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REACTION OR INTERACTION? SPATIAL PROCESS IDENTIFICATION IN MULTI-TIERED GOVERNMENT STRUCTURES

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Reaction or interaction?

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in multi-tiered government structures

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Abstract

This paper models horizontal and vertical fiscal externalities in a multi-tiered structure of government, and implements maximum likelihood (ML) and instrumental variables (IV) estimation techniques to identify the source of spatial dependence in English local government expenditures. The results show that upper tier (County) authority expenditure has two opposite effects on lower tier (District) authority spending decisions. By raising the local property tax burden, Counties reduce resources available to Districts and lower the demand for District services by an estimated elasticity of -0.45. On the other hand, County services are estimated to be complements of District services, with an elasticity of 0.25. Moreover, when vertical fiscal externalities are explicitly taken into account, the estimated magnitude of horizontal fiscal interactions is substantially reduced. The observed positive spatial auto-correlation among Districts can consequently be attributed to a large extent to common reaction to County fiscal policies, rather than to actual strategic interaction.

Keywords: local public expenditure; fiscal externalities; spatial auto-correlation.

1. Introduction

The interest of public economists in spatial processes originating from horizontal fiscal interactions among local governments has grown impressively over the past ten years. This is witnessed by the theoretical and empirical literature reviews by Wilson [37] and Brueckner [15] respectively. In this paper, I wish to point to an issue that seems to be largely unresolved. In their classical book on spatial modelling, Cliff and Ord [19] posed a question that yet waits for an answer in the local public economics domain:

"When we develop a model for a spatial process, we must always ask whether the levels of the process at two (neighboring) sites reflect interaction (between the sites) or reaction to some other variable. The case is rarely open and shut. For example, two adjacent trees may compete for resources (sunlight and nutrients), thus displaying between-tree interactive effects; but they will also react to the general availability of nutrients within the scope of their root systems, thus displaying a regression-like dependence for, say, tree size on the environment. Similarly, two adjacent supermarkets will compete for trade, and yet the turnover will be a function of general factors such as the distribution of population and accessibility." (Cliff and Ord [19]: 141)

While the spatial econometrics literature has produced a number of spatial testing and estimation techniques,[1] most empirical local public finance papers have failed to recognise that local governments operate within an institutional context that can help discriminate between reaction of local authorities to common economic/environmental conditions and actual inter-jurisdictional strategic interaction.

In this paper, I set up a theoretical and empirical framework in order to identify the underlying source of the observed spatial process in fiscal variables, by fully exploiting the multi-tier structure of government that one finds in many countries. I argue that the potential presence of both vertical and horizontal fiscal externalities, far from being a nuisance, can provide the key condition to identify the true source of the observed spatial process.

I focus on the English two-tier structure of local government and set up a model with both horizontal and vertical fiscal interactions. The former has long been studied in the theoretical public finance literature, but only in recent years have its implications been tested empirically. In principle, horizontal interdependencies among local governments can arise from: (1) tax competition for a mobile tax base – usually capital – whereby the tax base that locates in a jurisdiction depends both on own and on nearby jurisdictions' tax rates and other policy variables (such as infrastructure spending and environmental regulations);[2] (2) yardstick competition in an asymmetric information setting, according to which voters use neighboring governments' performances to evaluate their own government, forcing local incumbents to 'mimic' their neighbors;[3] (3) local public expenditure benefit spill-overs.[4]

On the other hand, the vertical fiscal externality argument has received attention among theoretical public economists only in recent years,[5] and the empirical literature in particular is a bit thin.[6] Vertical fiscal externalities can arise for three main reasons.

The first and most popular argument relates to the tax base sharing of authorities at different tiers of government, that is typical of federal countries and most multi-level structures of government. Since authorities at different levels co-occupy the tax base, and as long as the elasticity of the tax base with respect to the tax rate is non zero, each government tends not to take into account the negative externality it inflicts on other governments in terms of tax base drop. Consequently, and contrary to horizontal tax competition, the social marginal cost of public funds exceeds the marginal cost of public funds, and concurrent taxation will typically imply excessive tax rates with respect to socially optimal ones (Hoyt [29]).

Second, by increasing own taxes, any level of government reduces taxpayers' available income, and consequently tends to push down the demand for the (normal) goods provided by the other levels of government (Aronsson et al. [4]).

Third, public services provided at different levels of government could be complements or substitutes in consumers' utility functions, and social welfare maximising governments should take the expenditures on public services of other governments into account when determining their own expenditure levels (Aronsson et al. [4]).

Existing empirical investigations on horizontal fiscal interactions typically do not model the potential vertical fiscal externality. On the other hand, recent papers by Goodspeed [25], Hayashi and Boadway [27] and Esteller-Moré and Solé-Ollé [21] estimate vertical fiscal interaction parameters, while allowing for horizontal fiscal interdependence. The latter, though, plays little more than an ancillary role in their papers. Goodspeed [25] focuses on local-national tax externalities in a number of OECD countries, and controls for horizontal tax competition by introducing a proxy for tax base mobility (a poverty index) in a country-based local income tax equation. Hayashi and Boadway [27] analyse corporate income tax setting by federal and provincial governments in Canada, but do not model the spatial features of horizontal interaction. They estimate separate tax setting equations with vertical and horizontal effects for the federal government, the two major provinces, and an aggregate of the other provinces. Finally, Esteller-Moré and Solé-Ollé [21] do introduce a spatially weighted average of neighboring states' tax rates in an income tax rate setting equation for US states, still the main focus of their paper is on vertical tax externalities, and the potential link between vertical and horizontal interactions is not highlighted.

I concentrate in this paper on spatial fiscal interaction at the horizontal level, and point out the importance of explicitly modelling vertical fiscal externalities in order to better understand the horizontal interaction process. Since upper tier government policies can affect lower tier government fiscal choices in the ways described above, it seems indeed necessary to control for the former sort of externality when investigating the latter. In a two-tier system of government, municipal authority policies might actually exhibit positive spatial auto-correlation simply because they react in a similar fashion to provincial authority policies. That is, even though localities do not interact in a strategic sense, still they might give the (false) impression of doing so.

The paper is structured as follows. Section **2** gives a brief description of the English local government system, while section **3** presents a simple model of public spending determination that allows for fiscal externalities that can take place both horizontally and vertically. Section **4** turns to the estimation of a local public expenditure determination equation on a cross section of English local governments in financial year 2000-2001, and section **5** concludes.

