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IS THERE AN OPTIMAL SIZE FOR LOCAL GOVERNMENTS?

A SPATIAL PANEL DATA MODEL APPROACH

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Is there an Optimal Size for Local Governments? A Spatial Panel Data Model Approach

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Abstract

The paper presents a framework for determining the optimal size of local jurisdictions. To that aim, we first develop a theoretical model of cost efficiency that takes into account spatial interactions and spillover effects among neighbouring jurisdictions. The model solution leads to a Spatial Durbin panel data specification of local spending as a non-linear function of population size. The model is tested using local data over the 2003-2011 period for two aggregate (total and current) and four disaggregate measures of spending. The empirical findings suggest a U-shaped relationship between population size and the costs of providing public services that varies depending on (i) the public service provided and (ii) the geographical heterogeneity of the territory.

Keywords: Optimal Government Size, Spatial Panels, Spanish Municipalities

JEL codes: H11, H72, H77, R12

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1 Introduction

The Great Recession has put the public sector performance at the forefront. The sharp decline in revenues combined with an increase in the expenditure needs have forced much of the public policy debate to focus on the quality and efficiency of public spending, especially at the local level. Small municipalities have been blamed for an inefficient provision of public services, as economies of scale are not maximized and spillover effects are not internalized. Amalgamation reforms have been put to use, given that larger municipalities are expected to exploit economies of scale and internalize spillovers, thus lowering costs in public goods provision. The extent to which consolidated local governments take advantage of economies of scale has promoted a heated debate among academics as the empirical evidence is, at best, mixed. Some previous empirical studies provide evidence of their success (see, Reingewertz, 2012) as long as municipalities did not exceed a critical size (Hanes, 2015), while others show no cost savings (Frere *et al.*, 2014) or even the existence of diseconomies of scale (Moisio and Uusitalo, 2013).[1]

The debate about the amalgamation of local governments stems from the fact that the political border of a given jurisdiction may not coincide with the economic boundary required for an efficient provision of local public goods, hence violating the principle of fiscal equivalence (Olson, 1969). Most likely, the success of amalgamations is closely related to the critical size for municipal mergers, that is, the limits of these economic boundaries, which may vary depending on (i) the public good provided, and (ii) the geographical map. On the one hand, the existence of economies of scale is often taken for granted. However, the literature offers very limited evidence on the number of services offering real potential to benefit from economies of scale. Thus, if they exist, they may depend on the public service provided and the units of measurement, such as the jurisdiction size or the size of the facility (Slack and Bird, 2012). On the other hand, factors other than economies of scale shape these economic boundaries. As noted in Dafflon (2012), the usual reference to determine the size of a jurisdiction is the number of service users; drawing a geographical landscape of the model that is flat. But this is not so in practice and, since the map is no flat, the spatial distribution of the population, distance and physical geography also play a crucial role. As a result, the optimal size of a jurisdiction may depend both on the nature of the public services provided and on the socio-political and geographical context.

[1]See Byrnes and Dollery (2002) and Slack and Bird (2012) for a review of the empirical literature on the existence of economies of scale and the efficiency gains of consolidated local governments.

The analysis on the optimal size of jurisdictions is not of recent origin. A bulk of the economic and political science literature has devoted much attention to the efficiency gains of consolidated local governments and the formation of nations, as well as the trade-offs between economic and democratic concerns (see, e.g. Alesina and Spolaore, 2005). Nonetheless, neither the theoretical literature nor the empirical evidence provides a compelling, general answer to the optimal jurisdiction size. This paper seeks to shed light on this debate, quantifying the minimum efficient scale in the provision of a wide range of public services at the local level. More specifically, it is intended to determine (i) for which population levels there are (dis) economies of scale in the provision of public goods, so that a (decrease) increase in population size could lead to a decrease in local costs, and (ii) whether this efficient scale varies depending on the public service provided, and/or the geographical heterogeneity of the territory.

In this regard, Spain is a suitable case in which to study the optimal municipal size for a variety of reasons. First, Spain is a highly decentralized country. It consists of three different levels of government: the central government, 17 regional governments and about 8,100 local governments, most of them with less than 1,000 inhabitants. Additionally, Spanish municipalities are responsible for delivering a huge range of public services traditionally assigned to local governments. These services include water supply, sewage and waste management, public lighting, road maintenance, local police and public transportation, among others. [2] Second, local governments enjoy a relatively high degree of fiscal autonomy, as the services provided at the municipal level are financed mainly out of taxes and unconditional grants. Third, the Spanish local level of government is characterized by a high degree of fragmentation, which implies a structure of many independent units of government with very small populations, and limited public resources and management capacity. This fragmentation has been considered as one of the main causes of the lack of efficiency in the provision of public goods and services at the local level. In fact, the central government has promoted the reduction in the number of municipalities and the intensification of inter-municipal cooperation as a way of improving efficiency at the local level. Accordingly, the recent reform of the local administration (27/2013 Act of Rationalization and Sustainability of Local Administration) establishes measures to encourage the voluntary merger of municipalities and shifting services of municipalities of less than 20,000 inhabitants upwards to the Provincial Councils. [3]

[2]The responsibilities assumed by local governments are distributed according to the size of their populations. Note, however, that their list of responsibilities does not extend to include services that consume large amounts of resources, such as education or health.

[3]Recent examples of territorial reforms in Europe with a similar spirit can be found in Denmark, where in 2008, the number of municipalities was reduced from 350 to 100 or in Greece where, since 2010,

In order to contribute to the current policy debate on mergers and to the strand of research analysing the optimal size of local governments, this study makes three novel contributions to the literature.

First, we develop a theoretical model of cost efficiency that takes into account spatial interdependence in the provision of public goods among neighbouring jurisdictions (Salmon, 1987; Oates, 1999). The model builds upon similar models commonly used in the literature on local public spending (Borcheding and Deacon, 1972; Bergstrom and Goodman, 1973), where local government and citizens' behaviour are jointly modelled so as to derive an estimating equation where the level of per capita spending is specified as a function of the demand for public services and their provision costs. The model is tested for two aggregate (*total* and *current*) and four disaggregate (*General services*, *Community facilities*, *Local police*, *Basic infrastructures and transport*) spending categories. Nevertheless, a key difference with respect to previous studies is that the solution of the theoretical model developed here leads to an estimating equation that takes the form a Spatial Durbin model, where local spending is a non-linear function of population size. A feature of this model is that it allows us to investigate the nature of strategic government interactions and the existence of relations of complementarity/substitution in the provision of public goods. Following Downes and Pogue (1994) cost differentials are derived from the reduced form of the empirical model so as to analyse the minimum efficient scale and, therefore, the optimal jurisdictional size.

Second, our empirical analysis employs modern Bayesian and Frequentist spatial panel data econometric techniques to validate the theoretical model and to perform inference on the relationship between population size and government spending. Importantly, our empirical strategy, which relies on the estimation of a spatial panel data model with fixed effects and non-linearities in the population variable, helps us to solve some of the methodological problems that may affect the validity of the conclusions implied by previous empirical related literature (Bosch and Solé-Ollé, 2005; Hortas-Rico and Salinas, 2014). Unlike Bosch and Solé-Ollé (2005), where the omission of relevant spatial interaction terms could lead to bias/inconsistent and inefficient estimates (LeSage and Pace, 2009; Elhorst, 2014), we estimate a panel data version of the Spatial Durbin Model (SDM) which allows to quantify with accuracy the magnitude of spatial spillovers, thus minimizing the possibilities of overstating or under-estimating the optimal municipal size in this context. On the other hand, our analysis displays

the number of municipalities decreased from 1033 to 325. Similarly, the number of municipalities in Germany went down from 16,127 initial municipalities to 11,091 during 1991 to 2015. A similar case is that of Switzerland, where the number of municipalities decreased from 3,203 in 1850 to 2,352 in 2014. For a more detailed review see Steiner *et al.* (2016).

two key advantages when compared to the cross-sectional analysis based on the General Nesting Spatial Model (GNSM) of Hortas-Rico and Salinas (2014). First, unlike the GNSM, the SDM does not suffer from parameter identification issues (Elhorst, 2012). Additionally, the employment of panel data allows us to control for unobserved spatial heterogeneity by introducing municipal fixed effects, which decreases the risk of obtaining biased estimation results. [4]

Finally, we consider the conditional effects of geographical heterogeneity - a special case of unobserved heterogeneity where parameters are not geographically homogeneous - on the determination of the optimal size of municipalities by means of two different variables: an index measuring the ruggedness of the terrain, and its mean elevation.

The rest of the paper proceeds as follows. The next section presents a brief review of the literature. The theoretical model is developed in the third section, while the econometric strategy and the data used in the empirical analysis are discussed in the fourth section. The fifth section presents the main empirical results of the paper. Finally, in the last section, we conclude.

2 Literature Review

According to the Fiscal Federalism literature, the decentralization of public services to sub-central governments allows, in the absence of externalities and economies of scale, a better adaptation of public policies to local preferences and needs (Oates, 1972), so that resources will be allocated with the greatest efficiency, accountability and responsiveness. On the one hand, sub-central governments are better informed than the central government in relation to local preferences, leading to a clear efficiency gain from delivering services in a decentralized fashion. Smaller government units may also stimulate competition between local jurisdictions for mobile residents and tax bases that will induce them to offer the best possible mix of taxes and services (Tiebout, 1956). On the other hand, citizens' participation, democratic control and the process of accountability also improve under a decentralized system, where the dominance of special-interest groups over citizens' participation are less likely

[4] The empirical analysis carried out here presents some similarities with respect to Bastida *et al.* (2013) and Rios *et al.* (2017), as they also employ spatial econometric techniques to model local government spending. However, they do not focus on the link between population and spending. Rios *et al.* (2017) control for population density but does not include population and Bastida *et al.* (2013) do not consider the possibility of a non-linear effect.

to happen (Seabright, 1996; Inman and Rubinfeld, 1997; Oates, 2005; Hindriks and Lockwood, 2005). However, these positive effects might be offset by a number of negative impacts. In particular, as the size of jurisdictions decreases, economies of scale diminish and there is a greater likelihood of external effects on the provision of goods and services, leading to efficiency losses. Therefore, the optimal jurisdiction size is determined by a trade-off between scale economies and internalized spillovers on the one hand, and efficiency losses from heterogeneous preferences and reduced accountability and democracy on the other hand.

