Spatial Interdependence of Local Public Expenditures. Evidence from the Czech Republic.

Very preliminary

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Abstract

Local expenditures of neighbouring municipalities can be interdependent due to significant spillover effects. If we observe positive interdependence, increase in expenditures in neighbouring municipalities increases domestic expenditures; this effect can be interpreted as competition. However, we can also find negative interdependence which stems from the free riding. In this paper, we aim to test the spatial interdependence of local public expenditures using data on 205 Czech municipalities. We focus mainly on expenditures on industry and infrastructure, culture, sports and recreation and environmental protection.

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1 Theoretical background

Recently, a lot of attention has been devoted to studying spatial interdependence of local public policies. This part of literature has developed within the scope of fiscal federalism, in particularly, within the discussion on decentralization of fiscal policies as a potential source of competition among local governments.

Local policies are interdependent if fiscal decisions in neighbouring jurisdictions play an important role in the decision of domestic jurisdiction. Till lately, these aspects were analyzed only for tax policy and a lot of literature on tax competition emerged. However, due to the fact that a lot of local governments do not have large tax competencies the analysis has been extended to public goods provision.

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Fiscal interactions among local governments can be easily explained by the presence of spillover effects of their fiscal decisions affecting welfare in neighbouring regions. These effects can be either positive or negative. Concerning positive effects, expenditures on culture, environmental protection and infrastructure in one region can increase the welfare of residents in neighbouring regions, because these residents can utilize such goods and services. Optimal reaction of domestic government would be to free-ride on neighbouring regions and decrease expenditure.

However, some of these policies can also have negative consequences on neighbouring regions. This reasoning concerns new potential residents and potential businesses operating in the region. More residents and businesses in the region imply more revenues for local governments, therefore local governments have also incentives to attract people to settle in their region and new businesses to operate there. For example, higher spending on infrastructure in neighbouring region can decrease number of potential businesses operating in domestic region. The firm will be interested more in the region with better conditions for doing business. The similar inference can hold for potential residents. If people are sufficiently mobile, such that they can easily change their residence, the incentives for governments will be much higher. Consequently, these incentives can lead to competition among local governments via specific type of spending resulting in positive spatial interdependence.

Among the first authors who explored the topic of spending competition were Keen and Marchand (1997). They state that under fiscal competition, the composition of public expenditure is inefficient in that too much is spent on public inputs benefiting local business and too little on public goods benefiting residents, which stems from the labour immobility. Matsumoto (2000) and Borck (2005) further extend this paper theoretically. Kellermann (2006) analyzes special setting in which government provides public inputs creating rents which can be appropriated by the private capital. He shows that benevolent public decision-maker will tax mobile capital and then redistribute income in favor of the immobile factor labor. Boadway, Cuff and Marceau (2002) stress that impossibility to tax firms induces regions to compete by implementing inefficient redistributive policies. Gèrard and Ruiz (2006) model interjurisdictional competition for firms' investment as competition in the expenditure on higher education. They assume that firms make locational investment decisions according to the quality of human capital.

Besides theoretical explanation, several papers analyze these effects empirically, Brueckner (2003) provides the overview of empirical studies. Borck, Caliendo and Steiner (2006) study fiscal competition between jurisdictions via size and structure of public spending. They model reactions functions of jurisdictions on amounts of different public goods provided in neighbouring regions and estimate these functions for German communities. They found out significant positive reactions for facilities encouraging business development, then for general administration and for supporting business enterprises. Spending competition is empirically explored also in Brueckner (1998). He focuses on the adoption of growth-control measures by municipalities in California and seek evidence of policy interdependence. Lundberg (2001) test for effects for recreational and culture expenditure in Swedish municipalities and he shows that municipalities with similar expenditure levels are clustered to a greater extent. Revelli (2002) explores neighborhood effects in social service provision. He proves that the source of spatial autocorrelation in social spending is endogenous mimicking among neighboring localities. Foucalt, Madiès and Paty (2007) analyze interactions concerning different categories of local public spending among French municipalities. They found significant interdependence only for cities whose mayors share the same partisan affiliation. Ermini and Santolini (2007) test public spending interdependence among Italian jurisdictions and found significant interaction between their spending both at the level of total expenditure and also for different sub-categories. Heyndels, Werck and Geys (2008) found evidence that Flemish municipalities cultural expenditures are positively affected by the level of cultural spending of their neighbours.