2. The local government structure in England

The English system of local government offers a suitable framework for analysing horizontal and vertical fiscal interaction issues. First, in most non-metropolitan England a two-tier system of local government is in place – comprising 34 Counties and 238 Districts[7] – with upper tier and lower tier authorities sharing responsibility in a number of spending categories. Second, all authorities fund most of their expenditures through a local property tax (the Council tax), meaning that they co-occupy the tax base.[8]

Overall local public spending can be divided into four main categories: (1) education; (2) personal social services; (3) highway maintenance; (4) environmental, protective and cultural services. Counties retain exclusive responsibility in the former three categories – almost 90% of total public spending, as shown in table A.1 in the appendix – with Districts sharing responsibility with Counties in category (4).

In addition to Council tax revenues, all authorities fund their expenditures through grants from central government. For each local authority, grant is computed as the difference between a standard level of spending set by central government based on observed spending needs – standard spending assessment (SSA)[9] – and tax revenues that an authority would collect, conditional on the existing tax base (number and value of taxable properties), if it imposed the Council tax at a standard, uniform level. Grants can consequently be seen as substantially exogenous with respect to local tax setting and spending decisions, and can be treated as lump sum.[10]

While it is clear from table A.1 in the appendix that Districts have a relatively small overall spending and taxing power compared to the Counties, still they allocate larger per capita resources to environmental, protective and cultural services than Counties. Moreover, all Districts set their own Council tax on the same tax base (the value of domestic property) on which the Counties rely, and they are the billing authorities, in the sense that taxpayers are charged a unique bill at the District level, where it is specified the fraction of it going to the local authorities at the two levels.

As a result, one could well expect that the spending decisions at the District and County level will hardly be independent (a vertical externality), and that the nature of the services provided by the Districts – as will be argued more extensively in section **4** – makes them particularly likely to generate spill-overs into neighboring jurisdictions (a horizontal externality). The next section sets up a model of public expenditure determination in a two-tier system of local government, that explicitly accounts for vertical and horizontal fiscal externalities.

3. Theoretical set up

3.1 A two-tier structure of local government

Consider a two-tier structure of local government, where the upper tier (County) and lower tier (District) authorities co-occupy the property tax base, and let the utility function of a representative consumer residing in lower tier jurisdiction *i* (a subset of upper tier jurisdiction *I*) be represented by:

$$u_i = u(y_i, p_i, p_I; \Gamma_i) \qquad (1)$$

y_i, p_i, p_I represent individual consumption of private goods, individual consumption of public goods provided by the lower level of government (District), and individual consumption of public goods provided by the upper level of government (County) respectively. Γ_i is a vector of individual characteristics.

According to the individual consumer budget constraint, private consumption equals individual income q_i (net of national taxes and contributions), minus the local taxes paid to the County authority (k_{iI}) and to the District authority (k_{ii}):

$$y_i = q_i - k_{iI} - k_{ii} = q_i - (t_I + t_i)b_i \tag{2}$$

where b_i is the representative individual property tax base, and t_I and t_i are the County and District property tax rates.

While the property tax base b_i is inelastic with respect to t_I and t_i, still equations (1) and (2) show that the decisions at the County and District level are not independent, due to the following two effects. [11]

First, according to the budget constraint (2), a larger allocation of the County good reduces available resources for private consumption and District spending on the public good, determining a negative *income* effect (Aronsson et al. [4]). If the District good is normal, the income effect operates as to reduce its demand when the County increases the tax burden on resident taxpayers. More precisely, as total expenditures on public goods by County I (X_I) are funded by own property tax revenues over all taxpayers in jurisdiction I ($t_I B_I$) and by total central government grants to the County authority (G_I), the tax burden k_{iI} from County public expenditure on the representative individual in jurisdiction i can be expressed as:

$$k_{iI} = b_i t_I = \frac{b_i}{B_I} N_I (x_I - g_I) = \tau_{iI} (x_I - g_I) \tag{3}$$

where B_I is the total tax base within the County jurisdiction, N_I is the number of individuals living in County I, x_I is County per capita expenditure on public services, g_I is per capita grant to County I, and τ_{iI} is the implicit tax price for County provided services for the representative consumer in jurisdiction i. Analogously, the tax burden from District public expenditure k_{ii} can be expressed as:

$$k_{ii} = b_i t_i = \frac{b_i}{B_i} N_i (x_i - g_i) = \tau_{ii} (x_i - g_i) \qquad (4)$$

where B_i is the total tax base within the District jurisdiction, N_i is the number of individuals living in District i, x_i is District per capita expenditure on public services, g_i is per capita grant to District i, and τ_{ii} is the implicit tax price for the representative consumer for District provided services.

Second, the consumption of District services (p_i) might not be separable in the utility function (1) from the consumption of County services (p_I), that is County expenditures on public services might indirectly affect the utility consumers derive from District expenditures on public services – a *consumption* effect (Aronsson et al. [4]). If County services are substitutes (complements) for District services, higher expenditures on the former will tend to decrease (increase) expenditures on the latter. Clearly, then, in case of non-separability between District and County services, expenditures by the upper tier of government will affect the demand for the services provided by the lower tier of government both directly via the *income* effect, and indirectly via the *consumption* effect.

3.2 Horizontal externalities

Besides the two vertical externalities outlined above, expenditure of District i might also be affected by expenditures in nearby Districts – a horizontal externality or *spill-over* effect –

meaning that p_i might depend on neighboring governments' expenditures on public services. The extent to which District services actually spill-over into neighboring jurisdictions clearly is an empirical matter. It is not unreasonable, though, to expect that District expenditures on environmental, protective and cultural services – see section 4.2 below – tend to generate effects that fall outside own jurisdictions and onto people living elsewhere, possibly at an intensity that declines with distance. Actually, the geographical location of Districts is bound to be crucial in this respect, as it is difficult to believe that expenditures on environmental and recreational public services – such as expenditures on parks and swimming pools – in Cornwall will affect people living in Northumberland.[12]

Consequently, I explicitly model the above horizontal externality (*spill-over* effect) by making the District public good consumption in jurisdiction i (p_i) potentially depend both on the expenditures on public goods by own District authority and on the expenditures of neighboring District authorities:

$$p_i = p(N_i^{c_i} x_i, N_j^{c_j} x_j) \tag{5}$$

N_i and N_j denote the population sizes in own District and neighboring Districts respectively, with parameters c_i and c_j measuring the degree of 'publicness' in consumption of own District and neighboring District goods (Borcherding and Deacon [12]; Bergstrom and Goodman [5]). If the parameter equals one, the good is purely public (total expenditure matters, independently of the number of users), if it equals zero the good is purely private (per capita expenditure matters), and if it is negative, the good exhibits congestion: an increase in the number of consumers requires an increase in the level of per capita expenditure.[13]