In this context, the analysis of the optimal size of local governments is especially important, as evidenced by the growing interest that has emerged in the literature since the seminal work of Oates (1972). Determining the appropriate geographic unit is key to ensuring efficiency in public provision, that is, to minimize the cost of public services. According to the Fiscal Federalism literature, this cost will mainly depend on the existence of (i) economies of scale, (ii) economies of density, and (iii) external effects.

The existence of **(i) economies of scale** can be derived from the existence of economies of scale in production, which will depend on the existence of fixed costs and technology; or consumption, which will depend on the degree of publicity and congestion costs of goods and services (Buchanan; 1965; Allen *et al.*, 1974). In the case of pure public goods (in the Samuelson sense), where there is no rivalry in consumption, an increase in the number of users keeping the level of production constant will reduce the cost per inhabitant or per unit of consumption. On the other hand, if the public good is partly rival in consumption, the benefit derived from distributing the cost of provision among a larger number of users will be limited by the existence of congestion costs. In this sense, and following the seminal works of Borcheding and Deacon (1972) and Bergstrom and Goodman (1973), a good number of studies have investigated the effects of population size on the costs of providing local public services, without obtaining conclusive results. The empirical evidence for the Spanish case is relatively scarce and in most cases refers to very specific public services, such as urban transport or garbage collection (Bel, 2011). Bosch and Solé-Ollé (2005) analyse the relationship between population size and the aggregate cost of providing public services in 2003 and conclude that the population level that minimizes these costs is set at 5,000 inhabitants, whereas Hortas-Rico and Salinas (2014), using 2007 data, quantify the efficient scale in 500 inhabitants.

The existence of **(ii) economies of density** also influences the costs of public services, as they imply a decrease in cost per user as population density increases.

In the same vein, a greater dispersion of the population in the territory reduces the use of the density economies associated with public provision, thus increasing costs inefficiently (Carruthers and Ulfarsson, 2003; Hortas-Rico and Solé-Ollé, 2010), either because (i) the number of centres required to provide a certain level of service increases, or (ii) the average distance between service users and facilities increases, rising transportation and infrastructure costs. This is the case of services with a clear spatial dimension, like those based on networks (i.e. sewerage system, public lighting, road maintenance or waste management). However, there are also factors that, at higher population densities, make it necessary to increase the level of output needed to obtain the same level of output in certain areas of expenditure, such as policing or street cleaning (Ladd, 1992).

The costs of local public services may also depend on the existence of **(iii) inter-jurisdictional spending spillovers** that occur when the benefits (or losses) of the public provision in one jurisdiction spread across its boundaries, affecting the welfare of residents in neighbouring locations (see, e.g., Brainard and Dolbear, 1967, and Pauly, 1970). As a result, the spending decisions of a local government will depend on spending policies chosen elsewhere. Another source of inter-jurisdictional strategic interaction occurs when voters use information on their neighbouring jurisdictions' public services and taxes to judge their own government's performance (Salmon, 1987). If voters consider relative performance, rational politicians will do the same and mimic their neighbours' decisions.

Therefore, the existence of economies of scale or density and the external effects on the provision of certain public services can lead to the fact that, when they are provided locally, the size of the jurisdiction is suboptimal and the provision costs are not minimized. However, the centralization of service provision can also lead to higher coordination costs, problems of governance and representation (Dur and Staal, 2008), decrease the degree of government accountability and adaptation of provision to local needs and preferences (Bird and Slack, 2012).

The existing empirical evidence on the optimal size remains limited and, to some extent, controversial. Accordingly, further empirical research is required to clarify the nature of the link between population size and the costs of public services at the local level.

3 Theoretical Framework

The minimum efficient scale in public services provision can be defined as that level of provision that minimizes per capita costs, so that for its estimation it is necessary to determine the corresponding cost function in advance. The main practical drawback is that the empirical estimation of the cost function requires data on the level of output, which is usually unavailable. To solve this problem, it is common in the literature to assume that the provision of public goods and services in a municipality coincides with the level of provision demanded by citizens. Thus, combining in a theoretical model the decision-making process of municipalities and citizens, it is possible to carry out an estimation of the expenditure function of the local public sector without having data on the level of output (Borcheding and Deacon, 1972). From the estimated expenditure function, the parameters corresponding to the cost function can then be identified (Downes and Pogue, 1994).

Thus, we rely on the theoretical framework presented in Borcheding and Deacon (1972), and develop a model that incorporates spatial interactions and spillover effects among neighbouring jurisdictions. In this model economy, technological progress in the production of goods is assumed to be exogenous. The key distinct feature of the model with respect previous work is that includes technological externalities in the production of goods, which implies interdependence among the n municipalities denoted by $i = 1, \ldots, N$. These municipalities have the same production possibilities but they differ because of their spatial locations and their degree of spatial connectivity with the rest of the system.

Consider the following Hicks-neutral Cobb-Douglas production function:

$$Y_{it} = B_{it} K_{it}^{\alpha} \left(L_{it}\right)^{\beta}, \alpha, \beta > 0 \tag{1}$$

where Y is the level of output, K is the level of capital, L is the level of labor, B is the level of technology and the subscript i and t denote the value of the variables for municipality i at period t. We further assume exogenous technological progress such that:

$$B_{it} = \omega_i \prod_{j \neq i}^{N} B_{jt}^{\rho w_{ij}} \tag{2}$$

The global technological level in municipality i at period t, B_{it}, is determined not only by ω_i, which measures the specific level of technological development in i, but also by the level its neighbours B_{jt} which may spill over to economy i. The magnitude of the spillover effect is measured by ρ and w_{ij} specifies the connectivity structures on whether and how much the technology is transmitted from j to i. We assume $W = \frac{w_{ij}}{\sum_{j \neq i}^{N} w_{ij}}$ so that all weights are between 0 and 1. Additionally we assume zero diagonal elements to exclude self-influence. Rewriting previous expression in log form and stacking over i we get:

$$\ln \mathbf{B}_t = \ln \omega + \rho W \ln \mathbf{B}_t = [I_n - \rho W]^{-1} \ln \omega + \frac{1}{1-\rho} \iota_n \tag{3}$$

where ι_n is an $N \times 1$ vector of ones and because of W is row-normalized $[I - \rho W]^{-1} \iota_n = \frac{1}{1-\rho}$. [5] The cost function of each municipality can be obtained after solving the minimization cost problem below:

$$\begin{aligned} MinC_{it} &= w_{it} L_{it} + r_{it} K_{it} \\ st: Y_{it} &= f_i (L_{it}, K_{it}) \end{aligned} \tag{4}$$

where w_{it} represents the wage or price of the labour factor, and r_{it} the price of the capital factor in each municipality i. [6] Solving the previous cost minimization problem allows us to obtain the following cost function:

$$C_{it} = \kappa Y_{it}^{\frac{1}{\alpha+\beta}} B_{it}^{\frac{-1}{\alpha+\beta}} w_{it}^{\frac{\alpha}{\alpha+\beta}} r_{it}^{\frac{\beta}{\alpha+\beta}} \tag{5}$$

where $\kappa = \left[\left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} + \left(\frac{\alpha}{\beta}\right)^{-\frac{\alpha}{\alpha+\beta}} \right]$. This function measures the minimum cost of producing output given w_{it} and r_{it}. However, our interest does not rely in measuring the costs necessary to produce Y_{it}, but in those needed to produce a public service of quality, q_{it}. Therefore, we now establish how the output produced Y_{it}, is transformed into a determined level of public service provision q_{it}. It should be noted that, given the provision level of a public service, the results will not only depend on the degree

[5]Note that $[I_n - \rho W]^{-1} = \sum_r^{\infty} \rho^r W^r = \frac{1}{1-\rho}$ given that $\sum_r^{\infty} W^r \rho = \rho$ and $\sum_r^{\infty} \rho^r = \frac{1}{1-\rho}$ if $|\rho| < 1$.

