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Expenditure spillovers and fiscal interactions: Empirical evidence from local governments in Spain

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Abstract

The paper presents a framework for measuring spillovers resulting from local expenditure policies. We identify and test for two different types of expenditure spillovers: (i) "benefit spillovers," arising from the provision of local public goods, and (ii) "crowding spillovers," arising from the crowding of facilities by residents in neighboring jurisdictions. Benefit spillovers are accounted for by assuming that the representative resident enjoys the consumption of a local public good in both his own community and in those surrounding it. Crowding spillovers are included by considering that a locality's consumption level is influenced by the population living in the surrounding localities. We estimate a reaction function, with interactions between local governments occurring not only between expenditure levels, but also between neighbors' populations and expenditures. The equation is estimated using data on more than 2500 Spanish local governments for the year 1999. The results show that both types of spillovers are relevant.

Keywords: Local expenditures; Budget spillovers; Spatial econometrics

1. Introduction

Expenditure spillovers are a widespread feature of many services provided by local governments. For example, commuters use roads, public transportation, and recreation and cultural facilities in their working communities. Air pollution controls and sewage treatment enhance the environmental quality of neighboring jurisdictions. Radio and TV broadcasts can be seen away

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from the local border. Educational and job training expenditures may lead to productivity gains in workplaces outside the community. These spillovers have played an important role in the urban economic literature on local government. Its significance is widely recognized in the fiscal federalism literature, but most of the papers in this tradition simply assume the existence of spillovers and analyze their consequences. See, for example, Brainard and Dolbear [9], Pauly [30], Arnott and Grieson [3] and Gordon [20], for the efficiency consequences of expenditure spillovers, and Oates [29], Boskin [8] and Conley and Dix [16] for the implications for the design of optimal federal structures. The general conclusion of this strand of literature is that spillovers cause a divergence between private and social benefits, and thus lead to suboptimal decision-making.[1] Some authors have also worried about the equity consequences of expenditure spillovers, mainly in the context of the demise of US city centers (see Ladd and Yinger [26], for example), but also relating to the design of 'needs-based' equalization grants (Le Grand [27] and Bramley [10]).

However, some skepticism remains about the scale and importance of spillovers (Bramley [10]). This may be due to the lack of empirical studies verifying the existence of spillovers in the provision of local public services. Weisbrod [37] and Greene et al. [21] are classical empirical studies on this topic. The former estimates the extent to which local school expenditures provide benefits to other communities via the migration of educated population. He finds that school expenditure is lower in states with high rates of out migration. The latter quantifies the magnitude of local benefit spillovers in Washington DC, confirming the importance of the problem. Other papers include those by Bramley [10], which quantifies the magnitude of spillovers in recreation services provided by English local governments, and Haughwout [23], which analyses externalities between suburbs and central cities in local infrastructure policy.[2]

More recently, some papers have performed new tests of budget spillovers by looking for interactions between the expenditure levels of neighboring communities. See, for example, Case et al. [15] and Baicker [4] for an analysis of spillovers in state spending.[3] However, the only study of this type using local government data is the one by Murdoch et al. [28]. The results of this paper confirm the strength of interactions among local recreation spending in the Los Angeles metropolitan area. The lack of local expenditure interaction studies is striking, given that spillovers are generally expected to be more pronounced among local governments than at the state level. In fact, as mentioned above, one relevant policy question which fueled academic interest in expenditure spillovers was that of the organization and financing of local governments in metropolitan areas (Greene et al. [21]). The first purpose of this paper is therefore to fill this gap and provide empirical evidence on expenditure spillovers among local governments.

The second purpose of the paper is to be more precise about the exact nature of the local services analyzed and the type of spillover involved. The modeling strategy of previous papers

[1] In the case of positive spillovers, social benefits are higher than private ones and the service is underprovided. The general policy prescribed for dealing with this problem is a matching grant provided by a higher layer of government (Dalhby [17]). Other possible methods for internalizing spillovers are boundary reforms, assignment of capacity to tax non-residents, voluntary agreements, and the creation of a higher tier of government that enforces co-operation between communities (Haughwout [23]).

[2] There is also an independent strand of literature providing evidence on externalities in crime prevention (Furlog and Mehay [19] and Hakim et al. [22]).

[3] These papers can be included within a broader strand of empirical literature analyzing strategic interactions between subnational governments (see Brueckner [12] for a survey), but most of them focus on tax interactions (Besley and Case [5], Brett and Pinkse [11], Buettner, [14] and Brueckner and Saavedra [13]) and welfare competition (Saavedra [33] and Figlio et al. [18]).

on spending interactions is to consider that the representative resident obtains utility both from expenditure in the community of residence and in the neighborhood. This allows a reaction function for expenditure in one community vis-á-vis expenditure in other communities to be derived, which can be estimated after controlling for other variables (e.g., population, cost drivers and preferences in the community itself). However, although this strategy may be appropriate in the case of pure (non-rival) public goods, it may be not useful in the case of congestible services. In the case of commuting spillovers, for example, residents in one community enjoy services provided by others (e.g., roads, parks and other recreation facilities) but they simultaneously crowd these facilities. This second effect has not been taken into account in previous empirical analyses.

Therefore, following on from Conley and Dix [16] we shall differentiate between two types of expenditure spillovers: (i) “benefit spillovers,” arising from the provision of local public goods, and (ii) “crowding spillovers,” arising from the crowding of facilities by residents in neighboring jurisdictions. The introduction of crowding spillovers in the model has implications for the specification of the expenditure reaction function, since the neighbor’s covariates (e.g., population, cost drivers) should now also be included in the equation. Failure to control for neighbor’s covariates may result in false inferences. Given that the neighbor’s expenditures and covariates might be correlated, the omission of these variables will result in biased estimates of expenditure interaction effects. It may also be interesting in itself to ascertain the effects of the neighbor’s externalities on local spending, as the estimates may help to design ‘needs-based’ equalization grants (Bramley [10]).

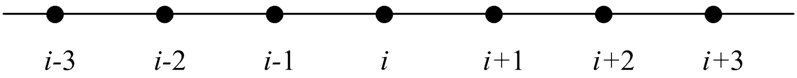
In short, the paper will estimate expenditure reaction functions, searching for interactions between expenditures of neighboring governments and for interactions between expenditures and other neighbors’ covariates. The results will shed light on the strength and type of spillovers—“benefit spillovers” and “crowding spillovers.” The equation will be estimated using data on twenty eight metropolitan areas and more than 2500 Spanish local government bodies for the year 1999. The remainder of the paper is organized into four sections. In the next section, we present the theoretical framework that allows us to account for the two types of spillovers and derive the empirical predictions. This is followed by a discussion of the estimation procedure and the data set used, and by a presentation of the results. Some concluding remarks are given in the final section.

2. Theoretical framework

Following on from Conley and Dix [16], we identify two main types of expenditure spillovers. On the one hand, there are spillovers of local public goods, which occur when a fraction of the local public good produced in one jurisdiction is used by residents in surrounding jurisdictions, and is a perfect substitute for their own provision of public goods. Radio or TV broadcasting is a good example of this category, which we will henceforth name “benefit spillovers.” There are also “crowding spillovers,” which are not a consequence of the provision of public goods, but from the crowding of facilities by residents in neighboring jurisdictions. The crowding of museums and parks by commuters and other visitors is a typical example of this externality. If the good is congestible, both types of spillovers could appear at the same time. In the remainder of this section, we will develop a theoretical framework in order to differentiate the empirical predictions arising from the two different types of spillovers.

2.1. The nature of spillovers

For illustrative purposes, we assume that communities are located on a line, so that each has two neighbors, one on each side. We henceforth denote a community with i, and its left and right neighbors with $i-1$ and $i+1$, respectively. The neighbors of $i-1$ will be $i-2$ and i, and those of $i+1$ will be i and $i+2$, and so on, as shown in the following simple diagram:



"Benefit spillovers" are modeled by assuming that the public goods enjoyed by the representative resident in i $(\tilde{z}_i)$ are the (weighted) sum of those provided by his community of residence (z_i) and by its neighbors. For the moment, we allow utility to be derived only from the services provided by first-order neighbors (z_{i-1} and z_{i+1}). Therefore

$$\tilde{z}_i = z_i + \theta(z_{i-1} + z_{i+1}), \tag{1}$$

where θ is the weight of public goods provided by neighbors in the representative resident's consumption. We assume that θ is a constant and is equal across communities. We are therefore analyzing a symmetrical case, in which spillover flows are of the same magnitude regardless of their direction.[4] Once this assumption is made, it is also easy to accept that $\theta \leqslant 1$, which means that people tend to consume more public goods in their jurisdiction of residence than outside it.

With congestion, the provision technology of the public good may be represented as:

$$z_i = z(E_i, \widetilde{N}_i, c_i), \tag{2}$$

where E_i is expenditure, $\widetilde{N}_i$ is the number of consumers of public goods and c_i is a cost driver. The signs of the derivatives are clear-cut from the literature; we should expect $z_E > 0$ and $z_c < 0$, while $z_{\widetilde{N}} = 0$ in the case of a pure public good and $z_{\widetilde{N}} < 0$ in the case of a congested public good. To derive some of our results we use a linear provision technology, so we assume that the second derivatives of this function are zero.