In our paper, we contribute to the empirical part of this literature. We aim to test the positive spatial interdependence of local public expenditures using data on Czech municipalities. We test hypothesis that Czech municipalities compete for residents and businesses via higher spending, focusing mainly on expenditures on infrastructure and industry support, culture, sports and recreation and environmental protection. Higher expenditures on infrastructure and higher support of firms improve conditions for doing business and thus can potentially attract firms into the region. Additionally, rich people who value high-quality environment, cultural and sport services are virtually more mobile, therefore can be attracted by better services.

The paper is organized as follows. Section 2 describes an estimation techniques, section 3 presents the data used, section 4 gives results of spatial autocorrelation tests for different weighting matrices. Section 5 shows the estimation results and section 6 concludes.

2 Econometric approach

To test whether spending is actually a strategic variable in the Czech municipalities, we aim to estimate general reaction function based on cross sectional data on 205 Czech municipalities in year 2005. Because of spatial dependence, we use the spatial lag model. The estimating equation for spending category k can be written as

$$z_i^k = \beta \sum_{j \neq i} w_{ij} z_j^k + \theta X_i + \epsilon_i \qquad (1)$$

where scalar β and vector θ are parameters to be estimated, $\theta = (\theta^1, \theta^2, ..., \theta^n)$, vector $X = (x^1, x^2, ..., x^n)$ represents explanatory variables, ϵ_i is error term, w_{ij} are weights illustrating relevance of spending in neighbouring jurisdiction j for strategic interaction.

Brueckner (2003) emphasizes three issues arising from estimation of this model, endogeneity of the z_j's, possible spatial error dependence, and possible correlation between X_i and the error term.

We can rewrite the system of equations (1) in the matrix form as

$$z = \beta W z + \theta X + \epsilon \tag{2}$$

where z is vector of the z_i's (we skip superscript k as it holds for $\forall k$), X is matrix of jurisdictional characteristics and W denotes the weighting matrix with elements w_{ij}. If neighbouring locations are denoted by i and j, then z_j enters on the right hand side in the equation for z_i, but z_i also enters on the right hand side in the equation for z_j (the neighbour relation is symmetric, possibly with nonsymmetric weights $w_{ij} \neq w_{ji}$). This endogeneity must be considered in the estimation process. By rewriting (2) we get

$$z = (I - \beta W)^{-1}\theta X + (I - \beta W)^{-1}\epsilon \tag{3}$$

where each element of z depends on all the ϵ's. Hence, each z_j in (1) depends on ϵ_i. When spatially lagged dependent variable is correlated with the disturbance term, the ordinary least squares estimator is inconsistent (see Anselin, 1988). This holds irrespective of the properties of the error terms. Therefore, it is necessary to use an alternative estimation method.

In the literature, we can find two main methods how to estimate spatial process models.[1] One is the maximum likelihood estimation which is used by Case, Rosen and Hines (1993), Brueckner (1998), Lundberg (2001), Brueckner and Saavedra (2001), Gosh (2006) and Foucalt, Madiès and Paty (2007). The alternative approach uses an instrumental variables estimation. This estimation technique can be found in the analysis of Kelejian and Robinson (1993), Fredriksson and Millimet (2000), Revelli (2001), Borck, Caliendo and Steiner (2006) or Ermini and Santolini (2007).

Estimation of (1) can be further complicated by the spatial error dependence arising when ϵ includes omitted variables that are spatially dependent. This effect can be explained by unmodelled shocks that spill over across units of observation and thus result in spatially correlated errors. In this case, the error vector ϵ satisfies

$$\epsilon = \rho M \epsilon + \xi \tag{4}$$

where M is weighting matrix which can be the same as W in (2), ρ is a autoregressive parameter to be estimated and ξ is a random error term typically assumed to be *i.i.d.*[2]

The last problem concerning correlation between X_i and ϵ_i can be reduced by using panel data as Brueckner (2003) argues.

In our analysis, we use both estimation techniques and compare results. Firstly, we estimate the model by maximum likelihood. However, in this case we can only estimate spatial lag model and spatial error model separately and

[1]Research on alternative methods for estimation of spatial regression models has expended rapidly, there exist further alternative approaches such as maximum entropy etc. (LeSage & Pace 2004).

[2]Kelejian and Prucha (2006) have recently developed new technique how to estimate ρ for heteroscedastic innovations ξ.

we are not able to combine them. But in case the only spatial lag is present, the estimation can bring reasonable results of municipalities' expenditures interdependence.

However, if we detect spatial error dependence[3] and still want to estimate spatial lag, we will prefer the generalized spatial two-stage least squares procedure (GS2SLS) introduced in Kelejian and Prucha (1998) which consists of three steps.

