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A Spatial Interaction Model of Benefit Spillovers from Locally Provided Public Services

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Abstract

In this paper, we test the hypotheses that recreational and cultural services provided at the local level of government are associated with benefit spillovers between Swedish municipalities. We also test the hypothesis that municipalities with similar expenditure levels are more clustered than would be expected from merely a coincidence. A representative voter model is derived and the demand for recreational and cultural services is estimated using spatial SUR techniques. The results suggest that these expenditures are associated with benefit spillovers and that municipalities with similar expenditure levels are clustered to a greater extent than would be expected from just a coincidence.

Keywords: *Local government expenditures, spatial econometrics.*

JEL: R10, R50.

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1 Introduction

This paper concerns local government expenditures on recreational and cultural services in Sweden. The main purpose is to analyze the possible benefit spillovers between municipalities in the provision of such services by examining if there is a negative relationship between neighboring municipalities' expenditure levels on recreational and cultural services. A demand model is derived for these services and estimated using spatially autoregressive techniques. This framework is convenient as the hypothesis of benefit spillovers between municipalities boils down to testable restrictions on the parameters to be estimated. We also explore the hypothesis that municipalities with similar expenditure levels on recreational and cultural services are spatially clustered to a greater extent than would be expected if this was coincidental. In this case, inferences are based on econometric tests for spatial autocorrelation between municipalities. The study is conducted by using a panel data set covering 276 Swedish municipalities during the period 1981-1990.

Traditionally, empirical models of local government expenditure determination have focused on the influence of 'local' characteristics.[1] This means that a particular municipality's expenditure is assumed to depend on information such as its average income level, the amount of intergovernmental grants it receives, its tax price, its demographic structure etc. While this approach is convenient for purposes of estimation, it may not give a correct description of the process that has generated the data. In this paper, we argue that the spatial dependence between municipalities' expenditures is an important factor that also needs to be taken into account. In particular, we assert that a municipality's expenditures on recreational and cultural services are influenced by its neighbors' expenditure levels on the same services. This is important from an econometric point of view because if the underlying data generating process includes a spatial dimension, and this is omitted, it could lead to serious problems. The estimates, for example, could become biased and inconsistent (see Anselin (1988)).

Benefits from local government services may not be bounded by the jurisdiction that supplies the service. It is reasonable to assume that the provision of some local government services also generate benefits for the inhabitants of neighboring munici-

[1] See for example the pioneering work by Borcherding & Deacon (1972) and Bergstrom & Goodman (1973).

palities. In the case of recreational and cultural services, spillover effects may be due to the fact that individuals are mobile between municipalities. That is, facilities such as theatres, libraries and parks may generate benefits to individuals visiting from other municipalities. Spillover effects may also be generated when the public service itself is mobile, such as military alliances (Murdoch *et al.* (1991)) or fire brigades (Hanes (1999)).

Murdoch *et al.* (1993) and Case *et al.* (1993) have addressed the spatial structure in the context of local government expenditure determination.[2] Murdoch *et al.* use cross-section data in their analysis of local authorities' expenditures on recreation in the Los Angeles area. They found that recreation expenditures in neighboring municipalities are complementary joint products implying that there is a positive relationship between neighboring municipalities expenditures. However, since their analysis is based on a cross-section of data it has to be assumed that the data is generated by a process that has reached equilibrium. If this is not the case, the empirical results may be dependent on the year selected. In their study of budget spillovers between U.S. states, Case *et al.* use a panel data set covering a period of 15 years. They find that a one dollar increase in the expenditures of a neighboring state induces an increase of 70 cents in the states own expenditures. Although Case *et al.* consider time specific effects, they do not account for time dynamic effects nor do they present any test for constant parameters over time in their analysis.

This paper contributes by combining space and time in the analysis of local government expenditures. The model is estimated using spatial autoregressive SUR techniques where the error terms are allowed to be correlated between time periods. In this way, we deal with both time dynamics and spatial autocorrelation and relax the restriction of constant parameters between time periods. Moreover, we complement the regression analysis with statistical tests for spatial clustering of high/low values for recreational and cultural expenditures.

The rest of this paper is organized as follows. The theoretical outline is presented in Section 2. Specification of the empirical model, econometric issues and the definition of 'neighbors' are discussed in Section 3. The data set is presented in Section 4. Section 5 contains the results from the econometric tests for spatial clustering of high/low

[2] Other examples of empirical studies that explicitly incorporate spatial deependence are LeSage (1993), Holtz-Eakin (1994), Benirschka & Binkley (1994) and Murdoch *et al.* (1997).

recreational and cultural expenditures and parameter estimates of the empirical models. Section 6 summarizes the paper.

2 Theoretical outline

The decision on how much recreational and cultural services to supply will be modeled as a utility maximization problem for a representative individual living in a particular municipality. Consider a situation with three municipalities, 1, 2 and 3. Here, 1 and 2 may be thought of as specific municipalities, while 3 may be considered as all other municipalities within the country. Suppose that a representative individual living in municipality 1, individual 1, receives utility from his/her consumption of locally provided public services and privately produced goods (c_1). The local government sector provides a variety of services. Some of these services are only beneficial for individuals living within the municipality (g_1), while others also benefit individuals living outside the particular municipality providing the service (x_1) (in this case recreational and cultural services). Hence, individual 1 also receives utility from recreational and cultural services provided by municipalities 2 and 3, here denoted x_2 and x_3.

The utility obtained by the individual in municipality 1 from x_2 and x_3 depends on how often she uses these services. The number of visits made by individual 1 to municipalities 2 and 3 are denoted as v_2 and v_3 respectively. Hence, x_2, x_3 and v_2, v_3 may be thought of as input factors in the production of the composite goods Ψ_2 and Ψ_3, where $\Psi_2 = f_2\left(x_2, v_2; \mathbf{Z}_1\right)$ and $\Psi_3 = f_3\left(x_3, v_3; \mathbf{Z}_1\right)$ are assumed to be concave in x and v. If the individual chooses not to consume the service x_2, $v_2 = 0$ and $f_2\left(x_2, 0; \mathbf{Z}_1\right) = 0$. It is required that $v_2 \geq 0$ and $v_3 \geq 0$.

Individual 1's utility function is assumed to take the form

$$U_1 = u_1\left(x_1, g_1; \mathbf{Z}_1\right) + f_1\left(c_1; \mathbf{Z}_1\right) + f_2\left(x_2, v_2; \mathbf{Z}_1\right) + f_3\left(x_3, v_3; \mathbf{Z}_1\right) \tag{1}$$

where $\mathbf{Z}_1$ is a vector of exogenous conditions that affect her utility. The additive structure of the utility function is convenient since it makes it easy to separate out the particular effects that we are interested in.

The cost per unit of x_1 and g_1 faced by individual 1 is the tax price p_1. The cost associated with her consumption of x_2 and x_3 is the travel cost, here denoted by k_2 and k_3 respectively. We disregard any potential additional costs associated with individual

1's use of the x:s. Denote real income by y_1. With this information, individual 1 maximizes (1) with respect to x_1, c_1, g_1, v_2 and v_3 subject to her budget constraint

$$c_1 = y_1 - p_1 \cdot (x_1 + g_1) - k_2 \cdot v_2 - k_3 \cdot v_3 \tag{2}$$

It should be noted that x_1, x_2 and x_3 are not perfect substitutes and that the individual has the freedom to choose not to consume x_2 and/or x_3. x_2 and x_3 are expected to have a positive impact on individual 1's utility whereas k_2 and k_3 will reduce her possibilities to consume other goods.