Let us now suppose that the residents of a community visit each neighboring community to consume its public goods as well as consuming in their own community. These "crowding spillovers" may be accounted for by assuming that the number of consumers in i is a (weighted) sum of the population in i (N_i) and that of its neighbors. We consider only first-order neighbors (N_{i-1} and N_{i+1}). Therefore

$$\widetilde{N}_i = N_i + \delta(N_{i-1} + N_{i+1}), \tag{3}$$

where δ is the weight of neighbors' population in the number of public good consumers. The number of consumers in the neighboring localities ($\widetilde{N}_{i-1}$ and $\widetilde{N}_{i+1}$) is computed in a similar way. As with θ, we assume that δ is a constant, is equal across communities and is lower than one. This means that the congestion introduced by a non-resident is lower than the one caused by a resident. The parameters θ and δ need not be equal (although the empirical evidence might show that they are indeed equal). We introduce these two parameters in order to analyze the effect of two different sources of externalities. These are "benefit spillovers," which occur when residents

[4] We understand that this is a simplification needed to keep the analysis tractable. However, in the empirical analysis we will allow for different interaction coefficients depending on the rank of the city in the urban system (i.e. city centers vs suburbs).

in one community obtain utility from the provision of public goods by other communities, and "crowding spillovers," which occur when residents in one community visit its neighbors and consume public goods therein. This specification allows for the simultaneous occurrence of both kinds of spillovers and also for the appearance of only one externality type.

By substituting (3) in (2) and the result in (1), we obtain $\tilde{z}_i$ as a function of own expenditure, costs and population, one spatial lag of expenditure and costs, and two spatial lags of population:

$$\begin{aligned}\tilde{z}_i &= z\big(E_i, N_i + \delta(N_{i-1} + N_{i+1}), c_i\big)\\ &\quad + \theta z\big(E_{i-1}, N_{i-1} + \delta(N_{i-2} + N_i), c_{i-1}\big) + \theta z\big(E_{i+1}, N_{i+1} + \delta(N_{i+2} + N_i), c_{i+1}\big)\\ &= z(E_i, E_{i-1}, E_{i+1};\ N_i, N_{i-1}, N_{i+1}, N_{i-2}, N_{i+2};\ c_i, c_{i-1}, c_{i+1}). \qquad (4)\end{aligned}$$

The derivatives of $\tilde{z}_i$ with respect each of these variables are:

$$\begin{aligned}&\frac{\partial \tilde{z}_i}{\partial E_i} = z_E > 0, \qquad \frac{\partial \tilde{z}_i}{\partial E_{i-1}} = \frac{\partial \tilde{z}_i}{\partial E_{i+1}} = \theta z_E \geqslant 0,\\ &\frac{\partial \tilde{z}_i}{\partial N_i} = z_N(1 + 2\theta\delta) < 0, \qquad \frac{\partial \tilde{z}_i}{\partial N_{i-1}} = \frac{\partial \tilde{z}_i}{\partial N_{i+1}} = z_N(\theta + \delta) \leqslant 0,\\ &\frac{\partial \tilde{z}_i}{\partial N_{i-2}} = \frac{\partial \tilde{z}_i}{\partial N_{i+2}} = z_N\theta\delta \leqslant 0,\\ &\frac{\partial \tilde{z}_i}{\partial c_i} = z_C < 0, \qquad \frac{\partial \tilde{z}_i}{\partial c_{i-1}} = \frac{\partial \tilde{z}_i}{\partial c_{i+1}} = \theta z_C \leqslant 0. \qquad (5)\end{aligned}$$

There are two kinds of testable hypotheses that can be devised from these results: exclusion hypotheses and hypotheses on the size of the coefficients of different variables:

Exclusion hypotheses. Note that expression (4) holds when both types of spillovers matter (i.e., if $\theta > 0$ and $\delta > 0$). It is interesting to note, however, that when only "benefit spillovers" matter, neighbor's expenditure and costs affect the level of services, but second-order population does not. That is, if $\delta = 0$ but $\theta > 0$, we have:

$$\frac{\partial \tilde{z}_i}{\partial N_{i-2}} = \frac{\partial \tilde{z}_i}{\partial N_{i+2}} = 0 \quad \text{and} \quad \tilde{z}_i = z(E_i, E_{i-1}, E_{i+1};\ c_i, c_{i-1}, c_{i+1};\ N_i, N_{i-1}, N_{i+1}). \quad (6)$$

When only "crowding externalities" matter neither the first-order neighbor's expenditure and costs nor the second-order population have an effect on the service level. That is, if $\theta = 0$ but $\delta > 0$, we have:

$$\begin{aligned}&\frac{\partial \tilde{z}_i}{\partial E_{i-1}} = \frac{\partial \tilde{z}_i}{\partial E_{i+1}} = \frac{\partial \tilde{z}_i}{\partial N_{i-2}} = \frac{\partial \tilde{z}_i}{\partial N_{i+2}} = \frac{\partial \tilde{z}_i}{\partial c_{i-1}} = \frac{\partial \tilde{z}_i}{\partial c_{i+1}} = 0 \quad \text{and}\\ &\tilde{z}_i = z(E_i;\ c_i;\ N_i, N_{i-1}, N_{i+1}). \qquad (7)\end{aligned}$$

When neither "benefit spillovers" nor "crowding externalities" are relevant we are back to our basic specification of the service level

$$\tilde{z}_i = z(E_i;\ c_i;\ N_i). \qquad (8)$$

Note that expression (8) is nested in expression (7), expression (7) is nested in (6), and (6) in (4). By estimating this equation and testing simple exclusion hypotheses one may therefore be able to ascertain which kind of spillover (if any) matters.

Hypotheses on the size of the coefficients. Note from (5) that the effect of a variable (in absolute value) decreases with distance, provided that $\theta \leqslant 1$ and $\delta \leqslant 1$. That is, the effect of E_{i+1}

(E_{i-1}) is lower than that of E_i, the effect of c_{i+1} (c_{i-1}) is lower than that of c_i, the effect of N_{i+2} (N_{i-2}) is lower than that of N_{i+1} (N_{i-1}), and this latter effect is lower than that of N_i. Moreover, θ coincides both with the ratio between the effects of E_{i+1} (E_{i-1}) and E_i, and with the ratio between the effects of c_{i+1} (c_{i-1}) and c_i:

$$\theta = \frac{\partial \tilde{z}_i/\partial E_{i+1}}{\partial \tilde{z}_i/\partial E_i} = \frac{\partial \tilde{z}_i/\partial E_{i-1}}{\partial \tilde{z}_i/\partial E_i} = \frac{\theta z_E}{z_E} = \frac{\partial \tilde{z}_i/\partial c_{i+1}}{\partial \tilde{z}_i/\partial c_i} = \frac{\partial \tilde{z}_i/\partial c_{i-1}}{\partial \tilde{z}_i/\partial c_i} = \frac{\theta z_C}{z_C}. \tag{9}$$

And once θ is known, δ can be calculated as follows:

$$\delta = \frac{\theta\lambda}{\theta - \lambda}, \quad \text{where } \lambda = \frac{\partial \tilde{z}_i/\partial N_{i+2}}{\partial \tilde{z}_i/\partial N_{i+1}} = \frac{\partial \tilde{z}_i/\partial N_{i-2}}{\partial \tilde{z}_i/\partial N_{i-1}} = \frac{z_N\theta\delta}{z_N(\theta+\delta)} = \frac{\theta\delta}{\theta+\delta}. \tag{10}$$

The problem with this testing methodology is that data on the level of service is not generally available to the researcher. A solution to this problem is to embed equation (4) in a fully specified model of expenditure determination. As we will see in the next section, the hypotheses presented in this section can also apply to this expenditure equation.

2.2. Local government expenditure

We assume that a representative resident of community i derives utility from the consumption of a composite private good (x_i) and the public service $(\tilde{z}_i)$:

$$V(x_i, \tilde{z}_i;\ b_i), \tag{11}$$

where b_i is a preference shifter. The problem of the local government is to maximize the utility of the representative resident (11) subject to the technological constraint (4) and to the budget identity of the representative resident:

$$y_i = x_i + (E_i - G_i)\tau_i, \tag{12}$$

where y_i is the exogenous income of the representative resident, G_i is unconditional grants and other exogenous revenues of the local government, $(E_i - G_i)$ is tax revenues, and τ_i is the share of taxes paid by this representative resident. By substituting (4) and (12) into (11), we obtain the indirect utility function

$$V(E_i, E_{i-1}, E_{i+1};\ N_i, N_{i-1}N_{i+1}, N_{i-2}, N_{i+2};\ c_i, c_{i-1}, c_{i+1};\ \tau_i;\ y_i + G_i.\tau_i;\ b_i). \tag{13}$$

This function relates the level of utility to the expenditures on public goods made by community $i(E_i)$ and its first-order neighbors (E_{i-1} and E_{i+1}), to the population of i (N_i) and various spatial lags of this variable (N_{i-1}, N_{i+1} and N_{i-2}, N_{i+2}), to the cost variables in i (c_i) and its neighbors (c_{i-1} and c_{i+1}), and to the tax-share (τ_i), extended income $(y_i + G_i\tau_i)$ and preference shifters (b_i) of the representative voter.