[6]r_{it} is assumed to be the constant across municipalities, due to the perfect mobility of capital

of congestion in the service, but also in a variety of demographic, social, economic and geographical factors outside the control of the local governments. To take these factors into account, we further assume that quality of the service depends on the level of output Y_{it}, the population N_{it}, which measures the number of users services of the municipality and a set of exogenous cost factors Z_{it}, which would include demographic, social, economic and geographical factors. This relationship can be expressed as:

$$q_{it} = \frac{Y_{it}}{f\left(N_{it}\right) h\left(Z_{it}\right)} \tag{6}$$

where $f\left(.\right)$ and $h\left(.\right)$ are two unknown functions. Plugging Equation (6) into Equation (5) it is possible to obtain the cost function as:

$$C_{it} = \kappa \left[q_{it} f\left(N_{it}\right) h\left(Z_{it}\right)\right]^{\frac{1}{\alpha+\beta}} B_{it}^{\frac{-1}{\alpha+\beta}} w_{it}^{\frac{\alpha}{\alpha+\beta}} r_{it}^{\frac{\beta}{\alpha+\beta}} \tag{7}$$

The empirical estimation of this cost function requires data on the quality of the provision level q_{it} and on the costs C_{it} level. Given the difficulty of having such data available, it is assumed that the level of output of services provided in each municipality is determined by the quantity demanded by the representative voter. The public goods' demand function of this representative voter is assumed to follow a Cobb-Douglas type, which is given by:

$$q_{it}^{r} = A p_{it}^{\eta} y_{it}^{\delta} \tag{8}$$

where q_{it}^{r} denotes the public good/service demand of the representative voter in municipality i, p_{it} represents the tax-price (or the price of the public good) and y_{it} represents disposable income. A is a parameter that measures the individual preferences for the public service and η and δ capture the price-elasticity and the income-elasticity of the demand, respectively. From Equation (8) it follows that the level of quality of the service demanded by the representative voter depends on the price of the public good in municipality i, p_{it} and disposable income, y_{it}. According to the existing literature, the tax-price can be calculated from the percentage of expenditure (per service unit) paid by the representative voter, or from the tax-share (T_{it}^{r}). Specifically, here it is assumed that:

$$p_{it} = T_{it}\left(\frac{C_{it}}{q_{it}}\right) \tag{9}$$

This implies that we can rewrite Equation (8) as:

$$q_{it}^{r} = AT_{it}^{\frac{\eta}{1+\eta}} y_{it}^{\frac{\delta}{1+\eta}} C_{it}^{\frac{\eta}{1+\eta}} \tag{10}$$

Assuming that each municipality provides the amount of service demanded by the representative voter, the local public expenditure per capita G_{it} can be obtained substituting the demand function of Equation (10)in Equation (7):

$$G_{it} = \psi B_{it}^{\frac{\eta-1}{\alpha+\beta}} w_{it}^{\frac{\alpha+\eta}{\alpha+\beta}} r_{it}^{\frac{\beta+\eta}{\alpha+\beta}} T_{it}^{\frac{\eta}{\alpha+\beta}} y_{it}^{\frac{\delta}{\alpha+\beta}} \left[f\left(N_{it}\right) h\left(Z_{it}\right)\right]^{\frac{1+\eta}{\alpha+\beta}} \tag{11}$$

where $\psi = \kappa^{1+\eta} A^{1+\eta}$. Assuming and $h\left(Z_{it}\right) = Z_{it}^{\gamma}$ stacking observations over i and taking logarithms the previous expression becomes:

$$\ln G_t = \varphi + \phi_1 \ln \mathbf{B}_t + \phi_2 \ln \mathbf{w}_t + \phi_3 \ln \mathbf{r}_t + \phi_4 \ln \mathbf{T}_t + \phi_5 \ln \mathbf{y}_t + \phi_6 f\left(\ln \mathbf{N}_t\right) + \phi_7 \ln \mathbf{Z}_t \tag{12}$$

where $\varphi = \ln\left(\psi\right)$, $\phi_1 = \frac{\eta-1}{\alpha+\beta}$, $\phi_2 = \frac{\alpha+\eta}{\alpha+\beta}$, $\phi_3 = \frac{\beta+\eta}{\alpha+\beta}$, $\phi_4 = \frac{\eta}{\alpha+\beta}$, $\phi_5 = \frac{\delta}{\alpha+\beta}$, $\phi_6 = \frac{1+\eta}{\alpha+\beta}$, $\phi_7 = \gamma\frac{1+\eta}{\alpha+\beta}$.

Stacking the parameters in $\Phi = [\phi_2, \ldots, \phi_7]$ and their corresponding covariates in $\ln \mathbf{X}_t = [\ln \mathbf{w}_t, \ldots, \ln \mathbf{Z}_t]$ and using the fact that $\ln \mathbf{B}_t = \left[I_n - \rho W\right]^{-1} \ln \omega_i + \frac{1}{1-\rho}\iota_n$ we get:

$$\ln \mathbf{G}_t \left(I_n - \rho W\right) = \varphi \left(I_n - \rho W\right) + \phi_1 \left[\ln \omega \frac{1}{1-\rho}\right] + \left(I_n - \rho W\right) \Phi X_t \tag{13}$$

which is a Spatial Durbin Model (SDM):

$$\ln \mathbf{G}_t = \tilde{\varphi} + \rho W \ln \mathbf{G}_t + \Phi X_t + \Theta W X_t \tag{14}$$

where $\tilde{\varphi}$ is a vector of heterogeneous intercepts, $\tilde{\varphi}_i = \ln(\psi) + \frac{\ln(\psi)+\phi_1 \ln \omega_i}{1-\rho}$ and Θ is given by $\Theta = -\rho\Phi$. Finally, also note that the estimated spending parameters cannot be identified as cost function parameters (Downes and Pogue, 1994). Cost differentials can be derived from the spending equation assuming that $\alpha + \beta$ equals one. Then, identification of cost function parameters for the cost variables can be achieved if the reduced-form expenditure coefficients are divided by $(1 + \eta)$.

4 Empirical Model

The theoretically-based empirical SDM specification is given by:

$$\ln \mathbf{Y}_t = \mu + \rho W \ln \mathbf{Y}_t + \Phi \ln \mathbf{X}_t + \Theta W \ln \mathbf{X}_t + \epsilon_t \tag{15}$$

where Y_t is a $N \times 1$ vector consisting of observations for the government municipal spending measured for every municipality $i = 1, \ldots, N$ at a particular point in time $t = 1, \ldots, T$, $\mathbf{X}_t$, is an $N \times K$ matrix of exogenous aggregate socioeconomic and economic covariates with associated response parameters Φ contained in a $K \times 1$ vector that are assumed to influence local government spending. $\epsilon_t = (\epsilon_{1t}, \ldots, \epsilon_{Nt})'$ is a $N \times 1$ vector that represents the corresponding disturbance term which is assumed to be i.i.d with zero mean and finite variance σ^2. W is a $N \times N$ matrix of known constants describing the spatial arrangement of the municipalities in the sample. The variable $W \ln \mathbf{Y}_t$ denotes contemporaneous endogenous interaction effects among the dependent variable, ρ is called the spatial auto-regressive coefficient. WX_t is the matrix of exogenous regressors of neighbouring municipalities with its corresponding $K \times 1$ vector of parameters Θ. $\mu = (\mu_1, \ldots, \mu_n)$ is a vector of municipal fixed effects that captures cross-sectional heterogeneity due to differences in technological development and geographical location. The ML estimator is biased when both the number of spatial units and the points in time in the sample go to infinity. However, by providing an asymptotic theory on the distribution of this estimator Lee and Yu (2010) show how to introduce a bias correction procedure that will yield consistent parameter estimates. Thus, the estimator employed in this research to explore the relationship between the population and government is the bias-corrected maximum likelihood BCML developed by Lee and Yu (2010).

Notice that the presence of spatial lags of the dependent and explanatory variables complicates the interpretation of the parameters in Equation (15). Therefore, some caution is required when interpreting the estimated coefficients in the SDM. As it is common in modern spatial econometrics analysis inference is based on a partial derivative interpretation and the computation of direct, indirect and total effects (LeSage and Pace, 2009; LeSage, 2014). The matrix of partial derivatives with respect to a change in a regressor X_k is given by:

$$\frac{\partial Y_t}{\partial X_t^k} = \left[(I - \rho W)^{-1}\right] \left[\mu + \beta^{(k)} + \theta^{(k)} W\right] \tag{16}$$

In this context, *direct effects* (diagonal terms in Equation (16) capture the effect on local government spending in i caused by a unit change in an exogenous variable X_k in i. *Indirect effects* (off-diagonal terms) can be interpreted as the effect of a change in X_k in all other municipalities $j \neq i$ on the spending in i. Finally, *the total effect* is the sum of the direct and indirect impacts.

4.1 Data

The empirical analysis conducted here is based on a sample of 5,556 Spanish municipalities for the period 2003-2011. This eventual sample reflects the availability of budget data. It represents about the 70% of total municipalities and 87% of the whole population. As for the time period covered, the analysis covers three terms-of-office (i.e. 2003, 2007 and 2011). [7] Descriptive statistics, data sources and expected effects of the variables used in this study are provided in Table (A.1) in the Appendix.

The dependent variable, Y

In the present study, we focus on those local responsibilities that we consider to be most directly influenced by scale economies, economies of density, external effects and geography: infrastructure and other facilities (such as sewerage, water supply or street paving and lighting) and certain local services (police protection, street cleaning, refuse collection). In so doing, we analyse the *five expenditure categories* of the municipal budget that include these responsibilities, as well as *total* and *current* local spending. In order to prevent problems of heteroscedasticity, all expenditure variables are measured in per capita terms. [8]

Control variables, X

As explained in the previous section, local public spending depends on both cost and

[7] To obtain a balanced panel in the 2003-2011 interval, we use four year steps, such that the time dimension of our panel is $T = 3$ and the years included are $2003, 2007$ and 2011. We proceed in this way as our aim is to maximize the sample size. The likelihood of measurement errors and the existence of missing values in budget data for the years 2005 and 2006 would have reduced considerably the sample size and the reliability of the data, specially affecting those municipalities with lower populations.

[8] The data used to define the municipal public expenditure have been obtained from the Spanish Local Consolidated Budgets of the Ministry of Finance and Public Administration. The current expenditure measure used here corresponds to operating expenses, as defined by Sections I to IV of the economic classification of local budgets. As such, it includes data on public wages and salaries, purchases of public goods and services, debt service and current transfers. The total spending measure additionally includes capital spending, that is, Sections VI (real investment) and VII (capital transfers) of the economic classification of local budgets. The different spending categories have been constructed according to the functional classification of local budgets. These categories represent about 60 per cent of total local spending and include *General services*, *Community facilities*, *Local police*, and *Basic infrastructures and transport*.

demand factors.