The Lagrangian of the optimization problem can be written as

$$\begin{aligned} \underset{x_1,c_1,g_1,v_2,v_3}{max} L_1 &= u_1(x_1, g_1; \mathbf{Z}_1) + f_1(c_1; \mathbf{Z}_1) + f_2(x_2, v_2; \mathbf{Z}_1) + f_3(x_3, v_3; \mathbf{Z}_1) + \\ &\quad \lambda_1 \cdot (y_1 - p_1 \cdot (x_1 + g_1) - k_2 \cdot v_2 - k_3 \cdot v_3 - c_1) \end{aligned} \tag{3}$$

The first order conditions are given by

$$\begin{aligned} \lambda_1 &: y_1 - p_1 \cdot (x_1 + g_1) - k_2 \cdot v_2 - k_3 \cdot v_3 - c_1 = 0 \\ x_1 &: \frac{\partial u_1}{\partial x_1} - \lambda_1 \cdot p_1 = 0 \\ g_1 &: \frac{\partial u_1}{\partial g_1} - \lambda_1 \cdot p_1 = 0 \\ c_1 &: \frac{\partial f_1}{\partial c_1} - \lambda_1 = 0 \\ v_2 &: \frac{\partial f_2}{\partial v_2} - \lambda_1 \cdot k_2 \leq 0,\ v_2 \geq 0 \text{ and } v_2 \cdot \left(\frac{\partial f_2}{\partial v_2} - \lambda_1 \cdot k_2\right) = 0 \\ v_3 &: \frac{\partial f_3}{\partial v_3} - \lambda_1 \cdot k_3 \leq 0,\ v_3 \geq 0 \text{ and } v_3 \cdot \left(\frac{\partial f_3}{\partial v_3} - \lambda_1 \cdot k_3\right) = 0 \end{aligned}$$

where corner solutions are characterized by $v_2 = 0$ and/or $v_3 = 0$. Assuming interior solutions, the demand for x_1 can be written

$$x_1^* = x_1(p_1, y_1, k_2, k_3, x_2, x_3; \mathbf{Z}_1) \tag{4}$$

Of particular interest here are the impacts of x_2 and x_3 on x_1, i.e. $\partial x_1^*/\partial x_2$ and $\partial x_1^*/\partial x_3$. The signs of these derivatives are determined by[3]

$$sgn\left(\frac{\partial x_1^*}{\partial x_2}\right) = -sgn\left(\frac{\partial^2 f_2}{\partial x_2 \partial v_2}\right)$$

[3] A complete derivation of these results is given in Appendix 2.

and

$$sgn\left(\frac{\partial x_1^*}{\partial x_3}\right) = -sgn\left(\frac{\partial^2 f_3}{\partial x_3 \partial v_3}\right)$$

respectively. The two derivatives $\partial^2 f_2/\partial x_2 \partial v_2$ and $\partial^2 f_3/\partial x_3 \partial v_3$ measure how the marginal utilities of visiting municipalities 2 and 3 are affected by increases in x_2 and x_3 respectively. These two derivatives are expected to be positive.

Another effect of interest here is the cross-price, or more correctly, the cross-cost effect. How do the costs, in this case the travel costs, associated with the use of x_2 and x_3 affect the demand for x_1? The sign of the cross-cost effects is determined by

$$sgn\left(\frac{\partial x_1^*}{\partial k_2}\right) = sgn\left(v_2 \cdot \frac{\partial^2 f_2}{\partial (v_2)^2} + \frac{\partial f_1}{\partial c_1} \cdot k_2\right)$$

and

$$sgn\left(\frac{\partial x_1^*}{\partial k_3}\right) = sgn\left(v_3 \cdot \frac{\partial^2 f_3}{\partial (v_3)^2} + \frac{\partial f_1}{\partial c_1} \cdot k_3\right)$$

Note that $\partial x_1^*/\partial k_2$ and $\partial x_1^*/\partial k_3$ are equal to zero if the individual decides not to visit the municipality in order to use x_2 or x_3. If $v_2 > 0$ and $v_3 > 0$, two effects are present here. One is an income effect, represented by $v_2 \cdot \partial^2 f_2/\partial v_2^2$ or $v_3 \cdot \partial^2 f_3/\partial v_3^2$, which is negative. As the costs k_2 and k_3 increase, ceteris paribus, individual 1 will have less real income to spend on consumption. The other is a substitution effect, $\partial f_1/\partial c_1 \cdot k_2$ or $\partial f_1/\partial c_1 \cdot k_3$, which is positive. Which of these two effects will dominate cannot be known a priori and it is, therefore, an empirical matter to determine the sign of $\partial x_1^*/\partial k_2$ and $\partial x_1^*/\partial k_3$.

3 Econometric model and estimation technique

3.1 Econometric model

The model set out in Section 2 implies that if an individual living in municipality i decides to use the recreational and cultural services provided in municipality j, this will affect her demand for similar services provided within municipality i. We shall here extend the model to cover the general case with n municipalities. Henceforth, if x_i affects x_j or vice versa, municipalities i and j are considered as 'neighbors' even if they do not share a common border.

To operationalize this empirically, we make use of spatial econometric techniques. Consider, for the moment, the linear regression model

$$x_i = \rho \cdot \mathbf{W}_i \cdot \mathbf{x} + \varepsilon_i \tag{5}$$

where $\mathbf{x}' = [x_1, ..., x_n]$, ρ is the parameter to be estimated and ε_i is an random error term. $\mathbf{W}_i$ is the ith row of an $(n \times n)$ weighting matrix, $\mathbf{W}$, that assigns the neighbors to each municipality. The $\mathbf{W}$ matrix used here can be characterized as $\mathbf{W} = \{w_i^j\}$ such that $w_i^j = 1$ if i and j are neighbors and $w_i^j = 0$. Note also that $w_i^i = 0$.[4] Accordingly, testing for spatial interaction is, in this case, related to the parameter ρ. If $H_0 : \rho = 0$ is rejected, two possibilities arise. The first is the situation where $\rho < 0$, in which case the recreational and cultural services are substitutes. This alternative hypothesis corresponds most closely with the theoretical model set out above, where ρ is measured by a second order derivative of the utility function. In general, however, one cannot rule out the situation where $\rho > 0$, in which case the recreational and cultural services provided by different (neighboring) municipalities are complements.

Equation (5) is easily expanded to an empirical specification of the demand function (4). Using the same notation as in the previous section and introducing time, the optimal demand for recreational and cultural services in municipality i at time t is assumed to take the form

$$\begin{aligned} x_{i,t}^* &= \alpha_t + \rho_t \cdot \mathbf{W}_i \cdot \mathbf{x}_t^* + \kappa_t \cdot k_{i,t} + \\ &\quad \delta_t \cdot p_{i,t} + \gamma_t \cdot y_{i,t} + \mathbf{Z}_{i,t} \cdot \boldsymbol{\theta}_t + \varepsilon_{i,t} \end{aligned} \tag{6}$$

where α_t, ρ_t, κ_t, δ_t, γ_t and $\boldsymbol{\theta}_t$ are parameters to be estimated. The parameter estimates may not be constant over time periods. Therefore, all parameters are allowed to vary

[4] Hence

$$\mathbf{W} = \begin{bmatrix} 0 & w_1^2 & \cdots & w_1^{n-1} & w_1^n \\ w_2^1 & 0 & \cdots & w_2^{n-1} & w_2^n \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ w_{n-1}^1 & w_{n-1}^2 & \cdots & 0 & w_{n-1}^n \\ w_n^1 & w_n^2 & \cdots & w_n^{n-1} & 0 \end{bmatrix}$$

where the elements w_i^j take the value one if the individual in municipality i decides to use recreational and cultural services provided by municipality j, otherwise w_i^j is zero. Note that the diagonal of $\mathbf{W}$ consists of zeros.

between time periods. However, they are assumed to be constant between municipalities. The time effect α_t is included in order to control for nationwide macroeconomic factors.

As mentioned above, testing for spatial interaction can be done by means of a significance test of ρ_t. Here $H_0 : \rho_t = 0$ is tested against the alternative $H_a : \rho_t \neq 0$. The cross-cost effect is represented by the parameter κ_t. If $\kappa_t < 0$, it means that the demand for x_i decreases as the cost for using x_j increases where $j \neq i$. The tax price effect is captured through the parameter δ_t and the correlation between the average personal income level and the demand for recreational and cultural services by the parameter γ_t. Finally, $\boldsymbol{\theta}_t$ is a vector of parameters that relate to the influence from municipality specific characteristics, $\mathbf{Z}_{i,t}$, which will be described in more detail in Section 4, and $\varepsilon_{i,t}$ is a random error.

3.2 Estimation technique

The next issue is how to estimate equation (6). In spatial lag models, like (6), OLS becomes biased and inconsistent, irrespective of the properties of the error terms (see Anselin (1988)). Instead maximum likelihood estimators are frequently used to estimate the parameters of spatial lag models.[5]

In our set up, there is a mixture of dependence in two dimensions, time and space. One way to incorporate both time and space in the same model is to apply spatial SUR technique.[6] This technique is suitable for situations where a limited degree of dependence is present between equations. In our case, one equation is specified for each year and all the equations are estimated simultaneously. The error terms are allowed to be correlated between time periods meaning that the interdependence between each equation (year) is allowed for via the error term. As one equation is specified for each year this technique allows us to relax and test the restriction of constant parameters between time periods. If we cannot reject the joint null hypothesis that the parameters are constant between periods (equations), the data may be pooled. The model will be estimated using maximum likelihood.