Community i chooses E_i to maximize V, taking the expenditures made by its neighbors as parametric. The F.O.C. for this problem is:

$$\Gamma = -\mathrm{V}_x\tau_i + \mathrm{V}_{\tilde{z}}\frac{\partial \tilde{z}_i}{\partial E_i} = 0. \tag{14}$$

Implicit in expression (14) is an equation relating expenditure in i to all the other variables included in (13):

$$E_i = f(E_{i-1}, E_{i+1};\ N_i, N_{i-1}, N_{i+1}, N_{i-2}, N_{i+2};\ c_i, c_{i-1}, c_{i+1};\ \tau_i, y_i + G_i\tau_i;\ b_i). \tag{15}$$

This expression says that in the presence of spillovers, the expenditure equation should include neighbors' spending levels (E_{i-1} and E_{i+1}) as well as neighbors' populations (N_{i-1} and N_{i+1}) and neighbors' cost drivers (c_{i-1} and c_{i+1}). Moreover, in the case of population (but not in the case of spending and cost variables), the equation should contain information coming from more distant (second order) neighbors (N_{i-2} and N_{i+2}). To be more precise, one must perform a comparative static analysis of (14) on the testable hypothesis regarding the sign of these variables. The impact on E_i of the change in one of the variables coming from the provision technology (denoted by α) is given by the following expression:

$$\frac{\partial E_i}{\partial \alpha} = -\frac{\partial \Gamma/\partial \alpha}{\Omega}, \tag{16}$$

where $\Omega = \partial \Gamma/\partial E_i$ is the S.O.C. and must be negative for a maximum. The sign of $\partial E_i/\partial \alpha$ therefore depends on that of $\partial \Gamma/\partial \alpha$. The expression of $\partial \Gamma/\partial \alpha$ is obtained by totally differencing (14):

$$\frac{\partial \Gamma}{\partial \alpha} = -\mathrm{V}_{x\tilde{z}}\tau_i \frac{\partial \tilde{z}_i}{\partial \alpha} + \mathrm{V}_{\tilde{z}\tilde{z}} \frac{\partial \tilde{z}_i}{\partial E_i}\frac{\partial \tilde{z}_i}{\partial \alpha} + \mathrm{V}_{\tilde{z}} \frac{\partial^2 \tilde{z}_i}{\partial E_i \partial \alpha}. \tag{17}$$

The sign of this expression is crucial for the results of the comparative static analysis. This sign is clear-cut if we assume that the provision technology $z(\cdot)$ is linear. Then expression (16) reduces to:

$$\frac{\partial E_i}{\partial \alpha} = -\frac{\tau_i(\partial \tilde{z}_i/\partial \alpha)\phi}{\Omega}, \tag{18}$$

where

$$\phi = -\mathrm{V}_{x\tilde{z}} + \mathrm{V}_{\tilde{z}\tilde{z}}(\mathrm{V}_x/\mathrm{V}_{\tilde{z}}). \tag{19}$$

In reaching (19), the F.O.C. in (14) is used in order to eliminate $\partial \tilde{z}_i/\partial E_i$ in (17). Note that $\phi < 0$ when x is a normal good. This condition ensures that the MRS expression declines as x increases holding z fixed, which is required for x to rise with income. The key implication of (18) is that $\partial E_i/\partial \alpha$ has the sign opposite to that of $\partial \tilde{z}_i/\partial \alpha$. For example, E_i falls when E_{i+1} (E_{i-1}) rises. This result is rather intuitive: the effect of E_{i+1} (E_{i-1}) on E_i should be negative in the case of a positive externality, indicating "free-rider" behavior. Another implication of expression (18) is that E_i rises when N_i, $N_{i+1}(N_{i-1})$, $N_{i+2}(N_{i-2})$, c_i and $c_{i+1}(c_{i-1})$ rise.

Note also that, since the expression of $\partial E_i/\partial \alpha$ is that of $\partial \tilde{z}_i/\partial \alpha$ multiplied by a factor (i.e., by $-\tau_i\phi/\Omega$), the same hypotheses that were valid for the $z(\cdot)$ are equally valid for $E(\cdot)$:

Exclusion hypotheses. Note that expression (15) holds when both types of spillovers matter (i.e., if $\theta > 0$ and $\delta > 0$), but comparative statics suggest that when only "benefit spillovers" matter, $\delta = 0$ and the coefficient on N_{i+2} will be zero. Then expression (15) becomes:

$$E_i = f(E_{i-1}, E_{i+1};\ N_i, N_{i-1}, N_{i+1};\ c_i, c_{i-1}, c_{i+1};\ \tau_i, y_i + G_i\tau_i;\ b_i). \tag{20}$$

And when only "crowding spillovers" matter, $\theta = 0$ and then the coefficients on E_{i+1} (E_{i-1}), c_{i+1} (c_{i-1}) and N_{i+2} (N_{i-2}) will be zero. The coefficient on N_{i+1} (N_{i-1}) will still be different from zero. In this case, expression (15) becomes:

$$E_i = f(N_i, N_{i+1}, N_{i-1};\ c_i;\ \tau_i, y_i + G_i.\tau_i;\ b_i). \tag{21}$$

Of course, if none of these types of spillovers matter, then $\theta = 0$ and $\delta = 0$, and we are back to a traditional expenditure equation, without any spatial effects (Borcheding and Deacon [6]):

$$E_i = f(N_i;\ c_i;\ \tau_i, y_i + G_i.\tau_i;\ b_i). \tag{22}$$

Note that expression (22) is nested in expression (21), expression (21) is nested in (20), and (20) in (15). By estimating this equation and testing simple exclusion hypotheses one may therefore be able to ascertain which kind of spillover (if any) matters.

Hypotheses on the sign and size of the coefficients. There are three different kinds of hypotheses of this type that can be tested. First, there are some hypotheses that refer to the sign of the different variables. The results in (18) show that the sign of E_{i+1} (E_{i-1}) should always be the opposite of that of N_{i+1} (N_{i-1}), N_{i+2} (N_{i-2}) and c_{i+1} (c_{i-1}). This result derives from two facts: first, the effect of these variables on the level of service z (see the derivatives in (5)) is the opposite to the one of E_{i+1} (E_{i-1}), and second, the sign of all the variables in the expenditure equation is the opposite to the one in the provision technology equation (as can be checked from (18)). Therefore, the validity of the "spillover" model rests not only on the sign of the expenditure interaction but also on the fact that the interaction with other neighbor's variables should be the opposite to the one obtained for the expenditure.

Second, there are the hypotheses related to the relative size of the parameters. Given the assumptions of $\theta < 1$ and $\delta < 1$, the effect of a variable in Eqs. (15), (20) and (21) decreases with distance. This means that the effect of N_{i+2} (N_{i-2}) should be lower than that of N_{i+1} (N_{i-1}) and the effect of c_{i+1} (c_{i-1}) should be lower than the effect of c_i. In fact, the ratio between the different lags of a variable provide information about the magnitude of the spillover. In Eq. (15), the ratio between the effects of c_{i+1} (c_{i-1}) and c_i provides an estimate of the "benefit spillover" parameter θ:

$$\theta = \frac{\partial E_i/\partial c_{i+1}}{\partial E_i/\partial c_i} = \frac{\partial E_i/\partial c_{i-1}}{\partial E_i/\partial c_i} = \frac{-\theta z_C \tau_i \phi/\Omega}{-z_C \tau_i \phi/\Omega}. \tag{23}$$

And once θ has been obtained, δ can also be identified from the effects of N_{i+1} (N_{i-1}) and N_{i+2} (N_{i-2}):

$$\delta = \frac{\theta\lambda}{\theta - \lambda}, \quad \text{where } \lambda = \frac{\partial E_i/\partial N_{i+2}}{\partial E_i/\partial N_{i+1}} = \frac{\partial E_i/\partial N_{i-2}}{\partial E_i/\partial N_{i-1}} = \frac{-z_N \theta\delta\tau_i\phi/\Omega}{-z_N(\theta+\delta)\tau_i\phi/\Omega} = \frac{\theta\delta}{\theta+\delta}. \tag{24}$$

Since we have assumed that both θ and δ are lower than one, a check of this condition will also provide a reliability test of our model's validity.