(i) Cost factors The first group of *cost factors* is related to population, responsibilities, input costs and the harshness of the environment. Thus, we first consider total population, which is expected to affect local government spending through economies of scale. The population variable enters the equation with a quadratic term (*population, population*^{2}), so as to account for the possible non-linear relationship between the number of inhabitants in a municipality and its per capita costs. The percentage of population over 65 (*population* $>$ 65) and the percentage of immigrant residents (*migrants*) are also included in the model to approximate both the number of residents with special needs (Ladd and Yinger, 1989) and the adverse conditions that may affect the level of provision necessary to maintain a certain level of service results. Additionally, in Spain, the level of responsibilities of each municipality varies with population size [9]. Consequently, the more responsibilities the municipality assumes, the higher the local public spending should be. To account for this effect - and to avoid that the population variable captures both its effect on costs and the effect of differences in the level of responsibilities- we add three dummies representing the different levels of responsibility (*Responsibility1, Responsibility2, Responsibility3*).

Input costs are include in the model with a wage variable (*wage*), measured as the ratio between total wages and salaries paid and the number of workers at the provincial level. Although these data refer to the private sector, the higher the wage in this sector, the higher the salary should be in the public sector in order to attract workers (Ladd, 1992).

Cost factors also include a set of variables that account for the *harshness of the environment*. First, we consider the number of population clusters (*pop.clusters pc*). This variable captures the spatial distribution of the population among the existing total number of clusters and is likely to affect local government spending through economies of density. The expectation is that the cost of public services is positively influenced by a highly dispersed population (Carruthers and Ulfarsson, 2003; Hortas-Rico and Solé-Ollé, 2010), as spatially extensive developments do not optimize on facility location of certain public services (Carruthers and Ulfarsson, 2008).

Second, the literature on local spending acknowledges the importance of *topogra-*

[9]Specifically, public provision is compulsory for all municipalities in services such as trash collection, street cleaning services, water supply, sewer system and street lighting, among others. Municipalities with a population greater than 5,000 inhabitants, additionally, have to provide parks, public libraries, and solid waste treatment. Municipalities with a population greater than 20,000 have to provide local police and social services. Finally, municipalities with a population higher than 50,000 inhabitants also have to provide public transport and environmental protection

phy in determining the cost of local public services (Bird and Slack, 2013). So far, however, previous empirical studies of the impact of geography on economic outcomes have relied on aggregated and coarse variables (Goerlich and Cantarino, 2010). The development of Geographical Information Systems (GIS) and the availability of digital elevation models allow us to construct different measures that quantify different topographic features of the landscape (i.e. altitude and ruggedness), as shown in the pioneering work by Burchfield *et al.* (2006). The presence of mountains limits accessibility, hence making basic infrastructure and public good provision more costly. In contrast, small-terrain irregularities have the opposite effect, as hillsides where public provision is more costly alternate with flat portions where public provision is less costly. Thus, two additional variables are constructed and included in the empirical specification to account for the impact of physical geography on spending. First, we introduce the mean altitude (*elevation*), to proxy the presence of mountains. Second, we include the *terrain ruggedness index*, to account for the presence of small-scale terrain irregularities.[10] Given the time-invariance of these two variables, they enter the model interacting with the population variable.

(ii) Demand factors

An additional group of control variables accounts for the effect of resources on the *demand for local public services.* On the one hand, we include the *tax-share* as a proxy of the price that residents face for public services. Because property taxes are the major revenue source used by local governments, the tax share is specified as the property tax bill of the representative resident divided by the overall property tax revenues of the municipality. Its coefficient refers to the price elasticity of demand (parameter η in Equation (12)) and is hypothesized to be negative, since the higher the tax bill paid by the resident with a lower average income will be their demand for public goods and services and, therefore, the lower the municipality's level of expenditure. On the other hand, the disposable income of the representative resident includes the average per capita income of each municipality (*income pc*), whose coefficient (parameter δ in Equation (12)) is the income elasticity of demand; and the per capita *transfers* received by each municipality (both current and capital). We expect a positive impact of these variables on local spending, since the higher the income of the representative resident, the greater the demand for public goods and, therefore, the higher the level of expenditure.

Finally, the last group of control variables accounts for the effect of *political factors* on local spending. According to the literature, the management of local public admin-

[10]These variables has been provided by Goerlich and Cantarino (2010).

istration is the result of a combination of political factors (Astworth and Mesquita, 2006; Volkerink and de Haan, 2001). Both partisan politics and political strength influence local spending. Thus, we consider the ideology (*idelology*) and the political strength of the governing party (*gov strength*). Partisan ideology measures the impact of ideological differences on fiscal policy outputs. In Spain, after the 2003 elections, the main parties (i.e. the left-wing "Partido Socialista Obrero Español", and the right-wing "Partido Popular") hold more than half of the mayoral offices. This result held in both the 2007 and the 2011 elections. The remaining majoralties are held by other left-wing parties (Izquierda Unida) regionally-based right-and left-wing parties, as well as local parties and candidates that run as independents, mostly in small municipalities. We categorize the ideology variable for a considerable number of parties with an index ranging from 0 (left) to 10 (right), taken from the Deusto Polls database and in our own revision of electoral programmes. It is commonly argued that left-wing parties favour income redistribution and promote an active role of the Public Sector, which may increase public spending (Tellier, 2006).

The theoretical debate over the influence of government strength on the fiscal situation of public entities is grouped in two different hypotheses. While Roubini and Sachs (1989) or Borge (2005) suggest that coalition governments face higher deficits and spending levels, others have argued that divided governments have a moderating influence on fiscal policy (Alesina and Rosenthal, 1994). We use the share of seats obtained by the ruling party in the local council. This variable is computed applying the electoral D'Hont rule, taking into account the minimum requirements of representation operating in Spain to the votes obtained by the different parties in each municipal election.

4.2 Bayesian Spatial Model Selection

The model in Equation (15) can be contrasted against alternative spatial panel data model specifications such as the *Spatial Lag Model* (SLM), the *Spatial Error Model* (SEM) and the *Spatial Durbin Error Model* (SDEM). Note that the SLM/SDM processes indicate that government spending levels rates are determined by a spatial interaction substantive process across municipalities. In fact, in the SDM endogenous interactions lead to a scenario where changes in one municipality set in motion a sequence of adjustments in (potentially) all units in the sample such that a new long-run equilibrium of spending arises. On the other hand, in the SEM/SDEM case, government spending is a function of a complex set of spatially correlated unobservable factors (Fingleton and López-Bazo (2006)). Hence, the nature of local government interactions in each case differs substantially. As can be checked, the SDM of Equation (15) can be simplified to the SLM by shutting down exogenous interactions $\theta = 0$:

$$Y_t = \mu + \rho W Y_t + X_t \beta + \epsilon_t \tag{17}$$

On the other hand, the SDEM is given by:

$$\begin{aligned} Y_t &= \mu + X_t \beta + W X_t \theta + \upsilon_t \\ \upsilon_t &= \lambda W \upsilon_t + \epsilon_t \end{aligned} \tag{18}$$

while theSpatial Error Model (SEM) containing error term interactions can be expressed as:

$$\begin{aligned} Y_t &= \mu + X_t \beta + \upsilon_t \\ \upsilon_t &= \lambda W \upsilon_t + \epsilon_t \end{aligned} \tag{19}$$

In any case, the estimation of the above models involves the definition of a spatial weights matrix. Indeed, the spatial weights matrix is a relevant source of model uncertainty in spatial econometric empirical analysis. A variety of row-standardized W geographical distance based matrices k-nearest neighbour matrices between the sample municipalities are considered. Specifically, we consider k-nearest neighbour matrices, with k = 5,6,7,8,9,10,11,12,13,13, 15 and 20. In order to choose between different potential specifications of the spatial weight matrix W, as well as to choose between SEM, SLM, SDEM and SDM specifications a Bayesian model comparison approach is applied following Da Silva *et al.* (2015), Rios (2017) and Rios *et al.* (2017). This approach determines the posterior model probabilities (PMP) of the alternative specifications given a particular W, as well as the PMP of different spatial weight matrices given a concrete model specification.

Columns (1) to (4), in Table (1) report the PMP for the different spatial specifications including country fixed effects given alternative specifications of W, which allows the comparison of the different models for each W. Columns (5) to (8) report, for a given spatial specification, the PMP across spatial weight matrices. As shown in Table (1), for all the spatial weight matrices the SDM appears to be best speci-

Table 1: Model Selection.

	Posterior Probabilities Across Spatial Models				Posterior Probabilities Across Spatial Weight Matrices			
Spatial Weight Matrix	SLM	SEM	SDM	SDEM	SLM	SEM	SDM	SDEM
k=5	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=7	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=8	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=9	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=10	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=11	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=12	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=13	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
k=14	0.00	0.00	0.02	0.01	0.00	0.00	1.00	0.00
k=15	0.00	0.00	0.98	0.99	0.00	0.00	1.00	0.00
k=20	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00

Notes: We develop Bayesian Markov Monte Carlo (MCMC) Matlab routines for spatial panels to compute Bayesian posterior model probabilities. We employ the normal-gamma conjugate prior for β, θ and σ and a beta prior for ρ: $\pi(\beta) \sim N(c, T)$, $\pi\left(\frac{1}{\sigma^2}\right) \sim \Gamma(d, v)$, $\pi(\rho) \sim \frac{1}{Beta(a_0, a_0)} \frac{(1+\rho)^{a_0-1}(1-\rho)^{a_0-1}}{2^{2a_0-1}}$. Non-informative diffuse priors for the model parameters $(\tau, \eta, \beta, \theta, \sigma)$. Thus, parameter c are set to zero and T to a very large number $(1e+12)$ which results in a diffuse prior for β, θ, τ, η while diffuse priors for σ are obtained by setting $d = 0$ and $v = 0$. Finally $a_0 = 1.01$.

fication and for the DSDM specification the W matrix with higher PMP is that of 15-nearest neighbours. Importantly, this finding supports the empirical SDM specification including endogenous and exogenous interaction derived from our theoretical framework. The model comparison also reveals that the SEM/SDEM are never the best candidates to describe local government spending interactions patterns, which is in line with contributions of the benefit spillovers literature.