[5] Bates & White (1985) and Heijmans & Magnus (1986a, 1986b, 1986c) have derived formal conditions for efficiency and asymptotic normality for the maximum likelihood estimator in spatial lag models.

[6] The SUR technique was originally developed by Zellner (1962).

3.3 The weights matrix W, the definition of 'neighbors'

As pointed out earlier, the elements of **W** assign to each municipality its neighbors. From equation (6), it is evident that the definition of the elements in **W** is crucial for the estimation results. In the best of worlds, the elements in **W** should be estimated along with the other parameters in equation (6). This is, however, not possible since there are not enough degrees of freedom, which means that **W** has to be (carefully) specified a priori. As the parameter estimates may be sensitive for the specification of **W**, we have elaborated with many different definitions of neighbors, or weights matrices. The results from the use of three different weights matrices are presented in this paper. All of these matrices are defined on the basis of travel time by car between municipal centers.[7] In **W1**, municipalities are defined as neighbors if their centers are located within a travelling time of less than 100 minutes by car, in **W2** for a travelling time of less than 200 minutes and, **W3**, for a travelling time of less than 300 minutes.[8]

We argue that the travel time by car reflects the accessibility of recreational and cultural services provide in neighboring municipalities, even if it is unlikely that the individual always travel by car to use these services. This definition implies that if the travel time by air between two municipalities A and B is one hour and the travel time by car between A and C is also one hour, individuals living in A are considered to have less accessibility to recreational and cultural services provided in B relative to C. We regard this as a reasonable assumption. Other possible definitions of geographical neighbors are two municipalities who share a common border or just the nearest neighbor/neighbors. However, while the former of these definitions does not necessarily reflect the accessibility of recreational and cultural services provided in neighboring municipalities, the latter suggests that there is a value in using the recreational and cultural services provided in neighboring municipalities regardless of the travel distance.[9]

[7] Travelling times are calculated by The Swedish National Road Administration and based on the road network and speed limits in 1985.

[8] The longest travelling time by car between one municipality center and its nearest neighbor is 96.06 minutes. In order to assign at least one neighbor to each municipality we have chosen 100 minutes as the shortest travelling time between municipality centers. We have also elaborated with weights matrices where neighbors are defined within a radius of, for example, 30, 60 and 90 minutes. However, the results from these estimations were similar to those presented later in this paper.

[9] For a more detailed discussion of other possible definitions of the elements in **W**, see for instance

4 Data

The data used in this study originate from the official statistics on municipalities provided by Statistics Sweden and refer to the period 1981-1990. During this period, the number of municipalities varied between 279 in 1981 and 284 in 1990. Responsibilities and structures differ somewhat between municipalities. The municipalities of Göteborg, Malmö and Gotland differ from other municipalities in that they are responsible for the provision of health care, which is normally provided at the regional level of government. This makes it difficult to obtain comparable data for these municipalities and they are, therefore, excluded from the empirical analysis. Municipalities created after 1981 are excluded. This leaves us with a data set containing 276 Swedish municipalities during a period of ten years. Tables 1-3 present descriptive statistics of the variables in the data set. Exact definitions are given in Appendix 1. All economic variables are deflated by the national consumer price index, using 1980 as the base year.

In the official statistics, the item recreational and cultural expenditures (x_i) at the local level consists of several components.[10] Some of these components, such as parks, may to some extent be treated as public or semi public goods. Other components, such as subsidies to study circles and leisure-time activities, which are generally given directly to private persons, may be treated as private goods. The share of recreational

Table 1. Descriptive statistics 1981.

Variable	Mean	Std dev	Min	Max
Recreational and cultural expenditures (x_i)				
- per capita	0.69	0.22	0.19	1.39
- per square kilometer	101.33	435.13	0.27	4 374.56
Average income level (y_i)	50.12	6.03	39.96	87.60
Taxprice (p_i)	0.83	0.11	0.47	1.00
Population (pop_i)	27 527.19	44 358.42	3 923.00	647 214.00
Population aged 0-15 years ($a015_i$)	0.22	0.03	0.13	0.34
Population aged 65 years or above ($a65_i$)	0.17	0.04	0.05	0.26
Area (s_i)	1 475.33	2 533.34	8.83	19 446.78

Anselin (1988) and Case *et al.* (1993).

[10] The item recreational and cultural expenditures include parks, marinas, youth recreation centers, libraries, culture and transfers to study circles and leisure-time activities.

Table 2. Descriptive statistics 1990.

Variable	Mean	Std dev	Min	Max
Recreational and cultural expenditures (x_i)				
- per capita	0.86	0.22	0.27	1.61
- per square kilometer	107.41	417.13	0.36	3 206.88
Average income level (y_i)	60.68	7.16	50.05	113.56
Taxprice (p_i)	0.83	0.12	0.50	1.00
Population (pop_i)	28 082.67	46 213.46	3 570.00	672 187.00
Population aged 0-15 years ($a015_i$)	0.20	0.02	0.14	0.28
Population aged 65 years or above ($a65_i$)	0.19	0.04	0.06	0.27
Area (s_i)	1 462.56	2 531.36	8.83	19 446.78

Table 3. Descriptive statistics 1981-1990.

Variable	Mean	Std dev	Min	Max
Recreational and cultural expenditures (x_i)				
- per capita	0.79	0.23	0.19	2.02
- per square kilometer	104.03	416.18	0.28	4 409.79
Average income level (y_i)	53.50	7.58	39.77	113.56
Taxprice (p_i)	0.83	0.11	0.47	1.00
Travel cost (k_i^1)	68.63	9.32	43.35	96.14
Travel cost (k_i^2)	128.53	11.94	102.14	154.05
Travel cost (k_i^3)	179.97	14.33	157.86	222.43
North ($north$)	0.24	-	0.00	1.00
Located close to Stockholm ($Stockholm$)	0.08	-	0.00	1.00
Located close to Malmö ($Malmö$)	0.07	-	0.00	1.00
Located close to Göteborg ($Göteborg$)	0.05	-	0.00	1.00
Population (pop_i)	27 736.71	45 315.20	3 524.00	679 364.00
Population aged 0-15 years ($a015_i$)	0.20	0.02	0.13	0.34
Population aged 65 years or above ($a65_i$)	0.18	0.04	0.05	0.28
Area (s_i)	1 464.49	2 527.47	8.83	19 446.78
Travel distance between municipality centers by car in minutes	330.67	-	5.87	1 212.00

and cultural expenditures that is regarded as a private good may be scaled by the number of users, whereas the share that is considered to be a public or semi public good may not be scaled. We have only information on total expenditures on recreational and cultural services within each municipality, and it is not obvious how great a proportion of these expenditures should be treated as private or public goods. We will return to this issue later in Section 5.2.1. Let us for now stick to two definitions of expenditures on recreational andcultural services; one where these expenditures are considered as private goods (measured in per capita terms), and one where they are treated as public goods (measured per square kilometers). The latter definition follows Murdoch *et al.* (1993). By controlling for size, they argue that such a measure reflects the quality of the service. The idea is that if the supply of recreational and cultural services is geographically concentrated this will have a positive effect on its quality.

The ideal measure of the cost associated with the use of recreational and cultural services provided in other municipalities (k_i) should reflect both the money cost and the time valuation of those individuals who travel between two municipalities in order to use such services. Here, information on the average of travel times by car to the municipalities defined as neighbors by the weights matrices, $\mathbf{W1}$, $\mathbf{W2}$ and $\mathbf{W3}$, is used as an approximation of this cost. For instance, consider the case when equation (6) is estimated using the weights matrix $\mathbf{W1}$. In this case, the costs associated with the use of recreational and cultural services for an individual living in municipality i, when these services are provided by other municipalities, are measured as the average of travel times to those municipalities defined as municipality i's neighbors by $\mathbf{W1}$. The travel cost associated with the other two weighting matrices are defined in a similar way. As argued above, we believe that the travel time by car reflects this cost, both in money value and time valuation, even though it is unlikely that all individuals actually travel by car.