In Eq. (21), the ratio between the effects of c_{i+1} (c_{i-1}) and c_i also provides an estimate of the "benefit spillover" parameter θ. In this case, however, there is one additional hypothesis to test, since this ratio should be equal to the ratio between the effects of N_{i+1} (N_{i-1}) and N_i:

$$\theta = \frac{\partial E_i/\partial c_{i+1}}{\partial E_i/\partial c_i} = \frac{\partial E_i/\partial c_{i-1}}{\partial E_i/\partial c_i} = \frac{z_C\theta}{z_C} = \frac{\partial E_i/\partial N_{i+1}}{\partial E_i/\partial N_i} = \frac{\partial E_i/\partial N_{i-1}}{\partial E_i/\partial N_i} = \frac{z_N\theta}{z_N} = \phi. \tag{25}$$

In Eq. (17), the ratio between the effects of N_{i+1} and N_i provides an estimate of the "crowding externalities" parameter δ:

$$\delta = \frac{\partial E_i/\partial N_{i+1}}{\partial E_i/\partial N_i} = \frac{\partial E_i/\partial N_{i-1}}{\partial E_i/\partial N_i} = \frac{z_N\delta}{z_N} = \delta. \tag{26}$$

Third, note that the absolute size of the coefficients of the lagged variables increase with the size of the "spillover" parameters θ and δ. For example, it is clear that the coefficients of E_{i+1} (E_{i-1}) and c_{i+1} (c_{i-1}) grow with θ, and that the coefficients of N_{i+1} (N_{i-1}) and N_{i+2} (N_{i-2}) grow both with θ and δ. If one is able to break the sample of municipalities according to a given rule that identifies two groups of municipalities, one more sensible than the other to the effects of "spillovers," then one would expect higher coefficients for the neighbors' variables in the first group that in the second one.

The way to test our model will therefore consist of various steps. First, we will estimate the equations in (15), (20), (21) and (22) and will test the different exclusion hypotheses involved. Second, we will look at the sign of the different variables and check whether they correspond to those expected. Third, once the correct spillover model has been selected, we will check the robustness of the model with regard to the predictions on the relative magnitude of the parameters, and we will obtain estimates for the two spillover parameters in order to check that they are indeed lower than one. Finally, we will re-estimate our equations for several subsamples of local governments (i.e., rural and urban, suburbs and city centers), grouped according to the expected relevance of the spillover phenomenon.

3. Empirical evidence

3.1. Empirical model

The theoretically-derived equation in (15) is approximated by a linear relationship between spending and its determinants. In order to prevent problems of heteroscedasticity and multicollinearity, we used per capita spending instead of total spending. For the same reason, we used the ratio between first- and second-order neighbors' population and own population—instead of neighbors' population—and we substituted the tax-share τ_i by the tax-price t_i—computed as the product of the tax-share τ_i and $1/N_i$-, including also the squared of the population in the equation.[5] Taking all these aspects into consideration, the estimated equation is:

$$\begin{aligned} e_i = {} & \alpha_1.\mathrm{W}e_i + \alpha_2.N_i + \alpha_3.N_i^2 + \alpha_4.(\mathrm{K}N_i/N_i) + \alpha_5.(\mathrm{K}_2N_i/N_i) + \alpha_6.c_i + \alpha_7.\mathrm{W}c_i \\ & + \alpha_8.t_i + \alpha_9.y_i + \alpha_{10}.g_i.t_i + \alpha_{11}.b_i, \end{aligned} \tag{27}$$

where e_i is per capita spending, $\mathrm{W}e_i$ is first-order neighbors' per capita spending, N_i and N_i^2 are the population and its squared, $\mathrm{K}N_i/N_i$ and K_2N_i/N_i are the ratios between first-order and second-order neighbors' population and own population, c_i is a cost variable and $\mathrm{W}c_i$ measures first-order neighbors' costs, t_i is the tax-price, y_i is per capita income, g_it_i is the product of per capita grants (g_i) and the tax-price,[6] and b_i are preference variables.

W and K are $J \times J$ matrices that identify which are the first-order neighbors of each municipality, with J being the number of municipalities in the sample. The only difference between matrices W and K is that W is row standardized and K is not. This means that $\mathrm{W}e_i$ and $\mathrm{W}c_i$ should be interpreted as the average of per capita spending and costs, respectively, of the municipalities considered as first-order neighbors, while $\mathrm{K}N_i$ is the sum (not the average) of the population of the municipalities considered as first-order neighbors. K_2 is a non-standardized $J \times J$ matrix identifying second-order neighbors', so K_2N_i is the sum of the population considered to be second-order neighbors.[7] Note that, since spending is expressed in per capita terms, it would have no sense to compute neighbors' spending as a sum of per capita spending of several municipalities. This argument does not apply to neighbors' population since, in this case, theory suggest that the magnitude of "crowding externalities" depends on the head count of the population living in the neighborhood.

[5] Note that, after this transformation, the own population coefficients do not pick only the effect of population on the level of service (i.e., congestion effect) but also its effect on the tax bill.

[6] Note that this is equivalent to multiply the overall amount of grants by the tax-share ($g_it_i = G_i\tau_i$).

[7] We delay to Section 4.2 the explanation of the way used to compute these matrices.

This slightly different specification does not alter the procedure presented in the previous section to test the exclusion hypotheses and the hypotheses regarding the sign of the variables. However, the hypotheses regarding the relationship between the size of the population parameters and distance cannot be tested directly, and a computation of the derivatives of E_i with respect to N_i, $\mathrm{K}N_i$ and K_2N_i based on the results of (27) is needed.

3.2. Local governments in Spain

The hypotheses developed above will be tested using data on a cross-section of Spanish local governments. Spanish municipalities have spending responsibilities similar to those in other countries (e.g., water supply, refuse collection and treatment, street cleaning, lighting and paving, parks and recreation, traffic control and public transportation, social services, etc.) with the only exception of education, that is a responsibility of regional governments in Spain. Unfortunately, we did not have access to spending data for each service, so our analysis will be confined to overall spending, leaving detailed service analysis for future work.

Despite of this, we consider that Spain is a good testing ground for our theory, for three different reasons. First, the local layer of government in Spain is highly fragmented. Spain has more than 8000 municipalities, most of them quite small. This fragmentation is not only a rural phenomenon but also an urban one. For example, the metropolitan area of Barcelona (the second city of the country) has more than 100 municipalities. Second, in Spain there are not effective supra-municipal service provision bodies. Regional governments in Spain are quite active, but its geographical area is much bigger than the typical urban agglomeration, metropolitan governments are absent,[8] and voluntary agreements between municipalities are residual or quite ineffective. Third, these services are financed mainly from taxes and unconditional grants. User charges are also relevant, but they use to be much lower than provision costs in most services (e.g., cultural and sports facilities) or cannot be charged in others (e.g., parks). Moreover, tolls are practically inexistent and parking charges are still below the efficient levels. Unconditional grants do not compensate municipalities for the costs created by visitors, and there are very few matching grants that could be considered as an externality-correcting device.

3.3. Data and variables

Equation (27) will be estimated using data on 2610 Spanish municipalities during the year 1999. The budget data comes from a survey on municipal finances undertaken by the Ministry of Economics. Most municipalities with a size higher than 20,000 inhabitants are included in the survey. The survey selects a representative sample for municipalities below this population threshold. However, we had to exclude municipalities with less than 1000 inhabitants because of a lack of income and tax-price data.

The dependent variable is current spending per capita. Spending has been computed from data on municipal outlays, and includes data on wages and salaries, purchases and transfers. Apart from population, we also include a cost measure, personal income, tax-price, grants and preference variables in the equation. The cost variable (c) has been constructed by multiplying

[8] The only remarkable attempt to build a metropolitan government occurred in the urban metropolitan area of Barcelona during the 80's (known as "Corporación Metropolitana de Barcelona"), but this institution was banned by a law of the regional government and its main responsibilities (water transportation and treatment, and public transportation) assigned to two different public agencies.

Table 1
Definition of the variables. Data sources and descriptive statistics

Variable	Definition	Data sources	1999	
			Mean	St. Dev.
Current spending: e_i	Wages, supplies and current transfers (outlays)	Ministry of Economics Municipal database	326.602	147.948
Population: N_i	Census of population	National Institute of Statistics (INE)	13,540	73,358
Cost index: c_i	Prepared by the author using data on wages, land area, immigrants, unemployed, and responsibilities	Salary Statistics (INE), Property Assessment Office, Census data (INE), Spanish Economic Yearbook (‘La Caixa), and weights from Bosch and Solé-Ollé [7]	327.511	621.241
Tax-price: t_i	Prepared by the author using data on population, urban units, number of vehicles, and tax revenues	Ministry of Economics Municipal database, National Institute of Statistics (INE), Property Assessment Office, Spanish Economic Yearbook (‘La Caixa)	75.028	22.425
Personal income per capita: y_i	Estimated personal income per capita	Spanish Economic Yearbook (‘La Caixa),	8.363	1.782
Current grants per capita: $g_i \times t_i$	Current grants per capita multiplied by tax-price	Ministry of Economics Municipal database	153.602	63.390
Share old population: $po_{i,t}$	Population older than 65 over population	National Institute of Statistics (INE)	20.272	7.194
Share young population: $py_{i,t}$	Population younger than 18 over population	National Institute of Statistics (INE)	15.605	3.692

Notes. Budgetary variables and income are measured in Euro; tax-price and population shares in %.

average per capita spending in the sample and a cost index, computed from a set of variables that are available for our sample of municipalities and which have been used in previous analysis of local government costs in Spain (Solé-Ollé [34], Bosch and Solé-Ollé [7]): urbanized land area per capita (*Land*), wage rate in the service sector (*Wage*), unemployed (%*Unemployed*), non-EU immigrants (%*Immigrants*),[9] and an index of service responsibilities (*Responsibilities*). The variable *Land* accounts for the effects of urbanization patterns on costs. The variable *Wage* rate measures input costs.[10] The variables %*Unemployed* and %*Immigrants* measure the effects of density related to poverty and the harshness of the environment (Rothenberg [32]). In order to compute the index of service responsibilities (*Responsibilities*) we used information on spending per head in the various expenditure programs for the municipalities of one of the main regions of the country (Catalunya). This information comes from a special survey carried out by a higher-tier of local government (“Diputación de Barcelona”) in order to compute the amount of spending due, respectively, to compulsory and non-compulsory responsibilities. With this information we are able to compute the average expenditure per capita in the additional responsibilities that municipalities are obliged by law to provide when they surpass the 5000, 20,000 and 50,000

[9] The definition, statistical sources and descriptive statistics of the variables are presented in Table 1.