5 Results

5.1 Baseline Results

Table (2) presents the results of the SDM estimation for current spending by means of the BCML estimator using the 15-nearest neighbours W matrix. First of all, it is important to notice that these estimated parameters do not refer to the cost function but to the expenditure function. Nonetheless, the non-significance of the price-elasticity of the demand (i.e., the estimated coefficient of the tax-share) allows us to interpret the estimated spending parameters of the cost variables directly as cost coefficients.

Column (1) reports the own-municipality coefficient estimates and those of the neighbours. As shown in Column (1), the coefficient estimates of the spatially lagged dependent variable WY_t is both positive and significant. This result suggests that the current spending decisions of a local government are influenced by its neighbouring municipalities' spending decisions. The positive effect obtained here is compatible with previous findings of positive benefit spillovers and complementarity in local public goods provision (Bastida et al, 2013; Foucault et al, 2008; Hortas-Rico and Salinas, 2014; Rios et al, 2017).

We now turn to the interpretation of the control variables that fill out vector X. Overall, they are in accordance with the literature and display the expected signs, albeit some of them turn out to be not significant. As mentioned in the previous section, a correct interpretation of the SDM estimates requires to look at the direct, indirect and total effects associated with changes in the set of regressors, instead of focusing on the single estimated parameters reported in Column (1). These effects are reported in Columns (2), (4) and (5), respectively, whereas feedback effects are shown in Column (3). Note that there are some differences between the direct effects and the SDM model coefficient estimates reported in Column (1). Differences between these two measures are due to feedback effects passing through the entire system and ultimately reaching the region of origin. We find that the direct effects are significant for several cost factors (including population, the share of old population and migration), whose impact on spending is negative, whereas all demand factors apart from the tax-share and the ideology exhibit a significant and positive effect on spending. On the other hand, the indirect effects appear to be relevant for all cost factors (with the exception of two of the variables that account for the level of responsibilities). These results show that the amplification phenomenon through space is particularly pronounced as in most of the cases they account for more than half of the total effect, thus corroborating the empirical relevance of spatial spillovers in this context. However, for some other variables (i.e. migrants, the number of population clusters, wages or ideology), the indirect effects have a different sign to that of the direct effect. In fact, in these cases, the indirect effect tend to dominate the direct effect. The interpretation of this result is that if all municipalities $j \neq i$ experience a change in X^k, this will have a stronger effect in i that if only municipality i experiences a change in X^k. This result is consistent with a highly interdependent and open economic environment, where changes in the rest of interacting municipalities of the system are more relevant than single municipal changes.

Table 2: Baseline Estimation Results and Effect Decomposition.

Variable	Coefficient (1)	Direct Effects (2)	Feedback Effects (3)	Indirect Effects (4)	Total Effects (5)
Ln Population	-0.558***	-0.593***	6.278%	-1.417***	-2.009***
(Ln Population)^2	0.002	0.005	ns	0.110***	0.115***
Responsibility 1	0.060	0.056	ns	-0.159	-0.103
Responsibility 2	0.042	0.036	ns	-0.266	-0.230
Responsibility 3	0.026	0.007	ns	-0.782**	-0.775*
Population < 65 (%)	-0.002***	-0.002***	15.86%	-0.012***	-0.014***
Migration (%)	-0.002***	-0.002***	-30.41%	0.031***	0.029***
Ln Wages	-0.076	-0.074	ns	0.165*	0.091**
Ln Pop. clusters pc	-0.009	-0.008	ns	0.056**	0.048*
Ln income pc	0.010**	0.010***	5.07%	0.020	0.030*
Tax-share	-0.003	-0.002	ns	0.039	0.037
Ln Current Transfers pc	0.260***	0.271***	4.306%	0.454***	0.724***
Ln Capital Transfers pc	0.011***	0.010***	-0.94%	-0.004	0.006
Ln Ideology	0.005	0.003	ns	-0.050***	-0.047***
Govt strength	0.000**	0.000***	11.84%	0.001	0.002*
Neighbour's Ln Pop	-0.191				
Neighbour's (Ln Pop)^2	0.041***				
Neighbour's Responsibility 1	-0.097				
Neighbour's Responsibility 2	-0.127				
Neighbour's Responsibility 3	-0.318				
Neighbour's Pop.< 65	-0.003***				
Neighbour's Migration	0.013***				
Neighbour's Ln Pop. clusters pc	0.027*				
Neighbour's Ln income pc	0.002				
Neighbour's Ln Wages	0.111				
Neighbour's Tax-share	0.017				
Neighbour's Ln C-Transfers pc	0.012				
Neighbour's Ln K-Transfers pc	-0.008**				
Neighbour's Ln Ideology	-0.022***				
Neighbour's Govt strength	0.000				
Neighbour's Govt Spending	0.625***				
R-squared	0.909				
Log-Likelihood	8753.750				
Sigma	0.028				

Dependent variable: Per capita current spending. Notes: ns denotes not significant, * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Inferences regarding the statistical significance of these effects are based on the variation of 1000 simulated parameter combinations drawn from the variance-covariance matrix implied by the BCML estimates. The results are obtained using the 15 nearest neighbour's spatial weights matrix

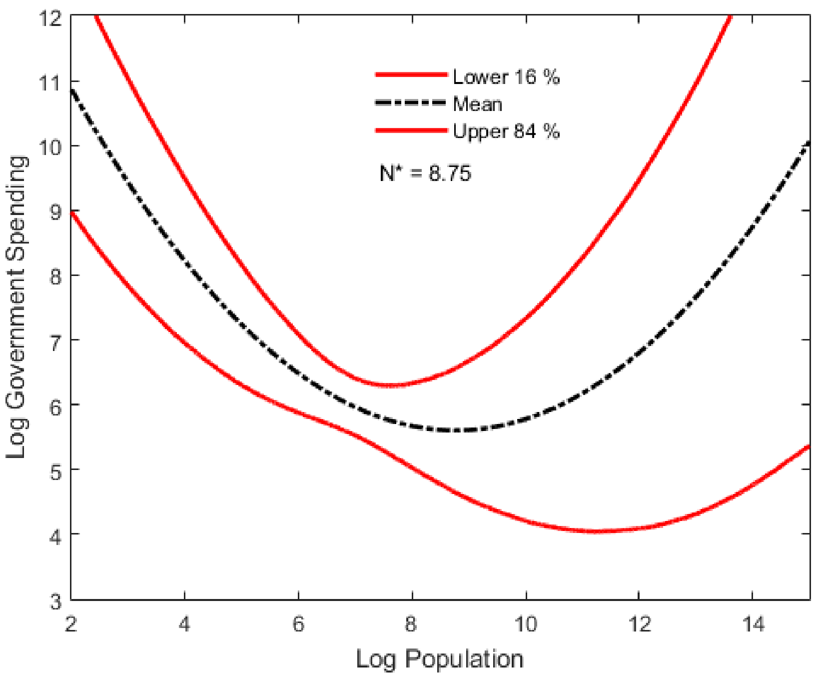
As mentioned above, the sum of direct and indirect effects allows us to quantify the total effect of the different control variables on government spending. When direct and indirect effects are jointly taken into account, Table (2) indicates that the total effect is statistically significant in the all cases but the level of responsibilities, the tax-share and per capita capital transfers.

Let us now focus on the results for the variables of primary interest, i.e. those relating to population size and the existence of economies of scale. Our findings reveal that the relationship between population and government spending is non-linear and describes a U-shaped pattern: current spending decreases with population and increases with the squared of the population. This result confirms the empirical evidence provided by Bosch and Solé-Ollé (2005) and Hortas-Rico and Salinas (2014), who also observed the existence of scale economies for municipalities with low population levels. Given the log-log specification, the estimated total effects for the linear term (-2.099) and the squared term (0.115) can be interpreted as elasticities, and the turning point N* can be obtained after solving the condition for the minimum. Our estimates imply an optimal municipal size of $\exp(8.75) \approx 6,323.61$ inhabitants. [11] Accordingly, the per capita spending of a given municipality may decrease due to the economies of scale up to a level of 6,323 inhabitants. In particular, a 1% increase in population leads to a 2% decrease in per capita current pending. Beyond this point, the per capita current spending rises with population. That is, at populations above 6,323 inhabitants, a 1% increase in population leads to a 0,115% increase in per capita current spending. Overall, our findings provide evidence of the existence of economies of scale in local public goods provision as long as the municipality does not exceed a critical size. Beyond that population cut-off, diseconomies of scale arise. Figure (1) shows the predicted relationship between the natural logarithm of population and the natural logarithm of spending per capita in the interval ranging from 0 to 3.5 million inhabitants implied by a Monte Carlo simulation of 10,000 draws from the estimated

[11] The equation implied by our estimates is $-2.099 + 0.115 * 2N* = 0$.

effects and the corresponding 84% and 16% confidence intervals.[12]

Figure 1: Optimal Local Government Size



Our estimates display a slightly higher efficient scale than the threshold of Bosch and Solé-Ollé (2005), who find that there are economies of scale for municipalities below 5,000 inhabitants and a considerably higher threshold than that of Hortas-Rico and Salinas (2014), who quantify the optimal scale in 500 inhabitants. It is important to highlight that Figure (1) shows the existence of a much higher level of uncertainty regarding dis-economies of scale for municipalities above the 6,323 inhabitants than economies of scale for municipalities under that level of population. This is reflected in the wider confidence bands for the relationship between population and spending per capita, specially once we consider municipalities above $exp(11) \approx 59,874$ inhabitants.