The average income level (y_i) is defined for the portion of the population aged twenty and above in each municipality and measured in thousands of SEK per year. y_i is defined in this way because of the data available. The tax price (p_i) is constructed using information on the Swedish grant-in-aid system. In principle, the tax price reflects the share of local government spending financed through the local income tax. The interpretation of an average tax price of 0.83 during this period is that 17 percent of municipality spending was financed by the central government.

The contents of $\mathbf{Z}_i$, i.e. the background characteristics that enter the demand function for recreational and cultural services are the age structure (the percentage of children aged 15 or below ($a015$) and pensioners aged 65 or above ($a65$)), the total population in the municipality (pop) and the municipality area in square kilometers (s). A more general functional form is obtained as population and municipality area are allowed to enter the demand function raised to their second power (pop^2 and s^2) as well as $s \cdot pop$ ($inter$). To capture regional differences, $\mathbf{Z}_i$ also contains four dummy variables indicating (i) whether the municipality belongs to the northern part of Sweden ($north$), or if it is located in one of the major city areas (ii) Stockholm ($Stockholm$), (iii) Malmö ($Malmö$) or (iv) Göteborg ($Göteborg$).

5 Results

5.1 Exploratory statistics

Before we proceed to estimate the empirical model (6), let us take a closer look at the data on recreational and cultural expenditures in Swedish municipalities and, in particular, look for the spatial correlation and clustering pattern in the data. That is, to test if municipalities with similar expenditure levels are more spatially clustered than could be caused by chance. We base this discussion on two commonly used test statistics for spatial autocorrelation, the Moran's I and the G_i^*-statistic.

5.1.1 The Moran's I-statistic[11]

The Moran's I is a test for spatial autocorrelation between observations that are specified as neighbors by the weights matrix. The test statistic is compared with its theoretical mean, $I = -1/(n-1)$, where n is the number of observations. Hence, $I \to 0$ as $n \to \infty$. The null hypothesis $H_0 : I = -1/(n-1)$ is tested against the alternative $H_a : I \neq -1/(n-1)$. If H_0 is rejected then there are two alternative interpretations depending on whether the test statistic I is significantly larger or lower than its expected value. If H_0 is rejected and $I > -1/(n-1)$, this indicates a positive

[11] Formally, the Moran's I is $I = [n/S] \cdot \left\{ \left[\sum_{i,j,i \neq j} w_i^j \cdot (x_i - \overline{x}) \cdot (x_j - \overline{x}) \right] / \left[\sum_i (x_i - \overline{x})^2 \right] \right\}$ where n is the number of observations, S equal to the sum of all elements in the weights matrix, w_i^j is the elements in the weights matrix, x is recreational and cultural expenditures with mean $\overline{x}$.

spatial autocorrelation meaning that municipalities with similar expenditure levels for recreational and cultural services are more spatially clustered than could be caused by chance. If H_0 is rejected and $I < -1/(n-1)$ this indicates a negative spatial autocorrelation, municipalities with high and low expenditure levels are mixed together. A perfect negative spatial autocorrelation is characterized by a checkerboard pattern of high and low values.

Table 4. Wald test for normality of the variable recreational and cultural expenditures.

	Per capita		Per sqare kilometer	
Year	Value	Prob	Value	Prob
1981	6.40	0.041	59 838.43	0.000
1982	17.91	0.000	59 717.91	0.000
1983	32.03	0.000	57 803.61	0.000
1984	2.68	0.262	56 542.74	0.000
1985	102.49	0.000	56 010.69	0.000
1986	45.81	0.000	55 540.58	0.000
1987	2.44	0.295	55 459.85	0.000
1988	3.02	0.221	58 122.03	0.000
1989	6.79	0.034	55 783.38	0.000
1990	7.65	0.022	61 708.02	0.000

If the variable that is to be tested follows a normal distribution, the I-statistic is compared with its theoretical mean, $-1/(n-1)$. However, if this is not the case, the reference distribution for I should be generated empirically. This is done by randomly reshu- ing the observed values over all locations. Wald test statistics for normality in the variable recreational and cultural expenditures are presented in Table 4, where H_0 is normality. Because of the non-normality of the variable for some years, the reference distribution of the Moran's I is generated using this approach.

Test statistics for the Moran's I for the different years and weights matrices are presented in Table 5. Irrespective of whether recreational and cultural expenditures are defined in per capita or per square kilometer terms and regardless of the year selected, the test statistics are positive and significant when using the weights matrices

Table 5. Moran's I for recreational and cultural expenditures.

		Per capita			Per square kilometer		
Weights matrix	Year	I	Mean	Prob	I	Mean	Prob
W1	1981	0.114	-0.004	0.001	0.170	-0.003	0.001
	1982	0.101	-0.004	0.001	0.167	-0.003	0.001
	1983	0.103	-0.004	0.001	0.170	-0.003	0.001
	1984	0.106	-0.003	0.001	0.174	-0.003	0.001
	1985	0.101	-0.004	0.001	0.176	-0.003	0.001
	1986	0.107	-0.004	0.001	0.181	-0.003	0.001
	1987	0.100	-0.004	0.001	0.184	-0.003	0.001
	1988	0.097	-0.003	0.001	0.182	-0.003	0.001
	1989	0.103	-0.003	0.001	0.187	-0.003	0.001
	1990	0.105	-0.003	0.001	0.183	-0.003	0.001
W2	1981	0.059	-0.004	0.001	0.035	-0.004	0.001
	1982	0.054	-0.004	0.001	0.035	-0.004	0.001
	1983	0.052	-0.004	0.001	0.035	-0.004	0.001
	1984	0.057	-0.004	0.001	0.036	-0.004	0.001
	1985	0.059	-0.004	0.001	0.037	-0.004	0.001
	1986	0.066	-0.004	0.001	0.038	-0.004	0.001
	1987	0.064	-0.004	0.001	0.038	-0.004	0.001
	1988	0.067	-0.004	0.001	0.037	-0.004	0.001
	1989	0.072	-0.004	0.001	0.038	-0.004	0.001
	1990	0.068	-0.004	0.001	0.037	-0.004	0.001
W3	1981	0.005	-0.004	0.017	0.001	-0.004	0.104
	1982	0.004	-0.004	0.043	0.000	-0.004	0.114
	1983	0.001	-0.004	0.102	0.000	-0.004	0.123
	1984	0.004	-0.004	0.029	0.000	-0.004	0.110
	1985	0.008	-0.004	0.007	0.001	-0.004	0.107
	1986	0.016	-0.004	0.001	0.001	-0.004	0.108
	1987	0.017	-0.004	0.002	0.000	-0.004	0.115
	1988	0.031	-0.004	0.001	-0.000	-0.004	0.130
	1989	0.033	-0.004	0.001	-0.000	-0.004	0.148
	1990	0.036	-0.004	0.001	-0.000	-0.004	0.141

W1 and **W2**. These results suggest that we can reject the null hypothesis and, furthermore, indicate a positive spatial autocorrelation. The interpretation is that municipalities with similar levels of expenditure on recreation and culture are more spatially clustered than could be caused by chance. If the definition of neighbors is expanded from a travel distance of 200 minutes to one of 300, the results change. In this case, when recreational and cultural services are defined as public goods (per square kilometer) the null hypothesis cannot be rejected. When the definition of recreational and cultural services as private goods (per capita) is used, H_0 cannot be rejected for the year 1983.

The results reported in Table 5 are not surprising. It is reasonable to assume that it is more likely that a clustering pattern of similar expenditure levels will be found when neighbors are defined within a more narrow range (using **W1** and **W2**). When the range is extended and the number of neighbors is increased for each municipality (using **W3**), it becomes less likely that a pattern of similar expenditure levels will be found within the defined area. Remember that all 'neighbors' have the same weight. However, these results do not reveal any information concerning whether the cluster consists of municipalities with high or low expenditure levels. The only information is that municipalities with similar expenditure levels, irrespective of the definition used, are more clustered than could be caused by chance, at least when the weights matrices **W1** and **W2** are used.