[10] Unfortunately, wage information is not available at municipal level, and has been computed using provincial data. Given that labor markets are usually much bigger than municipalities this need not be a limitation.

population thresholds.[11] All these variables have been aggregated into a single cost index using the coefficients obtained by Bosch and Solé-Ollé [7] for each of them as weights.[12] This procedure has the advantage of producing a more parsimonious equation to estimate, especially in the case of benefit spillovers, since all the cost variables (if entered alone) should be accompanied by the corresponding first-order neighbor's cost variables.[13]

The tax-price measure (t_i) aims to reflect the high degree of tax exporting in the Spanish case. The three main municipal taxes in Spain are the property tax, the business tax and the motor vehicle tax. In the case of the property tax, the burden of the tax falls partly on non-residents who own houses in the municipality, and partly on the owners of business property. The degree of tax exporting of the business tax is even higher. In the case of companies, the full amount of the tax is probably exported, and in the case of individual owners (e.g., small shops) they can hardly be considered to be the median or representative voter of the municipality. Something similar happens with the motor vehicle tax, since the burden falls partly on the business sector (e.g., trucks, vans, car renting). To account for these tax-exporting possibilities, the tax-price is measured as the ratio between the tax bill of a representative resident in those three taxes and per capita tax revenues in the municipality. The tax bill of a representative resident is computed as the sum of the property tax per urban unit divided by the average size of an urban unit in the sample, and the motor vehicle tax per vehicle divided by the average number of vehicles per capita in the sample. Note that the business tax does not appear in the numerator; we assume that the representative resident is not a business owner. Variation in our tax-price measure is high, ranging from 0.2 to 0.8, which is due mostly to the fact that the business tax base is distributed very unevenly across municipalities.[14]

The income variable (y_i) is personal income per capita in the municipality, since we have not been able to measure the income of the median voter. The variable that measures current grants per capita received by the municipality (g_i) includes the main unconditional transfer received from the central government ("Participación de los Municipios en los Ingresos del Estado") and other minor transfers. This variable has been multiplied by the tax-price $(g_i t_i)$. We include two variables in order to measure the resident's preferences for public goods (b_i): the shares of population older than 65 and younger than 18.

[11] The increases in expenditure at these thresholds are of 6.5, 1.97 and 1.66 per cent, respectively, meaning that our responsibility index takes the value of 1 if the population is lower than 5000, the value of 1.065 if the population is higher than 5000 but lower than 20,000, the value of 1.085 if the population is higher than 20,000 but lower than 50,000, and the value of 1.101 if the population is higher than 50,000.

[12] Bosch and Solé-Ollé [7] estimate a log-linear expenditure equation that allows for identification of the parameters of these variables in the cost function. Some of the variables are measured in logs, so the cost function is multiplicative: $constant \times Wage_i^{0.7} \times Responsibilities_i \times Land_i^{0.05} \times \exp(2 \times \%Unemployed_i) \times \exp(1.2 \times \%Immigrants_i)$. The constant of the cost function can not be identified, so costs have to be measured in relative terms, with an index computed by multiplying the above expression by the population, dividing by the summation of the results across all the municipalities of the sample, and dividing again by the population share of the municipality. See Solé-Ollé [34] and Bosch and Solé-Ollé [7].

[13] However, this two-step procedure may also introduce some biases into the estimation. To check this possibility, we have also the extended version of the model, with each cost variable entering separately and including also the neighbors' variables. The results of both procedures are qualitatively similar, with all the cost variables having a positive impact on expenditure, but the standard errors are higher in the second one. These results are available from the author.

[14] The measure of the tax price could be improved with information on the share of the property and vehicle taxes paid by the business sector. Unfortunately, this information is not available in our case. However, we feel that our measure captures a considerable proportion of the variation in the tax price that can be attributed to tax exporting.

Finally, we included a set of fifty provincial dummies in order to account for unobserved effects common to all the municipalities belonging to the same province. However, according to the results of a Wald test, these dummies were not jointly significant and we decided to drop them from the equation.

3.4. Econometric issues

In this section, we deal with the two main econometric problems that we encounter in the estimation of Eq. (27): the definition of neighboring municipalities and the endogeneity of neighbors' expenditure in the benefit spillovers model.

The first econometric problem concerns the way the neighbors of a municipality are defined. Identification issues allow neither the inclusion of tax interactions for each pair of municipalities, nor of the average value of the sample. Instead, an 'a priori' set of interactions has to be defined and tested. However, as Anselin [1] notes, there is some arbitrariness in the definition of these interactions. It is wise therefore to rely, when this is possible, on insights derived from the theoretical model and on auxiliary evidence. Our model suggests that interactions are derived from expenditure spillovers. Moreover, given the nature of local public services, the channel of transmission of these spillovers is the mobility of residents, which depends heavily on the distance between municipalities. The theoretical model suggests also that the expenditure equation should include first-order neighbors' spending and costs, and first- and second-order neighbors' population. It is not clear, however, how these first- and second-order neighbors should be defined. In fact, we could have included second-order neighbors directly in Eqs. (1) and (3), which define how the benefit and crowding spillovers operate. In this case, the expenditure equation should include first- and second-order neighbors' spending and cost variables, and up to fourth-order neighbors' population. The conclusion is that the number of lags for the population always should be twice the number of lags for spending and cost variables.

This suggests that we have to decide which radius defines first- and second-order neighbors, and which number of lags should be included in each of the neighbors' definitions. Daily mobility patterns in Spain may help us to take these decisions. We know, for example, that in the metropolitan area of Barcelona (the second biggest city in Spain) people travel an average distance of 18.1 km.[15] Moreover, 81% of these journeys are of distances of less than 20 km and 92% are of distances of less than 30 km. As a result of this evidence, we decided to use only one lag and to define first-order neighbors as the municipalities located less than 30 km away, and second-order neighbors as the municipalities located between 30 and 60 km away.[16] In order to account for the fact that the effect of spillovers decays with distance inside this radius, we use inverse distance weights. The matrices K and K_2 of Eq. (27) have elements k_{ij} and $k_{2,ij}$:

$$k_{ij} = \begin{cases} 1/d_{ij}^{\alpha} & \text{if } 0 < d_{ij} \leqslant 30 \text{ km}, \\ 0 & \text{otherwise}, \end{cases} \quad \text{and} \quad k_{2,ij} = \begin{cases} 1/(d_{ij} - 30)^{\alpha} & \text{if } 30 < d_{ij} \leqslant 60 \text{ km}, \\ 0 & \text{otherwise}, \end{cases}$$

where d_{ij} is the distance between municipalities i and j. We tried different values for α, between 0 and 2, but $\alpha = 0.5$ performed better than the others. These two matrices are not row standard-

15 *Enquesta de mobilitiat quotidiana de la Regió Metropolitana de Barcelona*, 2001. This mobility includes all the different modes (job, studies, shopping, etc.) and means (private and public).

16 We also performed the analysis with radius of 20 and 40 km (instead of 30 and 60 km). We also performed the analysis with two of first-order neighbors (15 km and 15 to 30 km) and two of second-order neighbors (30 to 45 km, and 45 to 60 km). In all cases, the results were very similar to those presented in this paper and are available from the author.

ized, contrary to what is usual in the spatial econometrics literature (Anselin [1]). The reason of this is that they are used only to compute neighbors' population and, according to the theory these variables should enter in the equation as the head count of the population residing in the neighborhood and not as the average of the population size of neighbor municipalities.