Finally, the horizontal *spill-over* effect embedded in (5) is not the only possible source of horizontal interdependence among local governments. As a matter of fact, there might be shocks to local public spending that are spatially auto-correlated, in the sense that they might affect neighboring authorities at the same level of government in a similar way, such as unpredictable rises in production factor prices or random changes in the population of local public service consumers. In the presence of a negative cost shock, less public spending is needed in order to yield a given level of public good consumption, while in the presence of a positive cost shock, public spending needs to rise in order to provide a given level of public services. Consequently, I rewrite equation (5) to take account of such shocks with the following log-linear specification:

$$p_i = (N_i^{c_i} x_i)(N_j^{c_j} x_j)^{\lambda_j} e^{-\eta_i} \tag{6}$$

where η_i is the cost shock, and parameter λ_j measures the extent to which horizontal externalities (*spill-over* effects) occur. A positive λ_j implies that other governments' expenditures are substitutes for own expenditures, while a negative λ_j implies they are complements. In order to capture spatially auto-correlated shocks to local public expenditure, η_i is assumed to have the following stochastic structure:

$$\begin{aligned} &E(\eta_i) = 0 \\ &Var(\eta_i) = \sigma_\eta^2 > 0 \\ &Cov(\eta_i, \eta_j) \neq 0 \end{aligned} \tag{7}$$

3.3 Optimal municipal expenditure determination

The optimal level of local public good provision by District *i* (p_i) is obtained by maximising the utility function (1), where the consumer and the government budget constraints – equations (2) to (6) – are explicitly accounted for. As is commonly done in the applied local public economics literature (Borcherding and Deacon [12]; Bergstrom and Goodman [5]; Gramlich and Rubinfeld [26]), let us write the demand function for the District public good p_i, conditional on the allocation of the County public good p_I, in log-linear form:

$$p_i = \Gamma_i^{\beta_\Gamma} \tilde{q}_i^{\beta_q} \tilde{\tau}_{ii}^{\beta_\tau} p_I^{\beta_I} \tag{8}$$

where the price term ($\tilde{\tau}_{ii}$) is the price of the District public good p_i relative to private consumption y_i, and is obtained by inserting (4) and (6) into the budget constraint (2):

$$\tilde{\tau}_{ii} = \tau_{ii} N_i^{-c_i} (N_j^{c_j} x_j)^{-\lambda_j} e^{\eta_i} \tag{9}$$

The income term ($\tilde{q}_i$) is the 'residual' income available to the consumer in jurisdiction *i* after paying County related taxes and receiving grants from central government:

$$\tilde{q}_i = q_i - \tau_{iI}(x_I - g_I) + \tau_{ii} g_i \tag{10}$$

In its turn, consumption of County public good p_I depends on County expenditures on public services:

$$p_I = N_I^{c_I} x_I \tag{11}$$

where c_I is the 'publicness' parameter for County services. Using (6), (9) and (11) and taking logarithms, (8) can be rewritten in terms of per capita public expenditure as:

$$\ln(x_i) = \beta_\Gamma \ln(\Gamma_i) + \beta_q \ln(\tilde{q}_i) + \beta_\tau \ln(\tau_{ii}) + \delta_i \ln(N_i) + \theta_j \ln(x_j) + \delta_j \ln(N_j) \\ + \beta_I \ln(x_I) + \delta_I \ln(N_I) + \varepsilon_i \tag{12}$$

where:

$\delta_i = -c_i(1+\beta_\tau)$, $\delta_j = -c_j\lambda_j(1+\beta_\tau)$, $\delta_I = c_I\beta_I$, $\theta_j = -\lambda_j(1+\beta_\tau)$ and $\varepsilon_i = \eta_i(1+\beta_\tau)$.

As equation (12) shows, expenditures at different locations might be correlated either because of substantive strategic interaction – parameter θ_j – or simply because of a spatial process in the error term. The former process implies that the value of the dependent variable is directly influenced by the value of the same variable in neighboring localities, and is known as *spatial lag dependence* in the Anselin [1] terminology, while the spatial process in the stochastic component of the equation is referred to as *spatial error dependence*. Since the two processes tend to 'mimic' each other, the spatial econometrics literature has stressed the difficulty to separately identify them (Anselin [1]).

In particular, the unobserved component of the expenditure equation can be given two alternative specifications. The first is a first order spatial auto-regressive process, that can be expressed as:

$$\varepsilon_i = \rho\varepsilon_j + \mu_i \tag{13}$$

where ρ is the crucial auto-regressive spatial parameter to be estimated, with $|\rho|<1$ to ensure spatial stationarity (Cliff and Ord [19]), and μ is i.i.d. over space. The second is a spatial moving average process, with spatial coefficient γ.

$$\varepsilon_i = \gamma\psi_j + \psi_i \tag{14}$$

where $|\gamma|<1$, and ψ is i.i.d. over space. It is well known in the spatial econometrics literature that the spatial processes in (13) and (14) give rise to a spatial data pattern that resembles the one originated by a spatial lag dependence model with parameter θ_j (Anselin and Florax [3]).

Moreover, in a two-tier system of local government there is a further potential source of mis-specification. If County fiscal policies actually affect District fiscal policies, omitting them from the District expenditure determination equation might generate a spatial process in municipal expenditure levels, that could wrongly be attributed to actual strategic interaction. While neighboring Districts simply react in a similar fashion to common County policies, still they might give the false impression of interacting strategically if the vertical fiscal externality is not properly accounted for.