We firstly compute 2SLS estimates of (2). As is standard in the spatial econometrics literature, we use neighbours' socio-economic covariates as instruments for neighbours' expenditure (e.g. Heyndels and Vuchelen, 1998; Sollè-Ollè, 2005; Geys, 2006; Werck, Heyndels and Geys, 2008). The Sargan test suggests that our instruments are valid for cases when we get significant overall results.

In the second step, we derive residuals ϵ from the first step and estimate ρ in (4) by general moments' method as suggested by Kelejian and Prucha (1999). This estimation method yields consistent estimate $\tilde{\rho}$. In the third step, we reestimate (1) by two-stage least squares procedure after transforming the model via a Cochrane-Orcutt type transformation to account for spatial correlation. By this transformation we get $z^* = z - \tilde{\rho}Wz$, $X^* = X - \tilde{\rho}W$, hence the new estimated equation takes form of

$$z^* = \tilde{\theta}X^* + \tilde{\beta}Wz^* + \epsilon \tag{5}$$

and $\tilde{\theta}$ and $\tilde{\beta}$ denotes GS2SLS estimators. If the spatial error dependence is not present, we will be satisfied with results obtained from the first step.

3 Data

The local institutional structure in the Czech republic currently consists of four tiers of government; the central government, 14 regions (territorial self-governing districts, NUTS 3), 205 municipalities with extended powers, 389 municipalities with authorized municipal office and 6 248 municipalities (basic territorial units, NUTS 5). Until the end of 2002, the structure was different, instead of 14 regions there were 91 districts, which still exist (as territorial districts NUTS 4). The reform of regional public administration dissolved competencies of districts such that around 20 % of competencies shifted from districts to the upper level of government, regions, and 80 % to the lower level of government, i. e. municipalities with extended powers.

For our purpose of measuring interrelationship among spending of local governments we use data on municipalities with extended powers which are responsible for social transfers payment, social care of old and disabled people, water industry, environment protection and infrastructure. If we test the interdependence for upper level of government, regions, we will get only a few observations. For homogeneity reasons, we exclude Prague since the capital city is simultaneously municipality with extended power and region. The Ministry of Finance

[3]Using residuals out of OLS regression, we can carry tests of spatial error dependence - Moran's I and simple Lagrange multiplier test as proposed in Anselin et al. (1996).

provides the complete database of municipality budgets ARIS where the total expenditures are decomposed into current and capital expenditures, divided further into various components.[4]

We aggregated these components into 10 groups of spending: agriculture; industry and infrastructure; education; culture, sports and recreation; health; housing, utilities and regional development; environment protection; social and labour market policy; public safety; and general administration. We disregard expenditures on science and research because they are zero for all the cities of the Czech republic in 2005. Our analysis contents per capita spending in 2005. Table 1 shows size of different expenditures. For each expenditure group we present only total expenditures and do not distinguish between capital and current expenditures.

Table 1. Summary statistics - expenditures per capita

Variable	Mean	Std. Dev.	Min	Max	Obs.
Aggregate	20532.40	5473.48	12637	54488	205
Aggregate capital	5491.42	3490.65	861	29991	205
Aggregate current	15040.97	3787.10	9999	50400	205
Agriculture	128.52	162.43	0	1335	205
Industry and infrastructure	2635.35	1885.26	241	15936	205
Education	1789.13	841.23	858	6781	205
Culture, sports and recreation	2223.67	1328.92	0	9920	205
Health	280.49	595.13	0	4033	205
Housing, utilities and regional development	3356.75	2941.08	338	31128	205
Environment protection	1159.14	687.21	0	7528	205
Social and labour market policy	3616.78	1582.69	1097	10210	205
Public safety	529.29	302.75	2	1668	205
General administration	4813.25	3154.57	1953	43003	205

Note: The expenditures are given in the Czech crowns.

As we can see from the Table 1, Czech municipalities spent on average 20 532 Czech crowns per one inhabitant. The largest share represents spending on general administration. Furthermore, significant part of the budget is spent on social transfers payment, housing and on industry support and infrastructure.

In the model of interaction of local public expenditure, we have to include various socio-economic and political characteristics of local jurisdictions. As economic characteristics, we use average gross wage, unemployment rate, grants and subsidies per capita and tax revenues per capita (both available in ARIS database). Unfortunately, we do not have data on GDP for this level of government, so we approximate it by average gross wage.