The matrix W of Eq. (27), used to compute first-order neighbor variables for per capita spending, is simply the matrix K row-standardized. The reason for row-standardization in this case is that it would have no-sense to compute the sum of several per capita spending or cost variables. That is, matrix W has elements w_{ij} computed as:

$$w_{ij} = \begin{cases} (1/d_{ij}^{\alpha})/(\sum_j 1/d_{ij}^{\alpha}) & \text{if } 0 < d_{ij} \leqslant 30 \text{ km}, \\ 0 & \text{otherwise.} \end{cases}$$

Note that the use of distance-based weights in the computation of both K and W has implications for the interpretation of the effects of spatially lagged population, since the effect of increasing the number of inhabitants in the a municipality on spending done in another one depends on the distance between these two municipalities. So, for example, the effect of an increase in the population of a first-order neighbor j and a second-order neighbor l on i's spending can be approximated by:

$$\frac{\partial E_i}{\partial N_j} = \left(-\alpha_1 \beta e_j \frac{N_i}{N_j} + \alpha_4\right)\frac{1}{d_{ij}^{0.5}} \quad \text{and} \quad \frac{\partial E_i}{\partial N_l} = \alpha_5 \frac{1}{(d_{ij} - 30)^{0.5}},$$
$$\text{where } \beta = \frac{1}{\sum_j 1/d_{ij}^{0.5}}. \tag{28}$$

The second econometric problem refers to the endogeneity of $\mathrm{W}e_i$ in Eq. (27): expenditure in municipality i depends on expenditure in j, but expenditure in j also depends on expenditure in i. In order to obtain consistent estimates of the expenditure-interaction parameter, a simultaneous estimation procedure is therefore required. The available procedures are either maximum-likelihood (Anselin [1]) or instrumental variables. I use the latter approach, following the practice of a number of papers in the policy-interactions literature (Besley and Case [5]; Figlio et al. [18]; Brett and Pinkse [11]; Buettner [14]; Baicker [4]). As is standard in this literature, the instruments used will be some of the determinants of neighbors' expenditure: first-order neighbors' tax-price $\mathrm{W}t_i$, personal income per capita $\mathrm{W}y_i$, current grants $\mathrm{W}g_i t_i$, share of old population $\mathrm{W}po_i$, and share of young population $\mathrm{W}py_i$.[17] Since the first-order spatial lags sufficed to explain a considerable portion of neighbors' spending variation in the first-stage regression,[18] we decided not to use further spatial lags of these variables to prevent over-fitting bias (Staiger and Stock [36]). Moreover, the results of the Sargan test suggested that these instruments are not correlated with the error term and are, therefore, valid.

Instrumental variable estimation has the added advantage of ensuring that the correlation in the level of spending is not due to common shocks, since IV estimates are consistent even in the presence of spatial error autocorrelation (as Kelejian and Prucha [25] demonstrate). However, in the case of spatially autocorrelated error terms (i.e., $\varepsilon_{it} = \lambda \mathrm{W}\varepsilon_{it} + u_{it}$), estimates are no longer efficient. To check this possibility, I have used the Anselin and Kelejian [2] version of the

[17] Note that neighbor's population and costs cannot be used as instruments since theory tells us that they should be included as explanatory variables in the expenditure equation.

[18] The F-statistics on the statistical significance of the instruments in the first-stage equation are always higher than 20, which exceeds the rule-of-thumb of 10 suggested by Staiger and Stock [36]. So we must conclude that our instruments are not weak.

Moran's test, which is suitable for testing for spatial autocorrelation in the presence of endogenous regressors. I computed this statistic using both the W and W_2 weights matrices. Although it is not possible to rule out that there is some autocorrelation in the residuals in the expenditure equations without spatially lagged variables, this autocorrelation disappears in the different models that include either the spatially lagged dependent variable or the spatially lagged population. These results suggests that our IV results are both consistent and efficient and that more sophisticated procedures as the GMM method proposed by Kelejian and Prucha [25] will not improve them.

3.5. Results

The results of the estimation of the different models are presented in Tables 2 and 3. Table 2 presents the results of the estimation of different specifications with the full sample of 2610 municipalities. The results of column (a) of Table 2 correspond to the *No-spillovers* model (expression (22)) and show that the different control variables introduced in the equation are able to account for a sizeable proportion of local spending variation (roughly 50%). Moreover, most of these variables are statistically significant and have the anticipated signs, with the proportion of young population being the sole exception to this rule. Local spending decreases and then increases with population. Local spending is higher as production costs increase, and the lower the tax-price, the higher the personal income and transfers received, and the lower the share of old population. All these results are consistent with previous analyses of local spending in Spain (Solé-Ollé [34]; and Bosch and Solé-Ollé [7]). However, it is unclear whether this is the appropriate model, since the results of the *Moran* tests suggest that there is spatial correlation in the error terms, both with the first- and second-order neighbors' matrices. This suggests a possible omission of spatially correlated variables and the need to test whether some of our spillover models are appropriate.

The results of columns (b) to (e) correspond to the *Benefit* + *Crowding spillovers* model. The OLS results of column (b) suggest positive interactions between the spending of neighboring municipalities and a positive effect of first- and second-order neighbors' populations, although these last two coefficients are not statistically significant. The effect of neighbors' costs, contrary to our expectations, is negative and not statistically significant. Things do not improve when second-order neighbors' spending and costs and third-order populations are added (column (c)), meaning that the problem does not seem to lie in the appropriate distance decay for these variables. When we re-estimate by Instrumental Variables, the results greatly improve—see the results of column (d) and note that we still obtain statistically significant spending interactions, although the sign is now negative. The results of the Sargan test at the bottom of the table suggest that the instruments we have used in the estimation are valid.[19] Moreover, the neighbors' cost index now has a positive and significant effect on spending, as suggested by our theoretical model. The results of column (e) tell us that while second-order neighbors' population does have an effect on spending, this is not true of second-order spending and costs, and of third-order neighbors'

[19] Given the high magnitude of the OLS bias implied by change in the sign of the interaction, we wondered if these results were driven by any of the instruments we used. To check this possibility we re-estimated by IV excluding the instruments one-by-one and using a "differences-in-Sargan" statistic (Hayashi [24]) to test for the validity of each instrument. This statistic has been computed as the difference of the Sargan statistics of the equations excluding and including the suspicious instrument, and is distributed as a $\chi^2(K)$ with $K =$ loss of over-identifying restrictions. All the instruments were valid and the results obtained when excluding one of them were not qualitatively different.

Table 2
Estimation of expenditure spillover models: full sample ($J = 2610$)

Variable	No spillovers	Benefit + Crowding spillovers				Benefit spillovers	Crowding spillovers	Spending interactions
	(a) OLS	(b) OLS	(c) OLS	(d) IV	(e) IV	(f) IV	(g) OLS	(h) IV
(i) *Neighbors' variables*								
First-order spending: $\mathrm{W}e_i$	–	0.272	0.255	−0.213	−0.220	−0.224	–	−0.064
		(5.045)***	(4.741)***	(−2.918)***	(−2.741)***	(−3.018)***		(−1.055)
Second-order spending: $\mathrm{W}_2 e_i$	–	–	0.041	–	−0.046	–	–	–
			(0.897)		(−0.631)			
First-order cost index: $\mathrm{W}c_i$	–	−0.077	−0.076	0.302	0.562	0.576	–	–
		(−0.354)	(−0.320)	(2.882)***	(2.841)***	(3.074)***		
Second-order cost index: $\mathrm{W}_2 c_i$	–	–	−0.000	–	-0.032	–	–	–
			(−0.013)		(−0.069)			
First-order population: $\mathrm{K}N_i/N_i$	–	0.913	1.021	1.433	1.468	1.861	1.187	–
		(1.632)	(1.332)	(2.407)***	(2.369)**	(3.150)***	(2.054)**	
Second-order population: $\mathrm{K}_2 N_i/N_i$	–	0.496	0.500	1.0	1.005	–	0.933	–
		(1.532)	(1.641)	(3.147)***	(3.056)***		(2.501)**	
Third-order population: $\mathrm{K}_3 N_i/N_i$	–	–	−0.154	–	−0.058	–	–	–
			(−0.368)		(−0.621)			
(ii) *Cost variables*								
Population: N_i	−0.175	−0.128	−0.125	−0.137	−0.141	−0.158	−0.132	−0.157
	(−3.658)***	(−2.707)***	(−2.723)***	(−1.914)*	(−1.900)*	(−2.214)**	(−2.869)***	(−2.706)***
Population squared: N_i^2	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001
	(1.745)*	(1.899)*	(1.745)*	(1.621)	(1.501)	(1.431)	(1.861)*	(1.786)*
Cost index: c_i	1.008	0.915	0.922	0.919	0.920	0.915	1.002	1.005
	(6.618)***	(5.078)***	(5.112)***	(7.506)***	(7.435)***	(6.948)***	(6.555)***	(7.113)***
(iii) *Voter demand variables*								
Tax-price: t_i	−0.885	−0.712	−0.736	−0.899	−0.910	−0.923	−0.801	−0.924
	(−4.440)***	(−3.392)***	(−3.449)***	(−6.361)***	(−6.029)***	(−6.655)***	(−3.893)***	(−4.269)***
Personal income per capita: y_i	0.027	0.021	0.025	0.030	0.032	0.030	0.027	0.027
	(5.439)***	(5.111)***	(5.239)***	(5.529)***	(5.505)***	(5.489)***	(5.517)***	(4.023)***
Current grants per capita: $g_i t_i$	0.927	0.937	0.915	0.956	0.944	0.956	0.926	0.942
	(5.516)***	(5.495)***	(5.333)***	(6.754)***	(6.632)***	(5.637)***	(5.617)***	(4.967)***
Share old population: $po_{i,t}$	−0.061	−0.053	−0.055	−0.065	−0.066	−0.066	−0.062	−0.059
	(−6.867)***	(−6.117)***	(−6.005)***	(−9.144)***	(−9.051)***	(−9.046)***	(−6.833)***	(−6.002)***
Share young population: $py_{i,t}$	0.029	0.018	0.017	0.022	0.021	0.025	0.032	0.038
	(0.345)	(0.448)	(0.465)	(0.328)	(0.305)	(0.211)	(0.258)	(0.204)
Adjusted R^2	0.502	0.522	0.519	0.488	0.485	0.471	0.514	0.475
White test	4.256	3.336	4.101	4.594	4.115	2.987	5.015	5.651
Moran's I (W)	2.354***	0.214	0.124	0.320	0.284	0.110	1.224	1.984**
Moran's I (W_2)	2.100**	0.584	0.210	0.054	0.110	2.001**	0.214	2.412**
Sargan test	–	–	–	0.000	0.000	0.004	–	0.021