[12]To characterize the relationship between population and expenditure we use the fact that the model's predicted level of spending can be decomposed as follows:

$$\hat{Y}_{it} = \eta_Y + \left(\ln N_{it} - \bar{N}_t\right) \hat{TE}_N + \left((\ln N_{it})^2 - (\bar{N}_t)^2\right) \hat{TE}_{N^2} \tag{20}$$

where Y denotes spending per capita, $\eta_y = \hat{\mu}_i + \sum_k \left(X_{it}^k - \bar{X}_t\right) \hat{TE}^k$ is the spending per capita explained by factors contained in X and the fixed effects, TE denotes total effects and N denotes the level of population. Hence, drawing many times $d = 1, \ldots, D$, from the empirical distributions of η_y^d and total effects $\hat{TE}_N^d$, $\hat{TE}_{N^2}^d$ and multiplying by a vector ν that spans over the interval that ranges from 0 to 3.5 million it is possible to obtain the distribution of Y as a function of all possible values of N:

$$Y^d = \eta_y^d + (\nu - \bar{\nu}) \hat{TE}_N^d + \left(\nu^2 - \bar{\nu^2}\right) \hat{TE}_{N^2}^d \tag{21}$$

Nevertheless, this higher level of uncertainty is consistent with previous findings of Bosch and Solé-Ollé (2005) and Hortas-Rico and Salinas (2014).[13]

We estimate the model given by Equation (14) using per capita total spending as the dependent variable. The results obtained are analogous to those for current spending (which have already been explained). We should stress, however, that the critical municipal size slightly increases up to 7,978 inhabitants (see Table A.4. and Figure A.1. in the Appendix). According to the Economic Theory, one should expect a larger optimal size once capital expenditures are also taken into account. Nonetheless, this result can be explained by the fact that local spending in Spain is largely composed of operating expenses. Indeed, in all expenditure functions apart from Basic Infrastructures and Transport, the spending component far exceeds the capital one.

Table (2) also provides interesting information about the different control variables included in matrix X. Regarding the other *cost factors*, we first observe a positive effect of the share of migrants on per capita current spending. This variable is a measure of disadvantaged residents (Ladd and Yinger, 1989). Given that some services, such as health or social services, are mainly provided to this group of people, a municipality with more disadvantaged residents will spend more than other municipalities in providing the same level of these services. On the contrary, the share of old population exhibits a negative effect that may seem counter-intuitive. However, this finding is consistent with previous results of Solé-Ollé (2006) and Rios *et al.* (2017). A plausible explanation for this empirical relationship is that municipalities characterized by older populations also have a less dynamic private sector, which erodes the tax-base and the possibility to finance public spending. The positive relationship between the number of population clusters and spending per capita can be rationalized in terms of the dispersion of the population in the territory and its associated negative effects on density and scale economies (Carruthers and Ulfarsson, 2008; Hortas-Rico and Solé-Ollé, 2010). Additionally, we find a positive effect of provincial wages on spending. As suggested by Ladd (1992), this result may reflect that environments characterized by higher salaries also imply higher costs to attract public sector personnel.

With respect to the *demand factors*, some interesting findings emerge from the results. As expected, per capita income is positively related to local spending, which is in line with previous findings of Hortas-Rico and Salinas (2014), Rios *et al.* (2017) and Solé-Ollé (2006) , and is consistent with the view that the higher the income

[13] Hortas-Rico and Salinas (2014) find that the link between population and spending is highly diffuse above the 500 threshold whereas in Bosch and Solé-Ollé (2005) dis-economies of scale appear between 5,000 and 50,000 inhabitants and no significant effects are obtained in municipalities with populations above 50,000 inhabitants.

of the representative resident, the greater the demand for public goods and services. Similarly, per capita current transfers have a positive effect on spending, with a coefficient that falls within the range established by the literature (see, e.g., Bastida *et al.*,2013; Hortas-Rico and Salinas, 2014; Rios *et al.*,2017). An additional euro of current transfers leads to an increase in spending 72 times higher than that produced by one euro of income, suggesting a strong *flypaper effect*. Interestingly, the effect of ideology on spending is negative as in García-Sánchez *et al.* (2012) but clashes with the results presented in Bastida *et al* (2013) and Rios *et al* (2017), who find an insignificant effect. Nevertheless, this impact is theoretically well grounded given that a higher value reflects the party in government is more right-wing oriented, thus promoting a limited intervention of the government. Finally, the positive effect of a stronger government provides evidence supporting the view that higher electoral margins allow local politicians to expand their budget (Bastida *et al*, 2013).

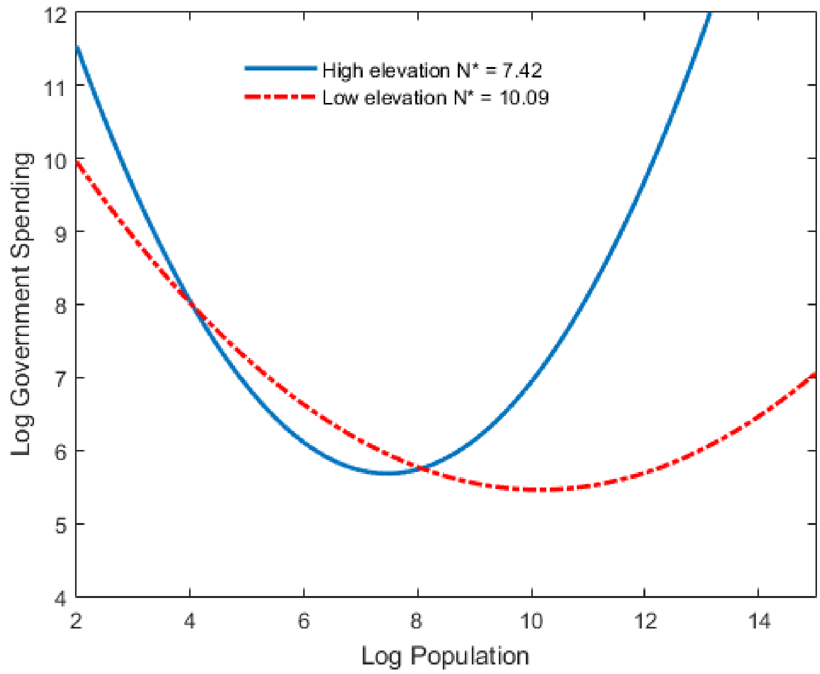
5.2 The role of Geography

Along with the spatial distribution of the population, the physical geography (proxied here with the mean elevation and the terrain ruggedness index) is expected to have an outstanding impact on the cost of providing local public services. Even in the absence of economies of scale, the characteristics of certain public goods force us to consider these variables when determining the optimal size of jurisdictions. This is the case of services with a clear spatial dimension, like those based on networks (i.e. sewerage system, public lighting, road maintenance or waste management). For such services, both the spatial distribution of the population and the physical geography of the municipality determine the geographic contiguity of urban settlements and the connectivity of public service networks (Bel, 2011).

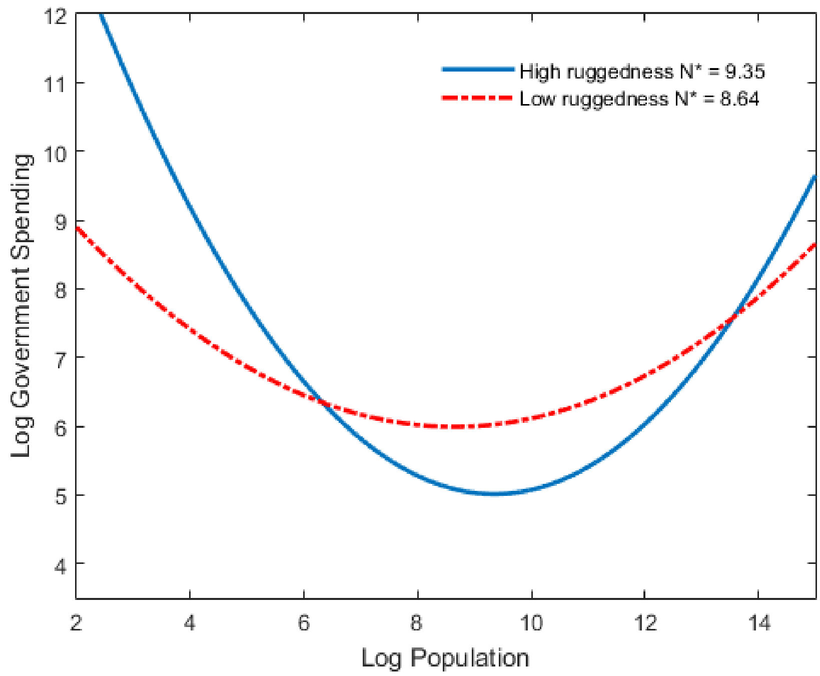
In this section we present a set of additional results where physical geography is included in the model as a cost factor. The time-invariance of both variables has forced us to introduce them in the SDM model interacting with the population function. Hence, the coefficient of these interactions capture the relationship between population size and per capita local spending, conditional on the physical geography of the municipality. Figure (2) displays the estimated efficient scales for municipalities located in high and low altitudes, and for those municipalities with high and low levels of terrain ruggedness.[14] As expected, the findings suggest that the optimal size of municipalities hinges crucially on their topographic characteristics, especially

[14] See also Tables A.2 and A.3 in the Appendix.