5.1.2 The G_i^*-statistic[12]

Another test for spatial autocorrelation is the G_i^*-statistics suggested by Getis & Ord (1992). Like the Moran's I, the basic idea behind this test is to define a set of neighbors for each municipality, i.e. municipalities that fall within a specified distance from the municipality in which we are interested. The G_i^*-statistic then indicates whether a particular municipality is surrounded by a cluster of other municipalities with equivalent recreational and cultural expenditures. This test complements the Moran's I in two

[12] Formally, $G_i^* = \left[\sum_{j=1}^{n} w_i^j(d)\, x_j\right] / \left[\sum_{j=1}^{n} x_j\right]$ where $w_i^j(d)$ are elements in a symmetric one/zero spatial weights matrix with ones for all links defined as being within distance d of a given municipality i. The numerator is the sum of all x_j within d from i including x_i. The denominator is the sum of all x. Ord & Getis (1995) have generalized the G_i^*-statistic to allow for non-positive observations as well as non-binary spatial weights.

ways. The G_i^*-statistic tells us which municipalities are surrounded by a cluster of municipalities with similar expenditures, not just that there is a cluster of municipalities with similar expenditures. It also tells us whether there is a clustering of high or low expenditure levels. H_0 :$G_i^* = 0$ is tested against the alternative H_a :$G_i^* \neq 0$ where H_0 is the absence of spatial clustering. If H_0 is rejected, two possible interpretations arise. A positive and significant test statistic indicates that the municipality is surrounded by other municipalities with high expenditure levels on recreation and culture, a negative and significant test statistic indicates the opposite.

The test statistics for recreational and cultural expenditures per capita and per square kilometer are presented in Tables 6 and 7 respectively. In order to save space and as the results were very much the same for each year and not sensitive for the choice of either **W1** or **W2** as the weights matrix, we only present test statistics for the year 1990 using weights matrices **W1** and **W3**.

Table 6. G_i^*-statistics for spatial association of recreational and cultural expenditures per capita. Year 1990.[13]

The ten highest G_i^*-values using the weights matrices					
	$W1$			$W3$	
Municipal	z-value	Prob	Municipal	z-value	Prob
Norsjö	5.281	0.000	Arvidsjaur	5.470	0.000
Åsele	3.908	0.000	Piteå	5.272	0.000
Lycksele	3.762	0.000	Arjeplog	5.123	0.000
Ludvika	3.543	0.000	Boden	5.105	0.000
Dorotea	3.492	0.001	Luleå	5.105	0.000
Vilhelmina	3.492	0.001	Gällivare	5.075	0.000
Borlänge	3.490	0.001	Skellefteå	5.056	0.000
Smedjebacken	3.465	0.001	Sorsele	5.032	0.000
Leksand	3.338	0.001	Jokkmokk	5.010	0.000
Säter	3.242	0.001	Kalix	4.824	0.000

[13]Norsjö, Åsele, Lycksele, Dorotea and Vilhelmina are located in the county of Västerbotten in the north of the country. Ludvika, Borlänge, Smedjebacken, Leksand and Säter are located within the county of Dalarna in the middle part of the country. Arvidsjaur, Piteå, Arjeplog, Boden, Luleå, Gällivare, Jokkmokk and Kalix are located in the county of Norrbotten. Skellefteå and Sorsele are located in the county of Västerbotten.

(Table 6 continued.)[14]

The ten lowest G_i^*-values using the weights matrices

	$W1$			$W3$	
Municipal	z-value	Prob	Municipal	z-value	Prob
Kungälv	-3.018	0.000	Falkenberg	-5.312	0.000
Tjörn	-3.851	0.000	Höganäs	-5.170	0.000
Stenungsund	-3.849	0.000	Bjuv	-5.117	0.000
Öckerö	-3.584	0.000	Höör	-5.108	0.000
Orust	-3.580	0.000	Burlöv	-5.037	0.000
Lysekil	-3.570	0.000	Klippan	-5.004	0.000
Ale	-3.475	0.001	Kristianstad	-4.994	0.000
Lilla Edet	-3.455	0.001	Båstad	-4.994	0.000
Munkedal	-3.444	0.001	Halmstad	-4.987	0.000
Uddevalla	-3.415	0.001	Hässleholm	-4.980	0.000

[14]Kungälv, Tjörn, Stenungsund, Öckerö, Orust, Lysekil, Munkedal and Uddevalla are located in the (former) county of Göteborg and Bohus. Ale and Lilla Edet are located in the county of Älvsborg, which borders on to the county of Göteborg and Bohus. Falkenberg and Halmstad are located in the county of Halland which borders on to the county of Malmö where Höganäs, Bjuv, Höör and Burlöv are located. Klippan, Kristianstad, Båstad and Hässleholm are located in the county of Kristianstad, which borders the counties of Malmö and Halland.

Table 7. G_i^*-statistics for spatial association of recreational and cultural expenditures per square kilometer. Year 1990.[15]

The ten highest G_i^*-values using the weights matrices					
	$W1$			$W3$	
Municipal	z-value	Prob	Municipal	z-value	Prob
Oxelösund	7.789	0.000	Sundsvall	3.312	0.001
Nynäshamn	7.677	0.000	Timrå	3.269	0.001
Vaxholm	7.497	0.000	Nordanstig	2.907	0.004
Östhammar	7.474	0.000	Härnösand	2.818	0.005
Värmdö	7.474	0.000	Hudiksvall	2.800	0.005
Haninge	7.438	0.000	Kalmar	2.705	0.007
Tyresö	7.438	0.000	Ljusdal	2.698	0.007
Norrtälje	7.410	0.000	Älvdalen	2.697	0.007
Ekerö	7.070	0.000	Söderhamn	2.618	0.009
Nacka	7.043	0.000	Bollnäs	2.607	0.009

[15] Nynäshamn, Vaxholm, Värmdö, Haninge, Tyresö, Norrtälje, Ekerö and Nacka are located in the county of Stockholm. Oxelösund is located in the county of Södermanland and Östhammar in the county of Uppsala. Södermanland and Uppsala border Stockholm. Sundsvall, Timrå and Härnösand are located in the county of Västernorrland which borders on to the county of Gävleborg. The latter contains the municipalities Nordanstig, Hudiksvall, Ljusdal, Söderhamn and Bollnäs. Kalmar is located in the county of Kalmar and Älvdalen in the county of Dalarna.

(Table 7 continued.)[16]

The ten lowest G_i^*-values using the weights matrices					
	$W1$			$W3$	
Municipal	z-value	Prob	Municipal	z-value	Prob
Jönköping	-1.441	0.150	Färgelanda	-3.275	0.001
Sävsjö	-1.410	0.159	Uddevalla	-3.097	0.002
Habo	-1.373	0.170	Munkedal	-3.093	0.002
Mullsjö	-1.353	0.176	Kungälv	-3.050	0.002
Värnamo	-1.340	0.180	Lilla Edet	-3.049	0.002
Växjö	-1.329	0.184	Ale	-3.046	0.002
Alvesta	-1.286	0.198	Stenungsund	-3.046	0.002
Vetlanda	-1.267	0.205	Orust	-3.040	0.002
Vaggeryd	-1.263	0.206	Lerum	-3.023	0.003
Eksjö	-1.246	0.213	Öckerö	-3.014	0.003

Let us start with the ten highest G_i^*-values and the definition of recreational and cultural services as a private good (per capita). These results are presented in the upper part of Table 6. The ten highest G_i^*-values using the weights matrix **W1** are found in the northern and middle parts of the country. When the weights matrix **W3** is used, the ten highest G_i^*-values are found in the two most northern counties, were distances between municipality centers are large. Exploring the highest G_i^*-values for the alternative definition of recreational and cultural services per square kilometer, the pattern changes. The results, presented in the top half of Table 7, suggest a cluster of high expenditures in the Stockholm region where municipalities are small in size and densely populated compared with the rest of the country except for the other two major city areas, Göteborg and Malmö.

When the weights matrix **W3** is used a cluster of high expenditures is found in the middle part of the country. One reason why none of the municipalities located in the Stockholm area are present among the ten highest G_i^*-values is that, when the definition of neighbors is expanded from a travel distance of 100 to 300 minutes, because of their small size in square kilometers, they become neighbors with a large number of municipalities. When a large number of municipalities are defined as neighbors to each

[16] Jönköping, Sävsjö, Värnamo, Vetlanda, Vaggeryd and Eksjö are located in the county of Jönköping, Habo and Mullsjö in Skaraborg and Växjö and Alvesta in Kronoberg.

other, it is again less likely to find an unambiguous pattern of high (or low) expenditure levels.