Additionally, jurisdictional demographic characteristics can affect the composition of public spending for services because they determine the needs and preferences of population for public goods. Therefore, among dependent variables we include the share of elederly (more than 65 years) and youth (less than

[4]http://www.mfcr.cz/cps/rde/xchg/mfcr/hs.xsl/aris.html

15 years). The size of the municipality in terms of its population can also influence its spending. We furthermore test impact of the density of population in the district which can represent a measure for the rate of urbanization in the region the municipality lies. We also include share of people above 15 years with university education and finally, we add the share of people traveling in their jobs. This variable can represent potential mobility of people in the region but revealed preference for staying in domestic region. The drawback of this and previous one indicator is that the most recent data were collected in the census in 2001. Most of these exogenous variables are provided by the Czech Statistical Office.[5]

We also introduce political variables to control for a number of important characteristics of the local governments ruling in the year 2005 (and which were elected in 2002). Firstly, we aim to test whether the local government complexion affect the level of spending. Left-wing governments are generally argued to have greater incentives to spend more. Unfortunately, it is almost impossible to distinguish parties or candidates according to their political ideology on municipal level. Moreover, we do not have data on coalitions formed in local governments. Therefore, we construct dummy variable indicating that communist party or social democratic party, major Czech left-wing parties, was the winner of municipality elections in 2002.

The other political variable represents party fragmentation. Number of parties and their relative power can also influence decisions on government spending. We compute Herfindahl index for party concentration in local government which is usually used as an indicator of party fragmentation in the government and normalize it from 0 to 1. Variables and summary statistics of exogenous variables can be found in Table 2.

Table 2. Summary statistics - explanatory variables

Variable	Mean	Std. Dev.	Min	Max	Obs.
Population	23288.66	38402.08	2911	366 757	205
Population density (per km^2)	143.36	174.65	31.98	1597.3	205
Share of youth	14.78	1.10	12.32	19.34	205
Share of elderly	13.82	1.54	10.27	17.09	205
Share of university educated people	6.26	1.85	2.536	17.928	205
Unemployment rate	10.34	3.97	3.31	24.19	205
Average gross wage (in Districts)	16367.25	1221.85	14580	21191	205
Workers' mobility	44.01	12.06	7.63	75.2	205
Subsidies per capita	1796.16	1821.42	162	15474	205
Tax revenues per capita	9913.57	1745.37	625.8	19734.9	205
Left-wing parties	0.171	0.377	0	1	205
Party fragmentation	0.767	0.124	0	1	205

[5]http://www.czso.cz

4 Testing for various neighbourhood matrices

The crucial point of study is the construction of a neighbourhood weighting matrix. It is fundamental when dealing with spatial correlation since it introduces the potential spatial correlation among units of observations. In our study we consider various matrices. For each matrix, we test for spatial autocorrelation which can be measured by Moran's I (Moran 1948) statistics or Geary's c (Geary 1954).

Moran's I statistic is given by

$$I = \Big[\frac{N}{\sum_{j=1}^{N}\sum_{i=1}^{N} w_{ij}}\Big]\Big[\frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(x_i - \bar{x}_i)(x_j - \bar{x}_j)}{\sum_{i=1}^{N}(x_i - \bar{x}_i)^2}\Big],$$

where N is total number of spatial units, x is variable of interest, $\bar{x}$ is its mean and w_{ij} is the spatial weight describing the relation between i and j. The significance of I is judged by constructing z-score, $z_I = \frac{I-E(I)}{\sqrt{var(I)}}$, and comparing it to standard normal distribution. If I is larger (lower) than its expected value, then the overall distribution of the variable of interest x can be characterized by positive (negative) spatial autocorrelation, e.g. the value of x at each location i tends to be similar (different) to the values of x at spatial contiguous locations.

Geary's c is computed by

$$c = (N-1)\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}(x_i - \bar{x}_i - (x_j - \bar{x}_j))^2}{2\sum_{j=1}^{N}\sum_{i=1}^{N} w_{ij}(x_i - \bar{x}_i)^2}.$$

Under the null hypothesis of no spatial autocorrelation, the expected value of c equals 1. For c greater (smaller) than 1, the overall distribution of x can be characterized by negative (positive) spatial autocorrelation. As in the case of Moran's I, the significance is judged according to z-scores given by $z_c = \frac{c-1}{\sqrt{var(c)}}$ compared to standard normal distribution.

Additionally, there exist one more measure of spatial autocorrelation – Getis and Ord's G, however it is limited to nonstandardized symmetric binary neighbourhood matrix. That is why we use only Moran's I and Geary's c in our analysis.