Figure 2: The effect of Geography



(a) Elevation



(b) Ruggedness

on elevation. On the one hand, municipalities with a high mean elevation (i.e. those above the median value) exhibit (i) a lower optimal size than those located in lower altitudes (1,670 versus 23,150 inhabitants), and (ii) important diseconomies of scale beyond that point (since costs increase considerably as population rises). It is important to notice that these locations are usually the less populated ones [15]. In this regard, Goerlich and Mas (2008) find that the population follows a spatial pattern of concentration on plains and coastal areas where altitude is lower. Their data show that mountain locations have experienced a depopulation process over time. As a result, the high altitude areas are characterized by a set of small, less accessible and worse connected municipalities where public service delivery becomes more costly and, therefore, their optimal size smaller.

On the other hand, the terrain ruggedness has a non-negligible effect on the efficient scale of jurisdictions, although it is considerably smaller than the role of elevation. Municipalities with a rugged terrain (i.e. those above the median value) can largely benefit from the realisation of economies of scale, as they exhibit a greater optimal size than those located in the plains (11,498 versus 5,654 inhabitants). This result could be explained as follows. According to previous empirical evidence (Burchfield et al, 2006), small-terrain irregularities lead to more urban sprawl. That is to say, those locations with rugged terrain exhibit scattered development and lower population densities. Given that in more rugged locations natural barriers limit the territory available for new urban settlements, it is likely that the population centres tend to cluster in the space (i.e. they concentrate in those plain areas of the municipality where development is less costly)[16], increasing the opportunities for agglomeration economies and economies of scale, and leading to a reduction in the costs of providing public services. On the contrary, the spatial distribution of the population is more compact in plain locations. As it is well known, higher density typically increases public spending, as congestion costs may arise (Ladd, 1992). Thus, there is a need for a smaller optimal size of the jurisdiction that minimizes these congestion costs.

[15] According to our data, about 70 per cent of the municipalities with less than 1,000 inhabitants were included in the high-altitude subsample.

[16] Available data shows that the number of population clusters is higher in rugged locations but, at the same time, the average distance between the population clusters within those municipalities is lower.

5.3 Does the optimal size vary depending on the public service provided?

In this Section we present the estimation results of the population function for the four disaggregated measures of public spending[17]. Figure (3) illustrates the predicted relationship between the natural logarithm of the population function and the natural logarithm of each per capita spending category, according to the estimated effects provided in Table (A.5) in the Appendix. On the one hand, these results suggest a U-shaped relationship between population and costs in all the spending categories except for *Basic Infrastructures and Transport*, where it takes the form of an inverted-U. Thus, there does not appear to be economies of scale with respect to most services once municipalities reach a certain population size. For those services, expenditures per capita actually raise as population increase beyond the critical size, indicating that there are diseconomies of scale. On the other hand, it seems that population has a different impact on local costs, depending on the type of public service under consideration. Economies of scale are specific to the particular public services provided. Thus, there is not one optimal size but many, one for each service.

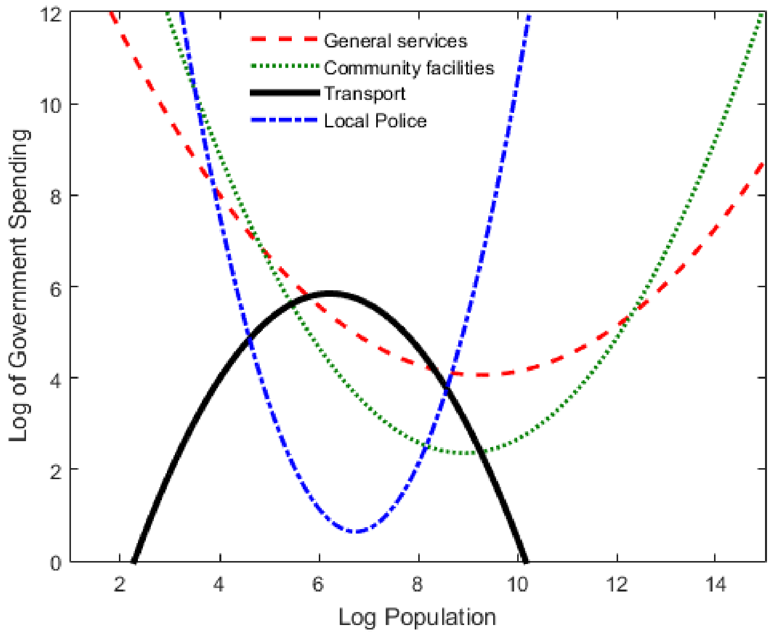
Let us start by discussing the results for *General Services*. Municipalities exploit economies of scale as long as they do not exceed a critical size that, according to the results provided in Table (A.5), is found at $\exp(9.28) \approx 10,764$ inhabitants. That is, in municipalities with less than 10,764 inhabitants, a population increase would significantly reduce costs (perhaps not surprisingly, since costs associated to general services are mainly fixed). Nonetheless, with populations exceeding that critical size diseconomies of scale arise, mainly because of increased bureaucracy, transaction and coordination costs (Bel, 2011).

In the same vein, *Community Facilities* - which include water, street cleaning, refuse collection and cemeteries - exhibit a critical size of $\exp(8.95) \approx 7,702$ inhabitants. A size increase in small municipalities exploits economies of scale, as the fixed costs of those services (capital investments in the acquisition of trash collectors or street sweeper vehicles, among others) are shared among a largest population. Nonetheless, the network-based nature of most of these labour-intensive services increase provision costs once a certain population size is reached.

The optimal size for *Local police* is found at $\exp(6.74) \approx 842$ inhabitants, the lowest scale among all spending categories considered here. According to the literature, this

[17] In order to save space, the estimation results for the control variables are not presented here but available upon request to the authors

Figure 3: Optimal Government Size by Spending Category



type of labour-intensive public services are unlikely to show significant economies of scale and may easily result in diseconomies of scale (Slack and Bird, 2012). Hence, they usually exhibit a lower efficient scale.

Finally, for *Basic Infrastructures and Transport*- which include road maintenance, sewerage, water supply and public transportation-, we find evidence of an inverted U-shaped cost curve. These capital-intensive public services are more efficient in larger government units and, as a result, economies of scale exist as long as municipalities exceed a critical size. In particular, costs per capita start declining with populations over $\exp(10.17) \approx 26,108$.

6 Conclusions

Frequently, the high fragmentation of local governments has been considered as the main source of their inefficient performance, an argument that has become increasingly relevant after the Great Recession. Many academics advocate municipal mergers on the grounds that larger jurisdictions promote efficiency, hence reducing costs and spending. However, evidence on their success is, at best, mixed.

Over the years, a bulk of the literature has focused on the analysis of local public spending efficiency and the optimal size of municipal jurisdictions, yielding to inconclusive results. There is no general answer to the optimal size of the producing jurisdictions and no *one-size-fits-all* model has emerged from this discussion (Bird and Slack, 2008).

This paper seeks to complement previous empirical findings and contribute to our understanding of the dilemmas involved in designing the jurisdiction size of political systems, as it will be highly relevant to policy-makers that deal with these questions in practice. To that aim, our model builds upon similar models commonly used in the literature of local public spending, and incorporates spatial interactions and spillover effects among neighbouring jurisdictions. The model solution leads to Spatial Durbin specification, where local spending is a non-linear function of population size, as well as other cost and demand factors. The population function allows us to determine the existence of (dis)economies of scale in public service provision, whereas the spatial population distribution aims at capturing economies of density. Unlike previous studies, the model incorporates the physical geography among its costs variables. Both the spatial distribution of the population and the physical geography are key cost factors for certain public services, especially in those based on networks, as they determine the geographic contiguity of urban areas and the connectivity of public service networks. Overall, the model allows us to simultaneously test for the significance of the factors that, according to the Fiscal Federalism literature, are crucial for determining the optimal size of local governments (i.e. economies of scale, economies of density, strategic government interactions and spillover effects), and adds the role of physical geography to the debate.

In addition, our empirical analysis employs modern Bayesian and Frequentist spatial panel data econometric techniques to validate the theoretical model and to perform inference on the non-linear relationship between population size and the costs of public services. The use of panel data avoids parameter identification issues and allows us to control for unobserved spatial heterogeneity by introducing municipal fixed effects, hence decreasing the risk of obtaining biased estimation results.

The results provide evidence of a U-shaped relationship between population and local costs. The possibility to realise economies of scale exist as long as the municipality does not exceed a critical size (6,000 - 8,000 inhabitants). Beyond that point, as municipalities' size increases the benefits arising from larger populations decrease. At some point the benefits from exploiting economies of scale would be smaller than the adverse effects of consolidated local governments, such as congestion costs or increased heterogeneity in tastes. In addition, the results indicate that both the spatial distribution of the population and the physical geography have a non-negligible impact on costs. On the one hand, more dispersed populations lead to diseconomies of density, hence increasing costs. On the other hand, the topography (especially the mean elevation of the municipality) is crucial in determining the optimal size of cities. According to these results, policy officials should encourage smaller jurisdictions to merge so as to reach their optimal size. Note that, given the high fragmentation of local governments in Spain, this reform would affect about 86% of municipalities. Nonetheless, a deeper analysis indicates that half of those local entities are located in the mountains, which implies a rather small efficient scale that would prevent them from merging. Finally, our findings suggest that the U-shaped relationship is consistent when evaluating specific service types (i.e. general administration, community facilities and policing). However, scale economies appear service specific, leading to different optimal sizes that range from 842 to 26,100 inhabitants, depending on the public service supplied.