As an example, consider Districts e and f belonging to the same County I and assume that no horizontal interaction process is actually going on ($\theta_j=\rho=\gamma=0$). On the other hand, assume that County expenditures do affect expenditures of Districts e and f via the vertical fiscal externality outlined above, but they are omitted from the equation. A standard expenditure determination model for Districts e and f will consequently be written as:

$$\ln(x_e)=\beta_\Gamma \ln(\Gamma_e)+\beta_q \ln(\tilde{q}_e)+\beta_\tau \ln(\tau_{ee})+\delta_i \ln(N_e)+u_e \tag{15}$$

$$\ln(x_f)=\beta_\Gamma \ln(\Gamma_f)+\beta_q \ln(\tilde{q}_f)+\beta_\tau \ln(\tau_{ff})+\delta_i \ln(N_f)+u_f \tag{16}$$

where the omitted vertical fiscal externality ends up hiding in the error terms:

$$u_e=\beta_I \ln(x_I)+\delta_I \ln(N_I)+\varepsilon_e \tag{17}$$

$$u_f=\beta_I \ln(x_I)+\delta_I \ln(N_I)+\varepsilon_f \tag{18}$$

An analysis of spatial interaction based on equations (15) and (16) – that fails to recognize the error structures given by (17) and (18) – might be misleading in three main respects. First, an analysis of the OLS residuals of (15) and (16) – see section 4.3 below – will detect positive and significant spatial auto-correlation and will consequently suggest that a spatial model is needed. Second, a model with a spatial structure in the error terms – a spatial error dependence model such as (13) or (14) – will yield high and significant estimates of the spatial auto-correlation coefficients. Third, estimation of a spatial lag dependence model – that is, a model with a spatially lagged dependent variable on the right hand side of the equation – will yield significant estimates of θ_j, due to positive correlation between neighbors' variables and error terms, even though no strategic interaction is actually going on.

In the next section, I turn to the empirical implementation of the District expenditure determination model in order to ascertain the respective importance of horizontal and vertical fiscal interaction phenomena.

4. Empirical implementation

4.1 Spatial specification

According to the model in section **3**, the (238×1) vector of English District per capita expenditures depends on neighboring Districts' expenditures due to horizontal externalities, on respective Counties' expenditures due to vertical externalities, and on a set of internal determinants.

Empirically, while there is a unique association between a set of Districts and a County based on their respective location, one needs to define a criterion in order to attribute a set of neighbors to each District. Once defined, the criterion is implemented by way of a spatial weights matrix *W*. In this context, *W* is a (238×238) matrix that assigns neighbors to each District, in the sense that the element (*h*, *v*) of matrix *W* is different from zero (usually one) if

Districts h and v are neighbors according to the predetermined criterion, and zero otherwise. Matrix W is commonly row-standardised (divided by row-sum) such that the elements of each row sum to one. This way, the product of the (238×238) matrix and the (238×1) vector of expenditures yields for each District a spatially weighted average of neighboring Districts' expenditures.

For most spatial processes of interest in applied local public economics, the use of a geographical criterion seems reasonable. Both in 'spill-over' and 'resource-flow' models (Brueckner [15]), close-by jurisdictions are more likely to affect each other than far away ones. Most empirical works have used either a straightforward contiguity criterion – according to which neighborliness is defined as border-sharing, and all contiguous jurisdictions are given equal weight (Case [17]; Besley and Case [6]; Revelli [33, 34]) – or a distance decay principle, whereby spatial weights are inversely related to their distance between two jurisdictions (Murdoch et al. [32]; Saavedra [35]).

The above criteria can be relaxed in two ways. First, while admitting the importance of proximity, one could argue that not all neighbors should be given equal weight, and use a spatial matrix whose elements are weighted by neighbors' characteristics, such as population size or income level (Brueckner [14]; Heyndels and Vuchelen [26]; Brueckner and Saavedra [16]; Fredriksson and Millimet [24]). Second, it could be argued that proximity might not even be a relevant factor, and that it may be sensible to build 'spatial' matrices whose weights are based on similarity in demographic or economic characteristics between jurisdictions, regardless of distance (Case et al. [18]).

In general, the definition of the weighting criterion should be driven by: a) the theoretical model; b) the size and number of local jurisdictions in the sample; c) parsimony: unless the theoretical model predicts differently, a parsimonious specification of the weights matrix – such as a binary one – is usually to be preferred to more structured (and often more arbitrary) ones.[14]

In light of the above considerations, the empirical analysis is performed using a weighting criterion that has the following characteristics. First, the criterion is based upon the geographical location of jurisdictions. Such principle makes sense in a model where inter-jurisdictional interaction originates from potential spill-overs from environmental and recreational expenditures.[15] Second, and due to the fact that Districts are rather homogeneous in terms of demographic and economic structure, the spatial weights matrix does not impose different weights on different Districts, but rather weighs all neighbors equally and is row-standardised.[16] Third, and due to the relatively small size of English Districts, the concept of 'neighborliness' is rather wide. For each District, the set of neighbors comprises all Districts in own County, and Districts from contiguous (border-sharing) Counties. Apart from being the one that turns out to perform best in the empirical analysis, it is justified by the fact that service provision within a District may well spill into other Districts, whether or not they share a boundary. Moreover, the fact that Districts in a given neighborhood belong to different Counties provides the necessary information to separately identify empirically the process of horizontal interaction among Districts from the process of vertical interaction between Districts and respective Counties.

4.2 Data set and choice of variables

The dependent variable in the expenditure determination equation (12) is the logarithm of District per capita current expenditure in financial year 2000/2001. Such variable – available from CIPFA (2000), part 3 – includes all current spending items under the general label of 'environmental, protective and cultural services,' namely: Culture & Heritage, Sport, Parks & Open Spaces, Planning, Economic Development, Waste Collection, Street Cleaning & Litter Responsibilities, Environmental & Public Health Services, Cemeteries & Crematoria, and other minor Administration expenditures. Overall, Districts spend about £110 per head on average.

On the other hand, Counties have exclusive responsibility in a number of services, ranging from Education to Personal Social Services. Still, they overlap with Districts in the environmental, protective and cultural services spending block, as they allocate expenditures (for an average of around £70 per head, corresponding to $1/10$ of their overall budget) to Libraries, Culture & Heritage, Parks & Open Spaces, Planning, Economic Development, Waste Disposal and Consumer Protection, besides other minor Administration services. As a result, it is clear that there is room for substantial overlapping between County and District authorities in public service provision.

As for the explanatory variables in the District expenditure determination equation (12), the distribution of the property tax base is unfortunately not available at the District level, but only the mean value is known. Consequently, as the tax price for District provided services (τ_{ii}) is supposed to be the ratio of the representative individual's tax base over mean tax base in the jurisdiction, the price elasticity β_τ cannot be identified.

On the other hand, the tax price for County provided services (τ_{il}) is computed as the ratio of mean property tax base within the District jurisdiction over mean property tax base within the County jurisdiction.