When interpreting results of the spatial autocorrelation tests, we have to be cautious. Detected spatial autocorrelation in case of public expenditures does not directly imply that municipalities' spending is interdependent. Similar spending levels can be caused by similar characteristics of neighbouring regions or similar shocks and effects neighbours face. On the other hand, in case of no spatial autocorrelation indicated by measures above we still cannot conclude that there is no spatial interdependence. If public spending is determined by an explanatory variable being highly different within neighbouring municipalities, the spatial autocorrelation will not be detected even in case that municipality's decision on spending is affected by neighbouring municipality's decision.

We use spatial autocorrelation tests as a basis for decision which neighbourhood matrices are more suitable in our analysis, because they can help us in recognizing relevant neighbours. Given the set of data, if we find higher and more significant spatial autocorrelation for one neighbourhood matrix than for other matrices, we will use it for our analysis.

In following sections, we introduce useful neighbourhood weighting matrices which can be possibly used and present results for autocorrelation tests for each of them. All weighting matrices are based on geographical specification. The diagonal elements of matrices are always zero and off-diagonal elements can be denoted by w_{ij} for jurisdiction i and its neighbour j.

4.1 First-order neighbourhood matrix

In this matrix, we positively weight only direct neighbours, e.g. if municipality i shares a common border with municipality j, then $w_{ij} > 0$ and if municipality i does not share a common border with municipality j, then $w_{ij} = 0$. We can use binary matrix in which weights of neighbours equal to one, $w_{ij} = 1$, or row-standardized matrix for which weights take into account the total amount of direct neighbours n_i of municipality i and $w_{ij} = \frac{1}{n_i}$. Elements of each row in standardized matrix are normalized such that they sum to unity.

Following Table 3 presents the results of spatial autocorrelation tests of various expenditures using binary and standardized first-order neighbourhood matrix. It contains only expenditure groups for which the spatial autocorrelation was at least for some cases significantly detected. In case that the spatial autocorrelation is not significant for total expenditures, but only for current or capital expenditures, we present the results for these particular expenditures.

Table 3. First-order neighbourhood matrix - Moran's I and Geary's c

	Binary matrix		Standardized matrix	
Variable	I	c	I	c
Total expenditures:				
Agriculture	0.190***	0.888	0.182***	0.832**
Education	0.066**	0.849**	0.066**	0.853**
Culture, sports and recreation	0.063**	1.042	0.050*	0.990
Social and labour market policy	0.317***	0.695***	0.298***	0.704***
General administration	0.064***	0.903	0.064**	0.952
Current expenditures:				
Aggregate	0.057**	0.944	0.050*	0.957
Housing, utilities and regional development	0.105***	0.873**	0.111**	0.876***
Public safety	0.134***	0.832***	0.139***	0.833***
Capital expenditures:				
Industry and infrastructure	0.059*	0.945	0.071**	0.915**

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

For this particular neighbourhood matrix, the spatial autocorrelation was detected at least for one type of expenditures (capital or current) for all the groups except environment protection and health. Moran's I indicated spatial autocorrelation more often than Geary's c.

Total expenditures on social and labour market policy and education are the most spatially autocorrelated.[6] This can be explained by the fact that expenditures per capita do not differ too much among regions (see the summary statistics in Table 1) in comparison with other expenditure groups. Similar reasoning can hold for the current expenditures on public safety. Spatial autocorrelation in agriculture expenditure can be on the other hand clarified by similar characteristics of neighbours, such as altitude, fertility of the agriculture land or climate conditions.

For remaining groups we can be suspicious of some spatial interdependence. Higher expenditures on culture, sports and recreation can attract residents highly valuing these luxury services, on the other hand expenditures on housing, utilities and regional development attracts not only these residents but also poorer ones. Additionally, capital expenditures on infrastructure and support of industries attracts businesses to the region. Concerning general administration, looking at the larger expenditures of neighbours, domestic governments can lack the efficiency of administration. However, the deeper analysis of the spatial interaction is necessary.

4.2 Second-order neighbourhood matrix

The second-order neighbourhood matrix positively weight not only direct neighbours, but also neighbours of its neighbours, e.g. if municipality i shares a common border with municipality j, then $w_{ij} > 0$ and moreover if municipality j shares a common border with municipality k, then $w_{ik} > 0$, otherwise the weight is zero. In comparison with previous matrix, by using the second-order neighbourhood matrix we extend neighbourhood.

We can use binary matrix in which weights of neighbours and neighbours of neighbours equal to one, $w_{ij} = 1$, or row-standardized matrix for which weights take into account the total amount of direct and indirect neighbours n_i of municipality i and $w_{ij} = \frac{1}{n_i}$.