Notes. (1) t-statistics are shown in brackets; (2) $*$, $**$ and $***$ = significantly different from zero at the 90%, 95% and 99% levels. (3) First-order neighbors are those located at a distance d_{ij} less than 30 km; Second-order neighbors are those located between 30 and 60 km; K and K_2 are computed using these criteria and with weights equal to $1/d_{ij}^{0.5}$ and $1/(d_i - 30)^{0.5}$, respectively; W and W_2 are K and K_2 once row-standardized. (4) OLS = Ordinary Least Squares; IV = Instrumental variables, using first-order voter demand variables as instruments: $\mathrm{W}\tau_i$, $\mathrm{W}y_i$, $\mathrm{W}g_i\tau_i$, $\mathrm{W}po_{i,t}$ and $\mathrm{W}py_{i,t}$. (5) White = statistic to test for Heteroskedasticity. (6) *Moran's* I = statistic proposed by Anselin and Kelejian [2] to test for spatial autocorrelation in the residuals, standardized and distributed as a $N(0,1)$. (7) Sargan test = statistic to test for instrument validity, distributed under the null of instrument validity as a $\chi^2(K)$ with K = number of instruments.

populations. Note that these results are fully consistent with the exclusion hypotheses presented in the theoretical section.

In order to check the robustness of these results we show in columns (f) to (h) the estimation of three alternative specifications. The results shown in column (f) correspond to the *Benefit spillovers* model (expression (20)). The only difference of this specification is the exclusion of

Table 3
Benefit + *Crowding* spillovers: *Urban* vs. *Non-Urban* and *Suburbs* vs. *Central* cities

Variable	Urban municipalities ($J = 1315$)		Non-Urban municipalities ($J = 1295$)		Suburbs ($J = 1259$)		City centers ($J = 36$)	
	(a) OLS	(b) IV	(c) OLS	(d) IV	(e) OLS	(f) IV	(g) OLS	(h) IV
(i) *Neighbors' variables*								
First-order spending: We_i	0.491	−0.573	0.184	−0.151	0.540	−0.509	−0.046	−0.128
	(8.756)***	(−2.773)***	(2.876)***	(−1.899)*	(9.100)***	(−2.399)***	(−0.044)	(−0.839)
First-order cost index: Wc_i	−0.183	0.712	0.158	0.125	−0.211	0.735	0.333	−0.284
	(−0.545)	(3.622)***	(3.255)***	(1.877)*	(−0.613)	(7.561)***	(0.620)	(−0.371)
First-order population: KN_i/N_i	0.651	1.789	0.988	1.282	0.380	1.629	119.330	150.926
	(1.900)*	(2.877)***	(1.853)*	(2.023)**	(1.436)	(2.501)***	(1.788)*	(2.384)***
Second-order population: $\mathrm{K}_2 N_i/N_i$	0.243	1.569	0.286	0.646	0.174	1.449	34.289	99.604
	(0.735)	(2.457)***	(0.018)	(1.564)	(0.911)	(2.143)***	(2.631)***	(1.794)*
(ii) *Cost variables*								
Population: N_i	−0.203	−0.183	−0.759	−1.113	−0.478	−0.210	−0.031	−0.093
	(−3.318)***	(−1.935)*	(−0.799)	(−1.045)	(−2.154)**	(−1.887)*	(−0.575)	(−0520)
Population squared: N_i^2	0.002	0.002	0.001	0.001	0.002	0.002	0.000	0.001
	(1.634)	(1.512)	(1.102)	(0.951)	(1.754)*	(1.531)	(0.241)	(0.355)
Cost index: c_i	1.179	1.059	0.878	0.892	1.168	1.397	1.022	1.181
	(5.063)***	(7.574)***	(3.331)***	(6.160)***	(4.995)***	(3.398)***	(1.938)*	(1.707)*
(iii) *Voter demand variables*								
Tax-price: τ_i	−1.114	−1.113	−0.485	−0.674	−1.110	−1.115	−0.951	−0.874
	(−3.189)***	(−5.103)***	(−1.748)*	(−3.376)***	(−3.178)***	(−5.148)***	(−2.114)**	(−1.874)*
Personal income per capita: y_i	0.014	0.034	0.024	0.031	0.013	0.033	0.015	0.047
	(6.001)***	(7.787)***	(7.709)***	(8.239)***	(5.398)***	(7.304)***	(2.996)***	(2.369)**
Current grants per capita: $g_i t_i$	0.792	0.978	0.957	0.912	0.794	0.984	0.785	0.954
	(5.189)***	(5.117)***	(6.075)***	(4.168)***	(5.207)***	(5.611)***	(1.987)**	(2.183)**
Share old population: $po_{i,t}$	−0.064	−0.114	−0.043	−0.048	−0.065	−0.111	−0.045	−0.033
	(−5.963)***	(−7.901)***	(−3.046)***	(−4.845)***	(−5.961)***	(−5.966)***	(−1.422)	(−1.365)
Share young population: $py_{i,t}$	0.023	0.048	0.063	0.026	0.025	0.048	0.020	0.094
	(0.177)	(0.268)	(0.257)	(1.142)	(0.244)	(0.256)	(0.371)	(0.522)
Adjusted R^2	0.572	0.483	0.508	0.473	0.595	0.563	0.480	0.364
White test	5.541	5.510	4.580	4.261	5.688	5.981	5.677	5.559
Moran's I (W)	0.412	0.335	0.455	0.235	0.745	0.555	0.449	0.620
Moran's I (W^2)	0.175	0.058	0.201	0.559	0.659	0.108	0.016	0.077
Sargan test	–	0.001	–	0.000	–	0.002	–	0.000

Note. (1) See Table 2.

Table 4
Estimated *Benefit* and *Crowding* spillovers parameters

Samples	*Benefit* spillovers		*Crowding* externalities	
	θ	z-value	δ	z-value
Full sample	0.329	(4.121)***	0.059	(2.632)***
Urban municipalities	0.675	(4.309)***	0.242	(2.131)**
Non-Urban municipalities	0.141	(1.601)	0.042	(1.578)
Suburbs	0.690	(3.128)***	0.273	(2.671)***
City centers	0	(0.551)	0.461	(1.801)*

Notes. (1) θ computed using expression (23); δ computed using expression (24) for all the samples to the exception of *City centers*; for *City centers*, δ computed using expression (26). (2) The derivatives of spending with respect the different variables used to compute θ and δ use sample-specific values for the estimated coefficients and for the different variables involved. (3) *z-values* distributed as a $N(0,1)$ and computed as the ratio between the value of the coefficient and its standard error; standard errors computed using the formula for the variance of provided in Rao [31]. (4) $*$, $**$ and $***$ = significantly different from zero at the 90%, 95% and 99% levels.

the second-order neighbor's populations. The OLS results are omitted to save space. The IV results are similar to the previous ones (see column (d)), with the relevant coefficients of the same sign and magnitude. However, the explanatory capacity of the model drops a little bit and the t-statistic clearly suggests that second-order neighbor's populations cannot be excluded from the equation. The results in column (h) correspond to the *Crowding* externalities model (expression (21)). The only differences between this specification and the full model (column (d)) is the exclusion of neighbor's spending and costs. The results are quite similar to those of the full model, with first- and second-order neighbor's populations having a positive and significant impact on spending. However, the results suggest that also in this case is not possible to exclude neighbor's spending and costs. Finally, column (h) shows the results of the *Spending Interactions* model. This specification does not correspond to any of the equations developed in the theoretical section. However, we have decided to show the results of this equation to allow the comparison of its performance with the other equations estimated, given that this is the specification used in previous studies (e.g., Case et al. [15] and Baicker [4]). We also omit here the OLS results and go directly to the IV ones, that show that the neighbor's spending coefficient is no longer statistically significant, while the OLS results (not included here) showed a positive and significant coefficient (as in the other OLS results with neighbor's spending included in Table 2). Note also that the *Moran*'s I statistic suggest both first- and second-order residual spatial correlation. Therefore, we should conclude that the *Spending Interactions* model is not the appropriate one.