As far as income is concerned, the level and distribution of disposable income at the District level are not available either. Consequently, I use as proxies two socio-demographic variables that should capture an income effect – percentage of people in poverty and rate of unemployment, available from UK DETR (2000).

Finally, according to the model all components of 'residual' income – equation (10) – should affect the demand for public spending in the same way. In particular, a 1£ reduction of central government grant to District *i* should affect the level of spending in the same way as a 1£ increase in County tax burden. To allow for a heterogeneous impact on District spending due to some sort of 'flypaper effect' (Wildasin [36]), I estimate separate coefficients on those two variables.

4.3 Spatial testing

Before estimating the District expenditure determination models, I perform a number of spatial tests. The widely used Moran I test (Cliff and Ord [19]) and the robust Lagrange Multiplier (LM) tests (Anselin et al. [2]) only require the OLS residuals from the estimation of the spatially restricted models, that is the models where the crucial spatial parameters have been set to zero.

First, based on the OLS residuals of a District expenditure determination model where the horizontal interaction parameters have been set to zero ($\theta_j = \rho = \gamma = 0$), and where vertical interaction with County expenditures is ruled out ($\beta_I = 0$), the Moran I test statistic confirms the presence of positive spatial auto-correlation between Districts. Being distributed as a standard normal, the Moran I statistic largely rejects ($z = 2.70$; p-value=0.0035) the hypothesis that the residuals are independently distributed across space (lower panel of table 1). Interestingly, though, the Moran I test on the OLS residuals of an expenditure determination model where vertical interaction between Districts and Counties is allowed for ($\beta_I \neq 0$) turns out not to be statistically significant ($z = 1.20$) – lower panel of table 2. Therefore, the Moran statistic suggests that, at least to a certain extent, the observed spatial auto-correlation among Districts might be attributable to the interaction with upper level authorities.

The same pattern of the Moran I test is exhibited by the two robust LM tests developed by Anselin et al. [2] against the hypothesis of spatial lag dependence ($\theta_j \neq 0$) and spatial error dependence ($\rho \neq 0$, $\gamma \neq 0$) respectively. In the District expenditure model with no vertical interaction with the Counties (lower panel of table 1), the LM test for spatial lag dependence – that is distributed as a χ^2 with one degree of freedom – does not exclude the presence of positive spatial auto-correlation at a reasonable degree of confidence (p-value<0.10). However, the spatial auto-correlation hypothesis is largely rejected by the same test once vertical fiscal externalities are allowed for (lower panel of table 2).

4.4 Estimation of the horizontal interactions model

The public expenditure function (12) is first estimated with OLS, not taking the endogeneity of neighbors' expenditures into account. Such benchmark estimates are then compared to maximum likelihood (ML) and – as a robustness check – to instrumental variables (IV) estimates of a model with a spatially lagged dependent variable. The ML estimates of the spatial lag dependence model are obtained via the non-linear spatial econometrics techniques developed in Anselin [1]. On the other hand, the (exactly identified) IV estimation approach uses neighboring Districts' per capita standard spending assessment as an instrument for neighboring Districts' actual per capita expenditure level. While there is no question about the correlation between actual and assessed spending levels – the correlation coefficient is 0.65, as shown in the appendix, graph A.1 – the fact that the latter is determined by central government based on observable spending needs provides the required orthogonality condition with the error term in the District equation. Finally, I estimate by ML methods an expenditure determination equation with a spatial process in the error term – equations (13) and (14) – again using the non-linear spatial econometrics techniques in Anselin [1].

The estimation results are shown in the upper panels of tables 1 and 2. Table 1 shows the results of a District expenditure equation where no vertical interaction is allowed for, while table 2 introduces vertical fiscal externalities between Districts and Counties and is discussed in section 4.5 below. All variables are expressed in logarithm, so that the estimated coefficients can be interpreted as elasticities. Summary statistics and data sources of all the variables used in the analysis are reported in the appendix.

Column (1) in table 1 presents benchmark OLS estimates of a non-spatial District expenditure equation, where the traditional determinants of local public spending are included (Borcherding and Deacon [12]; Bergstrom and Goodman [5]; Case et al. [18]). The results show strong effects of population, population density and central government lump-sum grants on per capita spending levels. In particular, the coefficient on population suggests that District provided services exhibit some degree of 'publicness.' A 10% increase in population would lead to an almost 1% decrease in per capita public spending. Population density is estimated to have a strong and significant positive impact on per capita expenditure, suggesting that more densely populated and urbanised areas tend to spend more in per capita terms. Finally, central government grant has a highly significant impact on expenditure. A 10% increase in lump sum grants from central government is estimated to raise expenditure by about 6%.

As far as the socio-demographic variables are concerned, the rate of unemployment and the percentage of people in poverty do not appear to have a significant impact on per capita spending. Both coefficient are estimated rather imprecisely. This is probably due to the fact that they are simultaneously picking up an 'income' effect – whereby poorer jurisdictions should exhibit a lower demand for local public services – and an opposite 'needs' effect – according to which the presence of people that are unemployed or in poverty generates a higher need for local public services.

Column 2 shows the OLS estimation results of a model that allows for horizontal interaction between Districts. Not controlling for the fact that own and neighbors' decisions are simultaneous, OLS should yield upward biased estimates of the spatial auto-regressive coefficient. The coefficient on the spatially weighted average of neighbors' per capita expenditure turns out to be positive and significant, with a point estimate of about 0.35, while the coefficient on neighbors' population is estimated not to be significantly different from zero, suggesting that neighbors' per capita expenditure matters, irrespective of neighbors' population. Neighbors' services are consequently perceived as private goods that are complements of own District services.

In columns 3 and 4, ML and IV estimates of the spatial lag dependence model are presented, while columns 5 and 6 report ML estimates of the spatial error dependence models.

IV and ML estimates of the first order spatial auto-regressive coefficient on the lagged dependent variable (θ_j) both yield the same result – an estimate of about 0.3 – with the IV estimation leading to larger standard errors. The fact that the two estimation methods yield virtually the same outcome is reassuring, and confirms that OLS leads to an upward bias in the estimation of θ_j, as it does not take into account the simultaneity of own and neighbors' decisions.

On the other hand, ML estimates of the models with a spatial process in the error term – columns (5) and (6) for the spatial auto-regressive and the moving average error processes respectively – lead to large estimates of ρ and γ. Overall, the spatial lag dependence model in column (3) and the two spatial error dependence models in columns (5) and (6) virtually have the same explanatory power, as the likelihood ratio tests with respect to the non-spatial model in the bottom panel of table 1 suggest.[17] Based on the above results, it is thus rather difficult to conclude whether neighboring Districts actually provide complementary local public services or they are simply hit by spatially auto-correlated shocks.