The other option is to set lower weights on second-order neighbours. Spending of these neighbours affects municipality's decisions on expenditures to lower extent than spending of direct neighbours. In our analysis, we choose weight 0.5 on indirect and weight 1 on direct neighbours. Again, as in previous case we can standardize the matrix.

Table 4 presents the results of spatial autocorrelation test of Moran's I[7] of various expenditures using different second-order neighbourhood matrices. It contains only expenditure groups for which the spatial autocorrelation was at

[6] For social and labour market policy we have the most significant Moran's I and Geary's c among all the expenditure groups and for expenditures on education Moran's I and Geary's c are always significant - for total, current and capital expenditures.

[7] Measure of Moran's I indicated spatial autocorrelation more often than Geary's c for first-order neighbourhood matrix, that is why we use it in further analysis.

least for some cases significantly detected. In case that the spatial autocorrelation is not significant for total expenditures, but only for current or capital expenditures, we present the results for these particular expenditures.

Table 4. Second-order neighbourhood matrix - Moran's I

	Same weights		Different weights	
Variable	Binary	Standardized	Ordinary	Standardized
Total expenditures:				
Aggregate	0.027^{*}	0.023	0.071^{***}	0.072^{***}
Agriculture	0.093^{***}	0.098^{***}	0.155^{***}	0.153^{***}
Industry and infrastructure	-0.033	-0.026	0.023	0.027^{*}
Education	0.028^{*}	0.038^{**}	0.079^{***}	0.092^{***}
Culture, sports and recreation	0.047^{**}	0.039^{**}	0.092^{***}	0.083^{***}
Health	-0.013	-0.015	0.032^{*}	0.033^{*}
Housing, utilities and regional development	0.025^{*}	0.018	0.051^{***}	0.049^{***}
Environmental protection	0.017	0.009	0.057^{***}	0.065^{***}
Social and labour market policy	0.234^{***}	0.223^{***}	0.287^{***}	0.278^{***}
Public safety	0.042^{**}	0.042^{**}	0.081^{***}	0.090^{***}
General administration	0.031^{**}	0.035^{***}	0.081^{***}	0.095^{***}
Current expenditures:				
Environmental protection	0.066^{***}	0.049^{**}	0.095^{***}	0.087^{***}
Capital expenditures:				
Industry and infrastructure	0.006	0.017	0.062^{***}	0.074^{***}

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

Table 4 compared to Table 3 illustrates that larger neighbourhood can slightly increase spatial autocorrelation. Moreover, we can see that setting diferents weights on direct and indirect neighbours can very strongly increase significance of Moran's I. Therefore, if we use the second-order neighbourhood matrix, it is useful to put different weights on second and first order neighbours.

Concerning expenditures on industry and infrastructure and environmental protection, we show that using capital and current expenditures, respectively, will yield more significant results of spatial autocorrelation than if we use total expenditures.

4.3 Neighbourhood matrix based on similarities

This matrix expresses the reasoning that municipalities can weight decisions on expenditures of similar municipalities more. If a region has two neighbours, one large and rich and the other one of similar size and economic conditions, its expenditures can be much stronger affected by expenditures in the latter region. As a basis for this matrix, we used second and first order neighbours and we constructed weights in the following way.

We characterize municipalities by population size, population density, share of young and old people, share of university educated people, average gross wage and unemployment rate. Each variable was normalized from 0 to 1. For variable k, we construct the specific weight of municipality i to municipality j, w_{ij}^k, which was given as $w_{ij}^k = 1 - |x_i^k - x_j^k|$ with x_i^k and x_j^k being normalized values of variable k in country i and j, respectively. If municipalities' characteristics do not differ at all and $x_i^k = x_j^k$, the weight will be set to $w_{ij}^k = 1$. On the other hand, if they are absolutely diverse, e.g. one is maximum and the other is minimum in the set of observations, the difference $|x_i^k - x_j^k|$ is equal to 1 and $w_{ij}^k = 0$. The final weight w_{ij} is set as an average of the weights for each variable, $w_{ij} = \frac{1}{7}\sum_k w_{ij}^k$.