Turning to the ten lowest G_i^*-values, e.g. clustering of low expenditure levels, presented in the lower parts of Tables 6 and 7. Clusters of low expenditure levels are found in three different regions in the south of the country. Partly in or near the Göteborg area, near Malmö and in the counties of Jönköping, Kronoberg and Skaraborg. In this part of the country, municipalities are relatively small in size and densely populated. Hence, distances between municipalities' centers are relatively short compared with municipalities located in northern Sweden.

5.2 Explanatory analysis

The results from the test for spatial autocorrelation described above, indicate that the spatial pattern of expenditures to some extend depend on whether these services are defined as public or private goods. The obvious question is then which definition is appropriate for our analysis. Accordingly, before we proceed and estimate the parameters of equation (6), let us discuss (i) whether recreational and cultural expenditures should be characterized as a public or a private good and (ii) if SUR is the appropriate estimation method.

5.2.1 The definition of recreational and cultural expenditures

The question if recreational and cultural expenditures should be treated as a public or private good is basically a question of the functional form of the demand function. One approach to determine the definition of $x_{i,t}^*$ that fits the data best is to estimate equation (6) where $x_{i,t}^*$ is specified as $\eta \cdot x_{i,t}/pop_{i,t} + (1-\eta) \cdot x_{i,t}/s_{i,t}$ for different values of η, where $0 \leq \eta \leq 1$ and $x_{i,t}$ is measured as total expenditures on recreational and cultural services. Next, the specification is selected, e.g. the value of η, that generates the highest log likelihood. This has been done for all three models and the results from this exercise are presented in Table 8. From this we conclude that $\eta = 0$, meaning that we follow Murdoch *et al.* (1993) and define $x_{i,t}^*$ in per square kilometers.

Table 8. Likelihood values.

η	$W1$	$W2$	$W3$
0.0	1414.03	1397.29	1394.37
0.1	453.27	441.85	441.36
0.2	-315.28	-323.39	-323.43
0.3	-919.35	-926.07	-925.60
0.4	-1413.07	-1418.99	-1417.92
0.5	-1827.74	-1832.95	-1831.20
0.6	-2183.60	-2188.00	-2185.55
0.7	-2496.07	-2499.55	-2496.43
0.8	-2778.37	-2780.98	-2777.33
0.9	-3041.14	-3043.25	-3039.30
1.0	-3290.63	-3292.76	-3288.74

5.2.2 Is SUR the right specification?

This discussion is based on two test statistics. The first is a likelihood ratio test of the diagonality of the error covariance matrix, which is a test of dependence between equations. If diagonality is rejected, the interpretation is that there is a correlation between equations (in our case, between periods). With likelihood ratio test statistics of 15 877.07, 15 895.68 and 15 899.70 (df = 45, Prob = 0.000 in all three cases) for Models 1, 2 and 3 respectively, we can by far reject the null hypothesis of the diagonally of the variance covariance matrix, i.e. that there is no dependence between the equations. The second test is a Wald test of whether all coefficients being constant across equations. With Wald test statistics of 4 714.22, 4 637.21 and 4 630.49 (df = 135, Prob = 0.000 in all three cases), we can, again, reject the null hypothesis of constant parameter estimates across equations. Therefore, we cannot reject that the SUR estimator is appropriate for our models.

5.2.3 Parameter estimates

The final issue is to estimate the parameters of equation (6) using the three weights matrices, $\mathbf{W1}$, $\mathbf{W2}$ and $\mathbf{W3}$, where x is defined as a public good. The three different versions will be referred to as Models 1, 2 and 3, respectively. The parameter estimates are presented in Tables 9-11. As the SUR estimation technique where one equation is estimated for each year is used to estimate (6), we end up with ten parameter estimates for each variable. For our proposes, it is of greater interest to discuss general results from all equations taken together instead of discussing estimates for separate years. Therefore, in Tables 9-11 we present the mean, minimum and maximum values of the parameter estimates from all ten equations instead of each equation separately. The standard deviation of the computed mean value, presented in column four in Tables 9-11, is based on the standard deviation of the estimated parameters. Results from tests of parameter homogeneity across equations are presented in Table 12. Here, H_0 is homogeneity, i.e. that the specific parameter is constant across periods. If the test statistic is significant, the hypothesis of constant parameter estimates across periods is rejected.

Table 9. SUR estimation results using weights matrix **W1** (Model 1).

	Estimate			
Parameter	Mean	Min	Max	Standard deviation of the mean
ρ	-0.018	-0.018	-0.017	0.003
α	3.646	2.572	4.802	2.658
δ	-0.114	-0.528	0.179	0.146
κ	-5.068	-5.354	-4.795	3.677
γ	-0.023	-0.184	0.182	0.052
θ_{north}	-0.132	-0.169	-0.108	0.524
$\theta_{Stockholm}$	7.379	6.891	7.730	1.136
$\theta_{Malmö}$	-0.096	-0.168	-0.035	0.968
$\theta_{Göteborg}$	0.017	-0.057	0.129	0.923
θ_{a015}	0.071	-0.185	0.271	0.092
θ_{a65}	-0.009	-0.167	0.085	0.100
θ_s	0.062	-0.045	0.131	0.694
θ_{s^2}	1.919	1.755	2.044	0.770
θ_{pop}	0.525	0.482	0.561	0.038
θ_{pop^2}	0.001	-0.009	0.010	0.010
θ_{inter}	-0.169	-0.176	-0.161	0.027

Let us first discuss the hypothesis of benefit spillovers which corresponds to the parameter ρ in equation (6). The results from Model 1, presented in Table 9, suggest the average estimate of the parameter ρ is negative. The average estimate of ρ is -0.018 with a standard deviation of 0.003. The Wald-test on constant parameter estimates across equations (periods) presented in Table 12, suggests that we can reject the hypothesis of constant estimates of the parameter ρ in Model 1. The interpretation of the negative estimates of ρ is that recreational and cultural expenditures are associated with benefit spillovers. In particular, the results suggest that the recreational and cultural services provided by neighboring municipalities are substitutes. Looking at the estimates of the parameter ρ from Models 2 and 3 (Tables 10-11), the average estimates are -0.006 and -0.005 respectively. In addition, the corresponding standard deviations of these mean values are 0.002 and 0.001 respectively. Therefore, we conclude that recreational and cultural services are associated with benefit spillovers between municipalities irrespective of the choice of weights matrix.

Table 10. SUR estimation results using weights matrix **W2** (Model 2).

	Estimate			
Parameter	Mean	Min	Max	Standard deviation of the mean
ρ	-0.006	-0.007	-0.006	0.002
α	2.854	1.755	3.770	2.936
δ	-0.122	-0.530	0.161	0.149
κ	-2.021	-2.149	-1.773	2.220
γ	-0.032	-0.195	0.171	0.052
θ_{north}	0.019	-0.025	0.057	0.521
$\theta_{Stockholm}$	5.899	5.527	6.191	0.844
$\theta_{Malmö}$	-0.130	-0.187	-0.066	0.909
$\theta_{Göteborg}$	0.146	0.075	0.227	0.905
θ_{a015}	0.073	-0.151	0.253	0.093
θ_{a65}	0.009	-0.141	0.105	0.101
θ_{s}	0.230	0.087	0.334	0.699
θ_{s^2}	0.002	1.531	1.747	0.755
θ_{pop}	0.523	0.482	0.562	0.038
θ_{pop^2}	0.002	-0.008	0.012	0.010
θ_{inter}	-0.177	-0.185	-0.168	0.027

Table 11. SUR estimation results using weights matrix **W3** (Model 3).

	Estimate			
Parameter	Mean	Min	Max	Standard deviation of the mean
ρ	-0.005	-0.005	-0.005	0.001
α	0.071	-0.832	1.110	2.816
δ	-0.113	-0.539	0.175	0.151
κ	0.328	0.300	0.373	1.573
γ	-0.025	-0.187	0.178	0.052
θ_{north}	-0.394	-0.421	-0.370	0.575
$\theta_{Stockholm}$	5.617	5.251	5.910	0.743
$\theta_{Malmö}$	-0.110	-0.166	-0.053	0.814
$\theta_{Göteborg}$	-0.151	-0.233	-0.042	0.931
θ_{a015}	0.175	-0.156	0.266	0.093
θ_{a65}	-0.005	-0.159	0.100	0.102
θ_{s}	0.341	0.232	0.433	0.699
θ_{s^2}	1.439	1.332	1.552	0.754
θ_{pop}	0.522	0.478	0.560	0.038
θ_{pop^2}	0.003	-0.007	0.013	0.010
θ_{inter}	-0.178	-0.187	-0.169	0.027

The own-price effect (δ) is, on average, estimated to be negative in the three models, which is to be expected. However, the estimates of δ fluctuate in sign between equations. Moreover, the standard deviation of the average parameter estimate suggests that it is not significantly different from zero. This is also the case for the estimated relationship between the average income level and recreational and cultural expenditures (γ).