4.5 Estimation of the horizontal and vertical interactions model

In table 2, an expenditure model is estimated that also allows for vertical fiscal externalities. County tax burden, County population and County per capita expenditures on environmental, protective and cultural services are included among the explanatory variables, as predicted by the model in section **3**. The County variables are treated here as exogenous with respect to District decisions. Due to the large size of Counties with respect to Districts, the hypothesis of the Counties 'moving first' seems reasonable and follows most of the recent literature on vertical fiscal interactions. However, the issue of the potential endogeneity of County variables is further discussed below.

The County tax burden – the part of overall County spending that is not funded by central government grants, and consequently falls onto local residents – turns out to have the expected negative sign, and is highly statistically significant. By imposing a higher burden on resident taxpayers and reducing available income, Counties inflicts a negative externality on Districts, thereby depressing the demand for public services at the lower level of government. Keeping everything else constant, a 10% increase in County tax burden tends to reduce District spending by about 4.5%. With respect to the coefficient on central government grants to Districts (0.6), the smaller size of the coefficient on County tax burden (-0.45) suggests that Districts tend to spend more out of their grant income than of personal income of their residents.

On the other hand, the effect of County population is not estimated to be significantly different from zero, suggesting that the congestion coefficient is about zero, and that County goods are perceived as being rival in consumption.

Finally, County per capita expenditures on environmental, protective and cultural services (category 4) have a large, positive and highly significant effect on District expenditures, suggesting that, on the consumption side, the two tiers of government provide complementary goods. More precisely, keeping everything else constant, a 10% increase in County expenditure tends to raise District spending by about 2.5%. Clearly, then, the overall impact of County spending on District spending depends on the way it is funded. If a 10% increase in County expenditure is funded by higher grants, then one should expect District expenditures to increase by 2.5%. If, on the other hand, the County expenditure increase is funded by a corresponding rise in property taxes, the net effect on District spending is about -2%, as the negative income effect more than offsets the positive consumption effect.

This result can have important implications for the assignment of spending responsibilities among different tiers of government, for the design of intergovernmental grant systems, and for the prediction of the overall impact of grant distribution formula reforms. However, it could be argued that County expenditures might be endogenous in the District expenditure equation.

The observed positive correlation between District and County spending could actually be due to the fact that the authorities at the two tiers of government are hit by common shocks, rather than to the fact that the two goods are complements. One way to tackle the potential endogeneity issue consists in instrumenting County expenditure in the District expenditure determination equation. As always with IV approaches, though, one needs to be extremely cautious, and make sure that proper instruments are available. In this case, it is required that the instrument be correlated with County per capita expenditure levels, while not being correlated with District level shocks. Finding such an instrument is a hard task. The most prominent candidate, the level of County spending in category 4 assessed by central government based on observable needs (the County SSA for environmental, protective and cultural services), turns out to be largely inadequate. The correlation between actual and assessed spending levels is -0.01 (as shown in the appendix, graph A.2). Moreover, an analysis of other potential determinants of County spending on environmental, protective and cultural services – that represents only 1/10 of total County expenditures – does not yield any satisfactory result.

One alternative way to tackle the endogeneity issue is to investigate whether District expenditures are correlated with County allocations in any other spending block – education (1), personal social services (2) and highway maintenance (3). Since it is hard to believe that any of those services are complements of environmental and recreational ones, a positive correlation of District expenditures with any of them would support the thesis of common shocks to public expenditure at the two tiers of government. When estimating the District expenditure equation with all four County expenditure blocks on the right hand side of the equation, it turns out that County expenditures on no block of services except the environmental one have a significant impact on District expenditures, as shown in column (2') in table 2. Moreover, all parameter estimates are virtually unaffected by the inclusion of the other County expenditures.

Finally, what is particularly interesting to notice is that when the impact of County fiscal variables on District spending is accounted for, horizontal interactions among Districts turn out to be negligible. In all spatial models shown in table 2, the crucial spatial coefficients drop considerably with respect to the ones in table 1, and largely fail to achieve statistical significance both in the ML and in the IV estimations. This confirms the results previously obtained with the spatial tests, and strengthens the idea that the observed positive spatial dependence in District expenditures can to a large extent be attributed to the existence of substantial vertical fiscal externalities.

5. Conclusions

After setting up a model of public spending determination in a two-tier system of local government, this paper has tested the main predictions in terms of horizontal and vertical fiscal interactions on UK local government data. The degree of vertical interaction between Districts and Counties is estimated to be substantial. On the revenue side, by increasing expenditures Counties raise the burden to taxpayers and tend to reduce the demand for District services. On the consumption side, upper level authority expenditures appear to work as complements of lower tier authority expenditures. As for horizontal interaction, while fiscal interactions appear to be large and significant when the empirical model does not allow for vertical fiscal externalities (suggesting that neighboring Districts might provide complementary services), explicitly modelling the latter substantially reduces the estimated magnitude of the former.

The main implication of the above result is that any exploration of the spatial pattern of fiscal variables in a local government context must carefully take into account the underlying institutional structure. This is particularly important in multi-tiered government structures, where municipal and provincial levels of government overlap in public service provision and often co-occupy the tax bases. Omitting the vertical fiscal interaction process can give the false impression of spatial interaction at the horizontal level, and lead to conclude that local jurisdictions behave strategically with respect to their neighbors, while no such process is in fact occurring.