Table 5. Second-order neighbourhood matrix based on similarities - Moran's I

	Ordinary	Standardized
Total expenditures:		
Aggregate	0.027*	0.023
Agriculture	0.098***	0.101***
Education	0.030*	0.041**
Culture, sports and recreation	0.051***	0.042**
Housing, utilities and regional development	0.025*	0.017
Social and labour market policy	0.238***	0.224***
Public safety	0.039**	0.039**
General administration	0.032***	0.037***
Current expenditures:		
Environmental protection	0.070***	0.050**

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

Table 5 shows results of spatial autocorrelation test. If we compare columns of Table 5 and first two columns of Table 4 we can see that they are more or less the same, with a little bit more significant results in the Table 5. Thus, introducing weights based on common characteristics improves results a little bit. This is also caused by the fact that neighbours' characteristics are very similar (unemployment rate or gross wages), so weights are often above 0.9. In case we combine constructed weights based on similarities and different weights on first and second order neighbours, we obtain a little bit more significant results compared to last two columns of Table 4. Therefore, it is reasonable to use the matrix including information about the characteristics differences.

4.4 Distance-based neighbourhood matrix

Finally, we can construct the neighbourhood matrix based on distance bands. For this purpose, we collect spatial coordinates for each municipality and we studied spatial autocorrelation for different distance bands.[8] The neighbour j

[8]We collected GPS coordinates for a location of each municipality. We approximated degrees of latitude and longitude by kilometers (the Czech Republic is relatively small, so

of municipality i is now defined as a municipality lying within given distance and the weight is given as $w_{ij} = \frac{1}{n_i}$ with n_i being total amount of municipalities lying from i within given distance, if the municipality j lies further than the given distance, the weight will be zero.

We study how spatial autocorrelation varies with setting different distance bands. Basically, we study the distance bands from 0 to 50 kilometers both, cumulatively and separately. Table 6 shows how the Moran's I changes with setting different distances of neighbourhood for aggregate expenditures.

Table 6. Aggregate expenditures - Moran's I spatial correlogram

Cumulative distance bands				Separate distance bands			
Km	Total	Current	Capital	Km	Total	Current	Capital
0–10	0.365**	0.172	0.145	0–10	0.365**	0.172	0.145
0–20	0.121**	0.140***	0.068	10–20	0.060	0.115**	0.084*
0–30	0.041	0.044*	0.054*	20–30	0.000	−0.001	0.054
0–40	0.011	0.025	0.025	30–40	−0.009	0.009	0.016
0–50	0.010	0.027*	0.039**	40–50	0.018	0.033	0.073**

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

Table 6 suggests that the most relevant neighbourhood to consider is from zero to 20 kilometers. Further extension of neighbourhood does not lead to more significant spatial autocorrelation. To explain better results for aggregate capital expenditures in band of 40 to 50 kilometers we can argue that this distance is so large, thus incorporating such distance band lead to exponential increase in neighbours and higher probability that there are neighbours with similar characteristics and therefore similar spending levels.

If we compute Moran's I spatial correlogram for various expenditure groups, we get almost similar results - highest spatial autocorrelation is found in distance band from 10 to 20 kilometers.[9] In following analysis, besides others we use the matrix based on the neighbourhood from 0 to 20 kilometers, although for such a neighbourhood there exist 14 municipalities with no neighbours.

To sum up, we found the highest spatial autocorrelation for neighbourhood matrix weighting positively, but differently first and second order neighbours. Results were furthermore improved when including the information on characteristics differences. Row-standardization is not very important.

In our further analysis, we will test spatial interdependence for three neighbourhoods defined. The first matrix, with the narrowest neighbourhood, is based on distance band of 20 kilometers; the second one, non-standardized matrix, includes only first order neighbours with information on characteristics

error is quite small), however we had to adjust degrees of latitude (multiplied it by constant 1.58) because one degree of latitude does not represent same distance in kilometers as one degree of longitude. So finally coordinates for municipalities are in interval from 0 to 6.58 for longitude, the coordinate of the most western municipality - Aš was set to 0, and from 0 to 3.50 for latitude, the coordinate of the most southerm municipality - Kaplice was set to 0.

[9] Overall results are available upon request.

differences; finally, the third one with the largest neighbourhood - ordinary matrix containing the first and second order neighbours together with information on characteristics differences.

5 Estimation results

In this section, we present estimation results of spatial interdependence of local public expenditures in the Czech municipalities. We focus on aggregate expenditures and three expenditure groups - industry and infrastructure (I & I); culture, sports and recreation (C, S & R) and environmental protection (EP). These expenditures are mainly voluntary from the point of view of municipality, therefore the local government is not too much limited by decisions of upper levels of government and can decide on its own.

If we find significant interdependence, we can conclude that there exist spillover effects, positive or negative, dependent on the sign of our estimate β. Positive interdependence of expenditures can be interpreted as a signal of possible competition between municipalities for businesses (for expenditures on industry support and infrastructure) and possibly also residents (mainly for expenditures on culture, sports and recreation and also environmental protection). However, if we find negative effect, we can say that the the positive spillover effect occurs and increasing expenditures abroad decrease domestic expenditures.