Turning to the cross-cost effect, the estimates of the parameter κ are negative in Models 1 and 2 (Tables 9-10), which indicates that when the costs associated with the use of recreational and cultural services provided in other municipalities increase, the demand for x_1 decreases. However, these results are not statistically significant and should be interpreted with caution. In addition, even though not significant, this effect is estimated to be positive in Model 3. From the Wald-test presented in Table 12, we cannot reject the hypothesis of constant estimates of the parameter κ in any one of the three models.

Table 12. Wald test on coefficient homogeneity across equations.

	W1		**W2**		**W3**	
Parameter	Value	Prob	Value	Prob	Value	Prob
ρ	26.52	0.002	7.74	0.560	10.28	0.328
δ	34.68	0.000	31.74	0.000	35.58	0.000
κ	4.98	0.836	3.35	0.949	1.36	0.998
γ	103.67	0.000	107.28	0.000	105.28	0.000
θ_{north}	9.73	0.372	9.11	0.427	7.74	0.560
$\theta_{Stockholm}$	54.11	0.000	82.07	0.000	89.48	0.000
$\theta_{Malmö}$	21.43	0.011	16.03	0.066	16.36	0.060
$\theta_{Göteborg}$	8.89	0.448	7.12	0.625	7.55	0.580
θ_{a015}	18.88	0.026	17.98	0.035	19.01	0.025
θ_{a65}	10.97	0.278	9.39	0.402	9.49	0.393
θ_{s}	3.14	0.958	4.04	0.909	3.56	0.938
θ_{s^2}	6.93	0.645	5.26	0.811	5.11	0.825
θ_{pop}	74.14	0.000	80.75	0.000	81.85	0.000
θ_{pop^2}	567.80	0.000	587.19	0.000	591.72	0.000
θ_{inter}	20.18	0.017	24.63	0.003	24.16	0.004

Do the sparsely populated northern parts and the major city areas exhibit a different pattern than the rest of the country? The results suggest that the only area that exhibits a different pattern compared with the rest of Sweden is Stockholm. According to the results presented in Tables 9-11, expenditures on recreational and cultural services are greater within the capital area. One possible explanation is the structure of this area and that municipalities 'compete' with each other regarding tax payers. Within this region, the municipalities are small in areal terms meaning that it is possible to move between municipalities without changing work place and friends. Hence, recreational and cultural facilities may serve as an instrument in making the municipality more attractive, which may be more important in this region.

Let us finally look at the parameter estimates related to the rest of the background variables. Only the impacts of two of the background variables are significantly determined in all three models, $pop_{i,t}$ and $inter_{i,t}$. The variable $pop_{i,t}$ is estimated to have a positive while $inter_{i,t}$ is estimated to have a negative impact on recreational and cultural expenditures. Municipalities with large populations are, besides Stockholm, Göteborg and Malmö, the municipalities that contain the seat of the county government. These municipalities are also often the regional cultural center, which is one possible explanation for this result. However, it is difficult to give a plausible explanation for the negative correlation between x and $inter$ as there is no obvious similarity between municipalities with high (or low) values on the variable $inter$.

The results presented above suggest that the spatial dependence between municipalities may be an important determinant of local recreational and cultural expenditures. However, it is reasonable a priori to have expected a negative own-price effect and a positive impact from the average income level on the demand for these services. Could these results be due to the weights matrix? Could it even be the case that the inclusion of the spatial dimension interferes with the other variables in the models and makes them non-significantly determined at the same time as the spatial dimension do not significantly contribute to the model? To study this possibility, we reestimated the different models without the spatial dimension. As it turned out, the other parameter estimates changed neither in sign nor significance. Moreover, a likelihood ratio test on the exclusion of the spatial effect rejected the hypothesis that it does not contribute to the model ($LR = 120.58$, 90.02 and 87.14 for Models 1-3 respectively, 1 degree of freedom and a critical value of 3.84 at the 95-percent level of significance).

6 Summary and conclusions

The main purpose of this paper was to test the hypothesis that recreational and cultural expenditures in Swedish municipalities are associated with benefit spillovers between municipalities and, further, to test whether municipalities with similar expenditure levels are more spatially clustered than could be merely coincidental. The exploratory statistics presented in this paper indicate that municipalities with similar expenditure levels for recreational and cultural services are more clustered than could be a coincidence. Clusters of high expenditure levels are found in the northern parts of the country where municipalities are large in area and sparsely populated, while clusters of low expenditures are found in southern Sweden where distances between municipality centers are short.

The regression results suggest a negative correlation between recreational and cultural expenditures provided by neighboring municipalities meaning that these expenditures are associated with benefit spillovers. This result is not sensitive to the different definitions of the weights matrices used here.

The main result in this paper, that recreational and cultural expenditures at the local level of government are more clustered than could be just a coincidence and that these services are associated with benefit spillovers between municipalities, may have implications for future research and understanding of economic decisions and interaction between decision makers at the local government level in Sweden. If a spatial correlation is present when it comes to recreational and cultural services, it may also be present and act as an important determinant of other economic decisions such as other types of expenditures and local income tax rates made at this level of government. However, this is a subject for future research.

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Appendix 1: Variable definitions

- Recreational and cultural expenditures, $x_{i,t}$. Measured in thousand of SEK per square kilometer and per capita.

- Taxprice, $p_{i,t}$. Calculated using information on the Swedish grant-in-aid system. Formally, $p_{i,t} = D1 + (D2 \cdot V1)/V2$ where $V1 =$ the municipality's tax capacity in percent of the average tax capacity, and $V2 =$ by the central government guaranteed tax capacity in percent of the average tax capacity. $D1 = 1$ if $V1 \geq V2$, otherwise $D1 = 0$. $D2 = 1$ if $D1 = 0$, otherwise $D2 = 0$.

- Travel costs, $k^1_{i,t}$, $k^2_{i,t}$ and $k^3_{i,t}$. Calculated as the average travelling time by car to those municipalities that are defined as neighbors to municipality i by the weights matrix.

- Average income level, $y_{i,t}$. Defined as the average income level for inhabitants aged 20 years or above. Measured in thousand of SEK.

The vector $\mathbf{Z}_{i,t}$ contains the following information:

- Population, $pop_{i,t}$. Defined as the total population on January 1 each year.

- Percentage of children, $a015_{i,t}$. Defined as the share of the population aged 0-15 years.

- Percentage of pensioners, $a65_{i,t}$. Defined as the share of the population aged 65 years or above.

- Municipal area, $s_{i,t}$. Defined as the area of the municipality in square kilometers.

- North, *north*: Dummy variable indicating whether the municipality is located in the northern part of the country.

- Stockholm, *Stockholm*: Dummy variable indicating whether the municipality is located in the county of Stockholm.

- Malmö, *Malmö*: Dummy variable indicating whether the municipality is located in the county of Malmö.

- Göteborg, *Göteborg*: Dummy variable indicating whether the municipality is located in the county of Göteborg- and Bohus.