Table 1

District expenditure equation with horizontal interaction

	non spatial model	spatial lag model			spatial error model	
	OLS	OLS	ML	IV	ML	ML
	(1)	(2)	(3)	(4)	(5)	(6)
constant	2.963*** (7.64)	0.937 (1.00)	1.255* (1.45)	1.232 (1.16)	2.417*** (3.85)	2.440*** (3.88)
population	-0.080*** (-2.87)	-0.078*** (-2.82)	-0.079*** (-2.84)	-0.079*** (-2.79)	-0.077*** (-2.75)	-0.079*** (-2.83)
density of population	0.043*** (5.29)	0.040*** (4.82)	0.041*** (4.83)	0.040*** (4.75)	0.035*** (3.91)	0.036*** (4.02)
% unemployment	-0.132** (-1.97)	-0.112* (-1.63)	-0.113** (-1.65)	-0.113* (-1.60)	-0.056 (-0.54)	-0.062 (-0.75)
% poverty	0.055 (0.66)	0.061 (0.73)	0.058 (0.70)	0.059 (0.68)	0.012 (0.10)	0.017 (0.18)
grant	0.635*** (11.33)	0.605*** (10.61)	0.611*** (10.79)	0.611*** (10.40)	0.612*** (10.46)	0.611*** (10.68)
neighbors' population		0.031 (1.09)	0.029 (1.03)	0.029 (1.01)	0.042 (1.21)	0.042 (1.21)
θ_j		0.347** (2.27)	0.283** (2.10)	0.288* (1.60)		
ρ					0.418** (2.19)	
γ						0.604* (1.62)
Moran I test $z_{(0,1)}$	2.70***					
robust LM test error $\chi^2_{(1)}$	0.02					
robust LM test lag $\chi^2_{(1)}$	3.37*					
likelihood ratio test $\chi^2_{(1)}$			4.79**		4.48**	4.40**
observations	238	238	238	238	238	238

Notes
1) Dependent variable = log(District per capita spending);
2) All variables are in logarithm;
3) Asymptotic standard normal statistics are given in parentheses;
4) θ_j = spatial auto-regressive coefficient on lagged dependent variable – equation (12);
5) ρ = spatial coefficient of spatial auto-regressive process in the error term – equation (13);
6) γ = spatial coefficient of spatial moving average process in the error term – equation (14);
7) * = significant at 90%; **=significant at 95%; ***=significant at 99%.
8) Descriptive statistics and data sources of the variables used are in the appendix.

Table 2
District expenditure equation with horizontal and vertical interaction

	non spatial model	spatial lag model				spatial error model	
	OLS	OLS	OLS	ML	IV	ML	ML
	(1)	(2)	(2')	(3)	(4)	(5)	(6)
constant	4.528*** (4.36)	3.389** (2.28)	3.193** (1.96)	3.538*** (2.49)	3.530** (2.12)	4.007*** (3.42)	3.905*** (3.21)
population	-0.077*** (-2.74)	-0.075*** (-2.64)	-0.076*** (-2.62)	-0.075*** (-2.66)	-0.075*** (-2.59)	-0.075*** (-2.69)	-0.077*** (-2.74)
density of population	0.040*** (4.79)	0.039*** (4.58)	0.041*** (4.60)	0.039*** (4.57)	0.039*** (4.46)	0.037*** (4.20)	0.036*** (4.01)
% unemployment	-0.109* (-1.50)	-0.096* (-1.29)	-0.116* (-1.47)	-0.096 (-1.27)	-0.096 (-1.24)	-0.086 (-1.06)	-0.080 (-0.97)
% poverty	0.046 (0.54)	0.046 (0.53)	0.057 (0.63)	0.045 (0.51)	0.045 (0.50)	0.039 (0.43)	0.037 (0.40)
grant	0.622*** (11.37)	0.612*** (10.85)	0.606*** (10.32)	0.614*** (10.96)	0.614*** (10.49)	0.615*** (10.94)	0.613*** (10.85)
County tax burden	-0.459*** (-2.90)	-0.420*** (-2.53)	-0.515*** (-2.70)	-0.428*** (-2.60)	-0.427*** (-2.46)	-0.457*** (-2.72)	-0.456*** (-2.61)
County population	0.029 (1.24)	0.014 (0.52)	0.006 (0.20)	0.015 (0.58)	0.015 (0.54)	0.015 (0.57)	0.013 (0.46)
County expenditure category 1			0.119 (0.76)				
County expenditure category 2			0.050 (0.48)				
County expenditure category 3			0.066 (0.90)				
County expenditure category 4	0.245*** (3.19)	0.237*** (2.82)	0.263*** (2.94)	0.241*** (2.91)	0.241** (2.72)	0.268*** (3.09)	0.279*** (2.90)
neighbors' population		0.033 (1.07)	0.038 (1.18)	0.032 (1.05)	0.032 (1.01)	0.040 (1.12)	0.047 (1.13)
θ_j		0.133 (0.77)	0.038 (0.19)	0.107 (0.70)	0.108 (0.51)		
ρ						0.192 (0.72)	
γ							0.366 (0.70)
Moran I test $z_{(0,1)}$	1.20						
LM test error $\chi^2_{(1)}$	0.01						
LM test lag $\chi^2_{(1)}$	0.36						
likelihood ratio test $\chi^2_{(1)}$				1.35		1.34	1.49
observations	238	238	238	238	238	238	238

Notes
1) Dependent variable = log(District per capita spending);
2) All variables are in logarithm;
3) Asymptotic standard normal statistics are given in parentheses;
4) θ_j = spatial auto-regressive coefficient on lagged dependent variable – equation (12);
5) ρ = spatial coefficient of spatial auto-regressive process in the error term – equation (13);
6) γ = spatial coefficient of spatial moving average process in the error term – equation (14);
7) * = significant at 90%; **=significant at 95%; ***=significant at 99%.
8) Descriptive statistics and data sources of the variables used are in the appendix.

