.

### Tab. 3 .Towns proximity matrix (no normalized)

| Towns | C.Peña | C.Pisuerga | D.Mont. | Muda | Pernia | Polentinos | S.C.Muda. | Triollo |
|---|---|---|---|---|---|---|---|---|
| Castrejon Peña | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| C. Pisuerga | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Dehesa Montejo | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Muda | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| La Pernia | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Polentinos | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| San C. Muda | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Triollo | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Finally the index of rent, J, is presented in table 4.

*Tab. 4 .Index of rent J*

| Towns | IRA | IGL | Index J |
|---|---|---|---|
| La Pernia | 24,068.412€ | 364.09€ | 1.62 |
| Triollo | 37,585.359€ | 768.32€ | 2.18 |
| San Cebrian de Muda | 19,740.727€ | 602.09€ | 1.22 |
| Polentinos | 25,174.156€ | 784.23€ | 1.45 |
| Muda | 20,854.738€ | 488.82€ | 1.34 |
| Dehesa de Montejo | 21,167.644€ | 809.69€ | 1.21 |
| Cervera de Pisuerga | 21,374.785€ | 625.21€ | 1.30 |
| Castrejon de la Peña | 17,461.692€ | 270.79 | 1.22 |

**Spatial commerce model calculation**

The estimation of the spatial model parameters (a, α, β, γ, λ, $\sigma^2$), as described by (6), have been calculated by Maximum Likelihood (ML) using Octave. The results are presented in table 5.

*Tab. 5*

| Parameters | value |
|---|---|
| lnA | 5.185 |
| α | 0.6567 |
| β | -0.0093 |
| γ | -1.2301 |
| λ | -0.990 |
| $\sigma^2$ | 0.0119 |

To be noticed first is that λ it is relevant in this model, which gives justification to the assumption in the model definition of spatial relations in the explanatory terms.

Second, with reference to A which value is 178 people for the zone, as average cut value for the commerce. The towns with cero local commerce range between 81 and 201 as permanent population. The effect of floating population has a significant impact in reducing the cut value.

Let us study the relations between the other parameters: α, β, γ. Two hypotheses are going to be tested. First the negative return to scale between the three parameters. Second the constant return between the first two. Both are described in the following formulas.

(14)
$$H_0^1 : \alpha + \beta + \gamma = 0$$
$$H_0^2 : \alpha + \beta = 1$$

The results of the Wild tests are positive, which means the hypothesis hold. This is very significant for the final expression of the model. The constant return represents that local commerce and spatially spill over commerce are interchangeable within the area, and how much this relation holds depends of the geography, the natural barriers, and favourable and practicable connections, meaning good roads, between the different towns of the area.

The final expression for the spatial model is the following:

(15)
$$P_i = L_{0i} S_{Li}^{\alpha} S_{Si}^{1-\alpha}$$
$$L_{0i} = A J_i^{-1}$$

The minimum population for each town $L_0$ in the zone is directly dependent of the cut population for the area A, and inversely dependent from J. That means that the more additional sources of rent the town has, the less permanent population is needed to maintain the local commerce. It can be seen that this is directly related to the amount of money available to spend in the commerce. J also reflects the attractiveness of the area for people, either work or leisure, and the ability to develop public services to support population.

## Conclusions

This work intended to build an econometric model, spatially based, to analyze the behaviour of rural commerce, considered not at a single location, but distributed in a geographical zone, that it has been named the "area of commercial interactions".

The outcome of the model is to facilitate the development of public policies regarding the development of rural communities, which in many territories are in fast decay, taking in consideration the towns and commerce distribution in the territory, the communications infrastructures, the movement of populations with destination the towns in the area, either because leisure or work, and the public budget and other special subsidies allocated to the development of the rural community.

The initial results from the evaluation of the model, after estimating the parameters, confirm the spatial hypothesis, as well as providing a production model of constant return, following the Cobb-Douglas formulation, with a single parameter to estimate. This represents that local commerce and spatially spill over commerce are interchangeable within the area, and how much this relation holds depends of the geography in the territory. Also the model allows accounting in the commerce spill over the effect of close commercial agglomerations, like those in large urban cities. If this relation remains true every time, it opens a new way to facilitate the policies for development and support of commercial infrastructure within a given area of interaction in a rural territory, and will facilitate the retention of population as well as new ways to increase the economical activity in decaying territories.

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