Appendix 2

Given the first order conditions

$$
\begin{aligned}
\lambda_1 &: \; y_1 - p_1 \cdot (x_1 + g_1) - k_2 \cdot v_2 - k_3 \cdot v_3 - c_1 = 0 \\
x_1 &: \; \frac{\partial u_1}{\partial x_1} - \lambda_1 \cdot p_1 = 0 \\
g_1 &: \; \frac{\partial u_1}{\partial g_1} - \lambda_1 \cdot p_1 = 0 \\
c_1 &: \; \frac{\partial f_1}{\partial c_1} - \lambda_1 = 0 \\
v_2 &: \; \frac{\partial f_2}{\partial v_2} - \lambda_1 \cdot k_2 \leq 0, \; v_2 \geq 0 \text{ and } v_2 \cdot \left(\frac{\partial f_2}{\partial v_2} - \lambda_1 \cdot k_2 \right) = 0 \\
v_3 &: \; \frac{\partial f_3}{\partial v_3} - \lambda_1 \cdot k_3 \leq 0, \; v_3 \geq 0 \text{ and } v_3 \cdot \left(\frac{\partial f_3}{\partial v_3} - \lambda_1 \cdot k_3 \right) = 0
\end{aligned}
$$

the bordered Hessian $\left|\overline{H}\right|$, which is required to be negative semidefinite, is

$$
\left|\overline{H}\right| = \begin{vmatrix}
0 & -p_1 & -p_1 & -1 & -k_2 & -k_3 \\
-p_1 & \frac{\partial^2 u_1}{\partial x_1^2} & \frac{\partial^2 u_1}{\partial x_1 \partial g_1} & \frac{\partial^2 u_1}{\partial x_1 \partial c_1} & 0 & 0 \\
-p_1 & \frac{\partial^2 u_1}{\partial g_1 \partial x_1} & \frac{\partial^2 f_1}{\partial g_1^2} & \frac{\partial^2 u_1}{\partial g_1 \partial c_1} & 0 & 0 \\
-1 & 0 & 0 & \frac{\partial^2 f_1}{\partial c_1^2} & 0 & 0 \\
-k_2 & 0 & 0 & 0 & \frac{\partial^2 f_2}{\partial v_2^2} & 0 \\
-k_3 & 0 & 0 & 0 & 0 & \frac{\partial^2 f_3}{\partial v_3^2}
\end{vmatrix} \leq 0
$$

The impact from x_2 on x_1^*, $\partial x_1^* / \partial x_2$ is given by

$$
\frac{\partial x_1^*}{\partial x_2} = \frac{\begin{vmatrix}
0 & 0 & -p_1 & -1 & -k_2 & -k_3 \\
-p_1 & 0 & \frac{\partial^2 u_1}{\partial x_1 \partial g_1} & \frac{\partial^2 u_1}{\partial x_1 \partial c_1} & 0 & 0 \\
-p_1 & 0 & \frac{\partial^2 f_1}{\partial g_1^2} & \frac{\partial^2 u_1}{\partial g_1 \partial c_1} & 0 & 0 \\
-1 & 0 & 0 & \frac{\partial^2 f_1}{\partial c_1^2} & 0 & 0 \\
-k_2 & -\frac{\partial^2 f_2}{\partial v_2 \partial x_2} & 0 & 0 & \frac{\partial^2 f_2}{\partial v_2^2} & 0 \\
-k_3 & 0 & 0 & 0 & 0 & \frac{\partial^2 f_3}{\partial v_3^2}
\end{vmatrix}}{\left|\overline{H}\right|}
$$

Using Laplace expansion

$$\frac{\partial x_1^*}{\partial x_2} = \frac{p_1 \cdot \begin{vmatrix} 0 & -p_1 & -1 & -k_2 & -k_3 \\ 0 & \frac{\partial^2 f_1}{\partial g_1^2} & \frac{\partial^2 u_1}{\partial g_1 \partial c_1} & 0 & 0 \\ 0 & 0 & \frac{\partial^2 f_1}{\partial c_1^2} & 0 & 0 \\ -\frac{\partial^2 f_2}{\partial v_2 \partial x_2} & 0 & 0 & \frac{\partial^2 f_2}{\partial v_2^2} & 0 \\ 0 & 0 & 0 & 0 & \frac{\partial^2 f_3}{\partial v_3^2} \end{vmatrix}}{\left|\overline{H}\right|}$$

$$= \frac{p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \begin{vmatrix} 0 & -1 & -k_2 & -k_3 \\ 0 & \frac{\partial^2 f_1}{\partial c_1^2} & 0 & 0 \\ -\frac{\partial^2 f_2}{\partial v_2 \partial x_2} & 0 & \frac{\partial^2 f_2}{\partial v_2^2} & 0 \\ 0 & 0 & 0 & \frac{\partial^2 f_3}{\partial v_3^2} \end{vmatrix}}{\left|\overline{H}\right|}$$

$$= \frac{p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot \begin{vmatrix} 0 & -k_2 & -k_3 \\ -\frac{\partial^2 f_2}{\partial v_2 \partial x_2} & \frac{\partial^2 f_2}{\partial v_2^2} & 0 \\ 0 & 0 & \frac{\partial^2 f_3}{\partial v_3^2} \end{vmatrix}}{\left|\overline{H}\right|}$$

$$= \frac{-p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot \frac{\partial^2 f_3}{\partial v_3^2} \cdot \frac{\partial^2 f_2}{\partial v_2 \partial x_2} \cdot k_2}{\left|\overline{H}\right|}$$

and

$$\frac{\partial x_1^*}{\partial x_3} = \frac{-p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot \frac{\partial^2 f_2}{\partial v_2^2} \cdot \frac{\partial^2 f_3}{\partial v_3 \partial x_3} \cdot k_3}{\left|\overline{H}\right|}$$

As p_1, k_2 and $k_3 > 0$ and $\partial^2 f_1/\partial g_1^2$, $\partial^2 f_1/\partial c_1^2$, $\partial^2 f_2/\partial v_2^2$ and $\partial^2 f_3/\partial v_3^2$ are generally expected to be negative, the signs of $\partial x_1^*/\partial x_2$ and $\partial x_1^*/\partial x_3$ depend on the cross derivatives $\partial^2 f_2/\partial v_2 \partial x_2$ and $\partial^2 f_3/\partial v_3 \partial x_3$. From the first order conditions $\lambda_1 = \partial f_1/\partial c_1$, and the impact from k_2 and k_3 on x_1^* is determined by

$$\frac{\partial x_1^*}{\partial k_2} = \frac{-p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot \frac{\partial^2 f_3}{\partial v_3^2} \cdot \left(v_2 \cdot \frac{\partial^2 f_2}{\partial v_2^2} + \frac{\partial f_1}{\partial c_1} \cdot k_2\right)}{\left|\overline{H}\right|}$$

and

$$\frac{\partial x_1^*}{\partial k_3} = \frac{-p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot \frac{\partial^2 f_2}{\partial v_2^2} \cdot \left(v_3 \cdot \frac{\partial^2 f_3}{\partial v_3^2} + \frac{\partial f_1}{\partial c_1} \cdot k_3\right)}{\left|\overline{H}\right|}$$

$v_2 = 0 \rightarrow k_2 = 0 \rightarrow \partial x_1^*/\partial k_2 = 0$ and $v_3 = 0 \rightarrow k_3 = 0 \rightarrow \partial x_1^*/\partial k_3 = 0$. If $v_2 > 0$ and $v_3 > 0$, the signs on $\partial x_1^*/\partial k_2$ and $\partial x_1^*/\partial k_3$ depend on the expression within parenthesis, where $v_2 \cdot \partial^2 f_2/\partial v_2^2$ and $v_3 \cdot \partial^2 f_3/\partial v_3^2$ correspond to the income effects and $\partial f_1/\partial c_1 \cdot k_2$ and $\partial f_1/\partial c_1 \cdot k_3$ are the substitution effects. $\partial f_1/\partial c_1$ is generally expected to be positive. If $\partial x_1^*/\partial k_2$ and $\partial x_1^*/\partial k_3$ are negative, $|v_2 \cdot \partial^2 f_2/\partial v_2^2| > \partial f_1/\partial c_1 \cdot k_2$ and $|v_3 \cdot \partial^2 f_3/\partial v_3^2| > \partial f_1/\partial c_1 \cdot k_3$. The income effect and the own-price effect have the expected signs and are determined by

$$\frac{\partial x_1^*}{\partial y_1} = \frac{-p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot \frac{\partial^2 f_2}{\partial v_2^2} \cdot \frac{\partial^2 f_3}{\partial v_3^2}}{\left|\overline{H}\right|} > 0$$

and

$$\frac{\partial x_1^*}{\partial p_1} = \frac{p_1 \cdot \frac{\partial^2 f_1}{\partial g_1^2} \cdot \frac{\partial^2 f_1}{\partial c_1^2} \cdot (x_1 + g_1) \cdot \frac{\partial^2 f_2}{\partial v_2^2} \cdot \frac{\partial^2 f_3}{\partial v_3^2}}{\left|\overline{H}\right|} < 0$$

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