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Appendix

Table A.1
Summary statistics by authority type

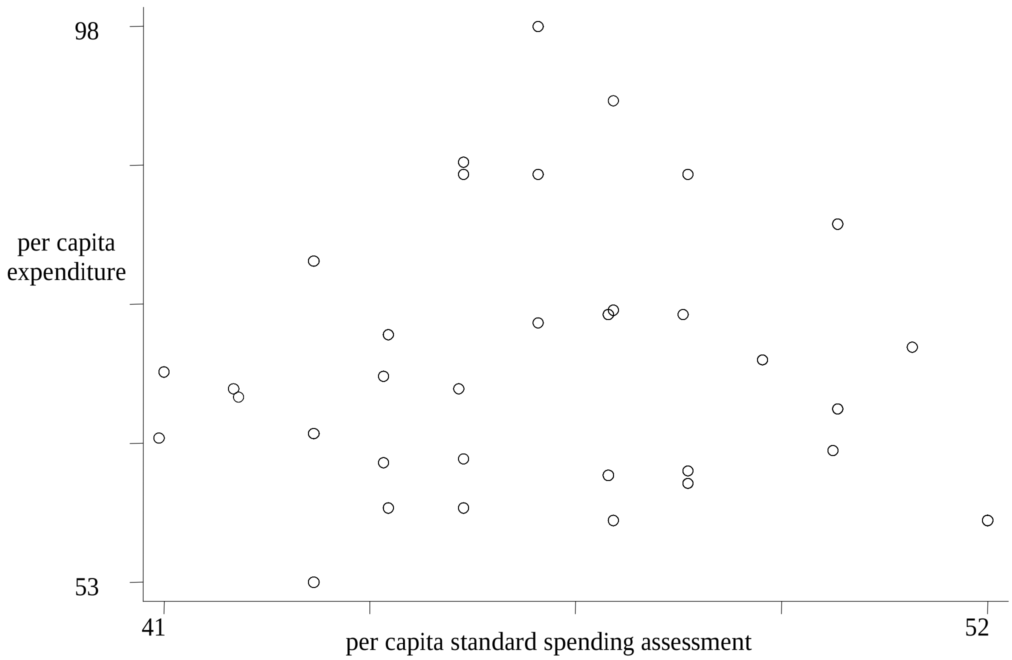
	Obs.	Mean	Std. Dev.	Min.	Max.
total per capita expenditure, £					
- Counties	34	712.6	49.1	612.2	832.5
- Districts	238	109.9	22.7	66	218
per capita expenditure in category 4: environmental, protective and cultural services, £					
- Counties	34	70.5	11.0	52.5	97.9
- Districts	238	109.9	22.7	66	218
per capita standard spending assessment in category 4: environmental, protective and cultural services, £					
- Counties	34	46.2	2.8	41.0	51.9
- Districts	238	93.7	12.4	67	138
Council tax (for property in band D), £					
- Counties	34	663.6	49.3	610.5	791.9
- Districts	238	123.4	27.5	28	265
per capita central government grant, £					
- Counties	34	482.3	46.8	381.4	573.6
- Districts	238	63.1	14.1	38	109
area (hectares)					
- Counties	34	320384	165612	118831	801579
- Districts	238	45764	39582	2136	221143
population					
- Counties	34	672667	275102	280390	1332004
- Districts	238	96095	29318	24992	195825
density of population (persons per hectare)					
- Counties	34	2.4	1.38	0.6	6.3
- Districts	238	2.4	7.69	0.3	38.2
% poor					
- Counties	34	16.9	3.8	9.5	27.4
- Districts	238	16.9	7.25	6.1	74.9
% unemployed					
- Counties	34	4.5	1.5	2.2	9.4
- Districts	238	4.5	2.3	1.4	16.7

Data sources

- CIPFA - Chartered Institute of Public Finance and Accountancy (2000) *Finance and general statistics*, 2000-2001, London.
- CIPFA - Chartered Institute of Public Finance and Accountancy (1999) *Local government comparative statistics*, 1999, London.
- UK DETR - Department of the Environment, Transport and the Regions (2000) *Local Government Financial Statistics* (*England*), 2000, London.

Graph A.1
District actual and assessed per capita expenditure levels in environmental, protective and cultural services
(£, 2000-2001; 238 observations; correlation coefficient = + 0.65)

Graph A.2
County actual and assessed per capita expenditure levels in environmental, protective and cultural services
(£, 2000-2001; 34 observations; correlation coefficient = – 0.01)



Notes

[1] See Anselin and Florax [3] for recent theoretical developments on spatial testing and estimation.

[2] A separate strand of the tax competition literature looks at welfare competition (Figlio et al. [22], Saavedra [35]), where competitive behavior arises from the mobility of high income taxpayers and welfare recipients.

[3] Empirical works based on this approach are Case [17], Besley and Case [6], Bivand and Szymanski [8, 9], Heyndels and Vuchelen [28], Revelli [33], Bordignon et al. [13].

[4] Formerly treated empirically by Case et al. [18], Murdoch et al. [32] and Revelli [34].

[5] Beginning with Flowers [23] and continuing with Boadway and Keen [10], Dahlby [20], Boadway et al. [11], Keen [30], Wrede [38] and Hoyt [29].

[6] Recent works include Besley and Rosen [7], Aronsson et al. [4], Goodspeed [25], Hayashi and Boadway [27] and Esteller-Moré and Solé-Ollé [21].

[7] Above 60% of the total English population reside in non metropolitan areas, about two thirds of which live in areas where two tiers of local government are present.

[8] The Council tax bill depends on which of eight bands of values a property is assigned to. Each local authority sets the Council tax bill for a property falling into the average value band (band D, £68,000-£88,000), while the percentage rise in bills between the bands is set by central government at about half the percentage rise in property values.

[9] When working out SSAs, the Government takes account of the population, social structure and other characteristics of each authority.

[10] While local authorities can freely determine their desired expenditure levels, central government can consider whether to limit budget increases. With respect to the early 1990s, though, when a formal system of 'capping' was in place, local authorities have substantially more discretion in selecting their own policies.

[11] Most of the existing literature on vertical tax externalities points to the elasticity of the tax base (corporate or labor income) with respect to federal and state tax rates as the main source of interaction (Flowers [23]; Boadway et al. [11], Goodspeed [25]; Hayashi and Boadway [27], Hoyt [29]). In the UK local government context, though, since the tax base is represented by the value of domestic property, it is reasonable to assume that it is inelastic with respect to the local property tax rates, at least in the short run.

[12] Some recent literature has suggested that even if public services were purely local, still the information on local public service quality and cost would spread into neighboring jurisdictions. Consequently, local decisions would be interdependent even in the absence of actual interjurisdictional flows of resources, tax-payers or public expenditure benefits (Case et al. [18]). Still, one can expect information to flow more easily among close-by localities (Besley and Case [6]; Bordignon et al. [13]).

[13] The degree of publicness in the consumption of own District and neighboring District services is allowed to differ in that it is the one perceived by the consumer in jurisdiction i.

[14] See Bivand and Szymanski [8, 9] and the references therein.

[15] Moreover, such criterion performs substantially better than 'non-spatial' criteria based on similarity in socio-demographic characteristics.

[16] The use of heterogeneous weights based on distance or population size did not produce substantially different results.

[17] Ideally, one would like to estimate a comprehensive model that allows for a spatially lagged dependent variable and spatial dependence in the error term. However, a spatially auto-regressive process in the dependent variable with spatial auto-regressive error terms is not identified, unless the weights matrices for the two processes are different (Anselin [1]). The only admissible specification – a SARMA model, with a spatially auto-regressive process in the dependent variable and moving average error terms – has not seen much application in applied spatial econometrics, due to the difficulty in separately identifying the spatial parameters (Anselin and Florax [3]).