Overall, these findings undermine quests for big mergers. In this context, other institutional options that have emerged as an alternative to mergers should be considered. These include inter-municipal cooperation for joint local service delivery, as it can be limited to certain public services where economies of scale can be achieved with fewer transaction costs and a minimal government restructuring (Bel, 2011). Thus, we believe that our results would help orientating governments' decision-making, as they should facilitate inter-municipal cooperation whenever required, and municipal amalgamation whenever possible.

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Appendix

Table. A.1. Descriptive Statistics.

Variable	Mean (1)	Standard Deviation (2)	Min (3)	Max (4)	Source (5)	Expected Effect (6)
Dependent Variable						
Total Spending pc	1,169.45	909.20	188.36	21,628.64	MPF	
Current Spending pc	688.71	378.50	114.03	8,278.86	MPF	
General Services pc	294.56	327.91	0.00	8,858.63	MPF	
Community Facilities pc	153.81	241.34	0.00	5,461.33	MPF	
Social Services pc	91.53	124.22	0.00	5,369.29	MPF	
Basic infrastructures pc	128.44	348.37	0.00	19,785.40	MPF	
Local Police pc	51.28	162.73	0.00	6,340.22	MPF	
Control Variables						
(i) Cost Factors						
Population	7,085.19	54,472.21	7.00	3.265.038	INE	
Responsibility 1	0.80	0.40	0.00	1.00		+
Responsibility 2	0.14	0.35	0.00	1.00		+
Responsibility 3	0.04	0.19	0.00	1.00		+
Population> 65 (%)	27.11	11.79	0.00	90.0	INE	?
Migrants (%)	6.02	7.34	0.00	77.62	INE	+
Population clusters pc	0.01	0.01	0.00	0.14	INE	+
Wages	25,247.3	3,338.3	18,446.1	35,755.8	INE	+
Elevation	646.00	380.75	2,439.5	0	NGI & GIS	+
Terrain ruggedness index	27.74	21.29	127.76	2.76	Goerlich (2010)	?
(ii) Demand Factors						
Tax-share (%)	0.392	0.730	0.00	14.28	MPF	-
Income per capita	14,543	18, 688.6	1,900	961,100.2	MPF	+
Current Transfers pc	316.45	239.16	0.00	6.790	MPF	+
Capital Transfers pc	307.06	576.57	0.00	24,671	MPF	+
Ideology	5.74	1.911	2.220	8.080	MI & Deusto Polls	-
Government strength (%)	62.33	17.140	18.18	100.000	MI	?

Notes: MPF denotes the Ministry of Public Finance, MI the Ministry of Internal Affairs, INE the National Statistics Institute, NGI the National Geographic Institute, GIS Geographical Information Systems.

Table A.2. Per capita local spending and Terrain Elevation

	Direct Effect	Indirect Effect	Total Effect
Ln Population & High Elev	-0.865***	-2.058***	-2.922***
$(\text{Ln Population})^2$ & High Elev	0.029***	0.168***	0.197***
Ln Population & Low Elev	-0.106	-1.262**	-1.368**
$(\text{Ln Population})^2$ & Low Elev	-0.028***	0.096***	0.068*
Responsibility 1	-0.004	-0.514	-0.517
Responsibility 2	-0.025	-0.655	-0.680
Responsibility 3	-0.030	-1.051**	-1.081**
Population < 65	-0.002***	-0.011***	-0.013***
Migration	-0.002***	0.031***	0.030***
Ln wages	-0.005	0.067***	0.062**
Ln Pop. clusters pc	0.011***	0.025	0.035**
Ln Income pc	-0.069	0.159*	0.089**
Tax-share	0.000	0.035	0.035
Ln Current Transfers pc	0.269***	0.452***	0.721***
Ln Capital Transfers pc	0.010***	-0.006	0.004
Ln Ideology	0.004	-0.040***	-0.036**
Gov Strength	0.000***	0.001	0.002*

Notes: * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Inferences regarding the statistical significance of these effects are based on the variation of 1000 simulated parameter combinations drawn from the variance-covariance matrix implied by the BCML estimates. The results are obtained using the 15 nearest neighbour's spatial weights matrix.

Table A.3. Per capita local spending and Terrain Ruggedness

	Direct Effect	Indirect Effect	Total Effect
Ln Population & High rugg.	-0.885***	-1.833***	-2.718***
(Ln Population)^2 & High rugg.	0.021***	0.124***	0.145***
Ln Population & Low rugg.	-0.225***	-0.915**	-1.140***
(Ln Population)^2 & Low rugg.	-0.019***	0.085***	0.066**
Responsibility 1	0.035	-0.294	-0.259
Responsibility 2	0.019	-0.392	-0.373
Responsibility 3	-0.002	-0.820*	-0.821*
Population $<$ 65	-0.002***	-0.011***	-0.013***
Migration	-0.002***	0.031***	0.030***
Ln wages	-0.008	0.062**	0.054**
Ln Pop. clusters pc	0.009***	0.012	0.021
Ln Income pc	-0.074	0.170*	0.095**
Tax-share	-0.004	0.040*	0.036
Ln Current Transfers pc	0.270***	0.465***	0.735***
Ln Capital Transfers pc	0.011***	-0.003	0.007
Ln Ideology	0.003	-0.054***	-0.051***
Gov Strength	0.000***	0.001	0.002*

Notes: * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Inferences regarding the statistical significance of these effects are based on the variation of 1000 simulated parameter combinations drawn from the variance-covariance matrix implied by the BCML estimates. The results are obtained using the 15 nearest neighbour's spatial weights matrix.

Table A.4. Estimation results for Total Spending

	Direct Effect	Indirect Effect	Total Effect
Ln Population	-0.436***	-1.029***	-1.465***
(Ln Population)^2	-0.008	0.089***	0.082***
Responsibility 1	-0.003	-0.148	-0.151
Responsibility 2	-0.066	-0.265	-0.330
Responsibility 3	-0.059	-0.499	-0.558
Population $<$ 65	-0.002***	-0.006***	-0.008***
Migration (%)	-0.001	0.010***	0.009***
Ln Wages	0.008	0.103***	0.111***
Ln Pop. clusters pc	0.022***	0.020	0.041***
Ln income pc	-0.283**	0.046	-0.237***
Tax-share	-0.016***	-0.013	-0.029
Ln Current Transfers pc	0.283***	0.279***	0.562***
Ln Capital Transfers pc	0.100***	0.008	0.108***
Ln Ideology	0.011*	-0.055***	-0.044**
Govt strength	0.001***	0.001*	0.002**

Notes: significant, * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Inferences regarding the statistical significance of these effects are based on the variation of 1000 simulated parameter combinations drawn from the variance-covariance matrix implied by the BCML estimates. The results are obtained using the 15 nearest neighbour's spatial weights matrix.

Figure A.1. Optimal Local Government Size (Total Spending)

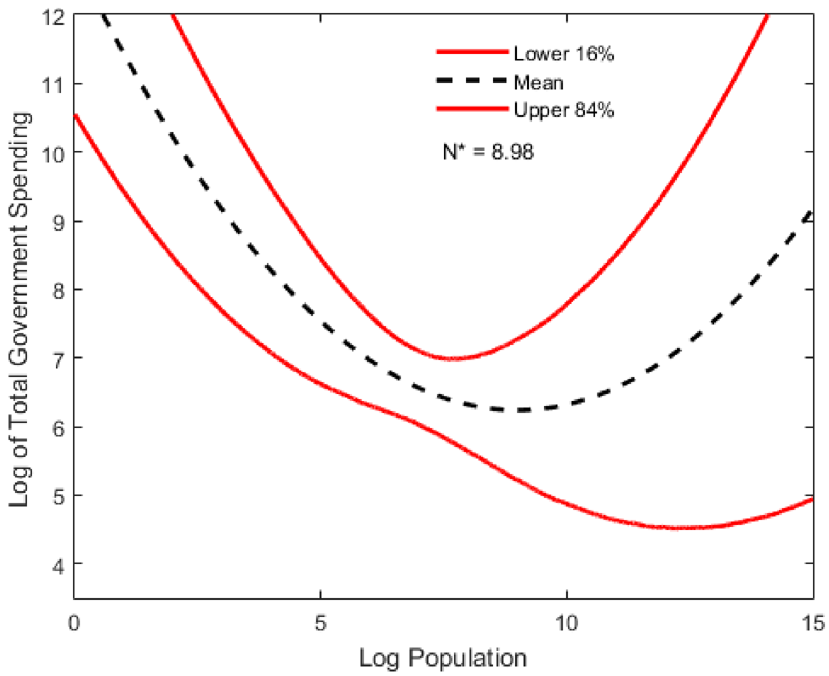

Table A.5. Optimal Local Government Size by Spending Category

	Direct Effect (1)	Indirect Effect (2)	Total Effect (3)	Implied N* (4)	Optimal Size (5)
General Services				9.28	10,764.24
Ln Population	-0.773***	-1.870***	-2.644***		
(Ln Population)^2	0.011	0.131***	0.142***		
Community Facilities				8.95	7,702.53
Ln Population	-1.000***	-3.776**	-4.776***		
(Ln Population)^2	0.042*	0.225*	0.267**		
Local Police				6.74	841.90
Ln Population	-0.895***	-11.419***	-12.315***		
(Ln Population)^2	0.040	0.874	***0.914***		
Infrastructure				10.17	26,108.08
Ln Population	1.283***	3.389**	4.672***		
(Ln Population)^2	-0.158***	-0.217**	-0.375***		

Notes: * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Inferences regarding the statistical significance of these effects are based on the variation of 1,000 simulated parameter combinations drawn from the variance-covariance matrix implied by the BCML estimates. The results are obtained using the 15 nearest neighbour's spatial weights matrix. All the regressions include the set of controls X.