The check on exclusion constraints presented in the previous section thus suggests that the correct model for including the effects of spillovers is the *Benefit* + *Crowding spillovers* model, which accounts simultaneously for spending interactions and for the effects on local spending of first-order neighbors' costs and first- and second-order neighbors' populations. We can check the robustness of the results by analyzing the additional hypothesis regarding the sign and the relative size of the coefficients developed in the previous section. First, note that, as expected, the sign of the neighbors' spending is negative while that of the neighbors' cost index is positive. Second, the effect of the own cost variable is much higher than the effect of neighbors' costs, as the model suggested. Moreover, we could use expression (28) to compute the derivatives of E_i with respect to first- and second-order neighbor's population. Since these derivatives are, however, contingent on the distance, we compute them at different distances (i.e, 1, 7.5, 15 and 30 km) using the mean sample values of the different variables involved.[20] The values we get for $\partial E_i/\partial N_j$ are 20.38 (1 km), 7.44 (7.5 km), 5.26 (15 km) and 3.72 (30 km) and the value we get for $\partial E_i/\partial N_l$ at 30 km is 1.016. Note that by construction, the effect of first-order population is decreasing in distance. In any case, however, the effect of first-order population at 30 km is three to four times the effect of second-order population at this distance.

Finally, we can use expressions (23) and (24) to compute the *Benefit* and *Crowding spillovers* parameters, respectively. In this case, these parameters take the values of $\theta = 0.33$ and $\delta = 0.059$ and are statistically significant at the 95% level (see Table 4 for a summary of the values of these parameters for different samples).[21] Spillovers therefore not only seem to be relevant, but they are also sizeable. One Euro of local spending provides the same utility to a typical resident as

[20] The values used for the parameters of expression (28) are: $\alpha_1 = 0.213$ (see Table 2), $\beta = 1/7.82$ (with an average distance between municipalities of 10.1 km and an average number of 36 neighbors per municipality), $e_j = 326$ (see Table 1), $N_i/N_j = 2,134$, $\alpha_4 = 1.433$ and $\alpha_5 = 1.016$.

[21] Standard errors have been computed using the formula for the variance provided in Theorem (ii) of Chapter (vi) of Rao [31], which can be expressed as $s_E^2 = \sum_i \nu_{ij}(\partial\chi/\partial a_i)(\partial\chi/\partial a_j)$, where $\chi \equiv (\theta, \delta)$ is the vector of structural parameters and $a \equiv (\partial E/\partial c, \partial E/\partial c_{+1}, \partial E/\partial N, \partial E_{+1}/\partial N_{+2})$ is the vector of estimated coefficients.

three Euro of neighbors' spending, and an additional non-resident living 30 km away leads to the quality of public services in the locality decreasing less than ten times less than an additional resident would.

Table 3 presents the results obtained when breaking the sample into *Urban* and *Non-Urban* municipalities, and when considering the *Suburbs* and the *City centers* separately. There are two intuitions behind this analysis. The first intuition is that if spillovers arise because of the daily mobility of citizens between municipalities, they should be more pronounced in large urban areas, where mobility is also more relevant. The second intuition is that in urban areas, *Benefit spillovers* may be more prevalent in the *Suburbs*, and *Crowding externalities*s may be more important in *City centers*. This is because *City centers* are much bigger than *Suburbs* and play a prominent role as employment and administrative centers. *City centers* therefore usually experience a net inflow of population while *Suburbs* usually experience (on average) a net outflow. It is therefore to be expected that residents in the *Suburbs* tend to benefit more from the services provided in other localities than *City center* residents and, at the same time, we can expect also that the services in the *City centers* are more crowded by non-residents than the services in the *Suburbs*.

To test these hypotheses, we divided our sample into *Urban* and *Non-Urban* areas. In line with previous analyses, urban municipalities were defined as those located less than 35 km from a city center with more than 100,000 inhabitants (Solé-Ollé and Viladecans [35]). Using this procedure, we are able to identify 36 large urban areas that contain 1259 *Suburbs* and 36 *City centers*. We therefore have 1315 *Non-Urban* and 1295 *Urban* municipalities. The results of Table 3 show important differences between *Urban* and *Non-Urban* municipalities. The results for the *Urban* municipalities (columns (a) and (b)) are similar to those presented for the full sample (see Table 2), since both *Benefit* and *Crowding* spillovers matter. However, the size of the coefficients for the neighbor's variables is now bigger than before, suggesting that spillovers are of a higher magnitude. This intuition is confirmed by the identification of the two spillover parameters, since we found that $\theta = 0.67$ and $\delta = 0.24$. These coefficients are statistically significant at the 95% level (see Table 4). It should be remembered that these parameters were 0.33 and 0.059 for the full sample. The results for the *Non-Urban* municipalities (columns (c) and (d)) are similar, but the size of the neighbors' coefficients is lower and some of them are not statistically significant (second-order population) or only statistically significant at the 90% level (first-order neighbors' spending and costs). The value of the spillover coefficients is now much lower, since we found that $\theta = 0.14$ and $\delta = 0.04$, but these coefficients are not statistically significant at conventional levels (see Table 4). We can conclude, therefore, that spillovers are more relevant in *Urban* than in *Non-Urban* areas, as expected.

The results of Table 3 also show significant important differences between *Suburbs* and *City centers*. The results for the *Suburbs* (columns (e) and (f)) are virtually the same as for the full sample of *Urban* municipalities. The results for the *City centers* are different. Both first-order neighbors' spending and costs are not statistically significant, suggesting that *Benefit spillovers* are not present, and that only *Crowding externalities* are relevant. The fact that second-order neighbors' populations have a positive and statistically significant effect does not necessarily contradict this statement, since it may simply mean that the distance decay function may be different for *City centers* than for *Suburbs*. The identification of spillover coefficients confirms these conclusions. For the *Suburbs*, we found that $\theta = 0.69$ and $\delta = 0.27$ while for *City centers*, we found that $\theta = 0$ and $\delta = 0.46$.[22] The coefficients are statistically significant at the 95% level for *Suburbs* but in the case of *City centers* only the δ coefficient is statistically significant at the 90% (see Table 4). These results confirm our expectations. We admit, however, that the results for *City centers* should be taken with caution, given the small number of observations involved and the lower explanatory power of the expenditure equation.

4. Conclusion

The simple model sketched in this paper allowed us to test for the presence of spillovers, confirming that this is a relevant problem in Spain, and that this problem is more acute in *Urban* areas than in the rest of the country. The model allowed us to differentiate between different types of spillovers. We showed that two different kinds of spillovers (*Benefit spillovers* and *Crowding externalities*) should be taken into account in this kind of analysis. Failure to account for one of these types of spillovers leads false inferences being drawn, suggesting either that spillovers are present when they are not or that they are not relevant when they are. Both kinds of spillovers are important in the *Suburbs* but only one type (*Crowding externalities*) is relevant in *City centers*. The model also allowed us to obtain an estimate of the size of each type of spillovers. These results suggest that spillovers are not only present but also are of a considerable magnitude, especially in *Urban* areas. The magnitude of the inefficiencies (and inequities) associated with these spillovers should therefore be a concern for policy-makers.

However, we have to admit that the approach used in the paper may have at least two fundamental weakness that merit some further comments. First, it can be argued that the expenditure interactions generated by the model may also arise as a result of alternative behavioral models. For example, as Brueckner [12] points out, interactions between local governments may also be predicted by the standard tax competition model (Brueckner and Saavedra [13]). Note however that, although the model has not been designed to provide a test against other competing hypotheses, it provides a set of predictions that must be fulfilled by the empirical results in order to accept the spillover story is plausible. These hypotheses refer not only to the statistical significance of spatially lagged expenditure, as in previous analyses (Case et al. [15]), but also to the inclusion of other neighbors' covariates, and to the sign and size of the coefficients of the different variables. Moreover, household fiscal mobility is not seen as a tight constraint on the operation of local governments in Spain. This is the result of the limited scope of Spanish local governments, which do not provide the services that cause the mobility experienced in other countries (e.g., education in the US).

Second, one may wonder to what extent the fiscal interactions identified are driven by the operation of matching grants, user charges, or any other fiscal instruments designed to deal with the externalities, instead of being the result of the reaction of local governments to the spillover's problem. But as we have argued in Section 4.2, Spanish local governments make little use of most of the instruments that use to be recommended to internalize these externalities. And, in any case, if these instruments where used effectively we should observe no interactions between the fiscal choices of neighboring municipalities. Note that, instead of this, we have found evidence of sizeable spillovers. If externality-correcting instruments were present but not fully effective, then the estimated magnitude of the spillovers obtained in the paper should be considered a lower bound of its real value.

[22] Given that $\theta = 0$, in this case we made use of expression (26) to identify δ, using the expression $\partial E_i/\partial N_i = (\alpha_2 N_i - 2\alpha_3 N_i^2) + e_i$.

Therefore, although we acknowledge that further efforts to explicitly test our hypothesis against competing ones are necessary, we therefore consider that the results provided in this paper show some preliminary evidence in favor of our model.

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