5.1 Diagnostic test for spatial lag and error dependence

To decide which model for particular expenditures to use, we can firstly perform several diagnostic tests for spatial lag and spatial error dependence. These test are based on OLS regression. We performed three tests for spatial error dependence with null hypothesis that $\rho = 0$, Moran's I_ρ, simple Lagrange multiplier LM_ρ and robust Lagrange multiplier LM_ρ^*, and two tests for spatial lag dependence with null hypothesis $\beta = 0$, Lagrange multiplier LM_β and robust Lagrange multiplier LM_β^*. Unfortunately, I_ρ and LM_ρ also respond to nonzero β and LM_β to nonzero ρ, however, the robust tests LM_ρ^* and LM_β^* were designed to avoid this problem.[10]

Following table gives an overview of possible spatial error and lag dependence. Due to the fact that some effects observed for total expenditures can be driven particularly by current or capital expenditures, we do not show the results only for total expenditures, but distinguish also between current and capital expenditures for each group. We never get significant I_ρ, that is why we do not show this test in Table 7, similarly any tests for current aggregate expenditures and capital expenditures on environmental protection were never significant. By $W1$ we denote the neighbourhood matrix including first-order neighbours, by $W2$ matrix including also second-order neighbours and by $W20$ matrix based on distance of 20km.

[10] For further details on these tests see Anselin and Hudak (1992) and Anselin et al. (1996).

Table 7. Spatial error and lag dependence - diagnostic tests

	LM_ρ			LM_ρ^*			LM_β			LM_β^*		
	W1	W2	W20	W1	W2	W20	W1	W2	W20	W1	W2	W20
Aggregate				*								
Aggregate capital		*						**			*	
I & I		*	**		***	***					*	
I & I capital		**	***		**	*			*			
I & I current		***	**		***	***					**	*
C, S & R		***					**	***		**	*	
C, S & R capital		***						***			*	
C, S & R current		**			*							
EP		**			***		*			**	***	
EP current		***			***		**			***	***	

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

As we can infer from the table above, for matrix $W1$, we almost never observe spatial error dependence (except aggregate expenditures). It also detects spatial lag the least often compared to other matrices - only for culture, sports and recreation and environmental protection. Neighbourhood based on distance of 20 kilometers also seems quite small for discerning spatial interdependence, however it shows interesting pattern for industry and infrastructure expenditures.

Most of the effects observed when using $W1$ and $W20$ are present also in case of $W2$. Therefore, we can conclude that spatial dependence is very relevant for second order neighbours and that is why we decided to use only this type of neighbourhood in further analysis. For aggregate capital expenditures we get significant spatial lag, but not error. Significant LM_ρ is probably mostly signal of spatial lag than of spatial error as robust LM_ρ^* does not show any significant result. If we study the group of expenditures on industry and infrastructure, we can see significant spatial lag and also spatial error. However, these effects for total expenditures are mainly driven by spatial pattern observed for current expenditures. For expenditures on culture, sports and recreation we get significant spatial lag but here, the capital expenditures are more important when analyzing spatial dependence. Looking at environmental protection, we found spatial lag and also error, however, instead of total expenditures, we should focus on current expenditures.

These tests advise us what methods of estimation we can use and furthermore, what effects we can expect. For example, for current expenditures on industry and infrastructure and environmental protection we should use the GS2SLS procedure described above, because we get significant both, lag and error. However, for capital cultural expenditures, we can use simple instrumental variables or maximum likelihood. However, to verify that there is no spatial error dependence, when using IV estimation we proceed to the second step of GS2SLS and estimate ρ. If we cannot reject the null hypothesis that ρ is zero, then we conclude that there is no proof of spatial error. In case we do not find significantly nonzero ρ, we interpret estimates of GS2SLS as estimates from the 1st step (so estimates of ordinary IV estimation). In case we get significant nonzero ρ, we interpret estimates of GS2SLS as those found in the 3rd step.

5.2 Aggregate expenditure

In our analysis of aggregate expenditures, concerning second-order neighbourhood matrix we observe spatial pattern only for capital aggregate expenditures. However, it is also interesting to find determinants of overall aggregate expenditures, so in Table 8, we present also results of OLS regression. We tested the effects of various explanatory variables, however we realized that share of young and old people does not affect aggregate expenditures significantly contrary to share of people in productive age. Furthermore, we get very bad effect of unemployment rate so we disregard it in our estimation.

Table 8. Aggregate expenditures

Regressor	Total	Capital		
	OLS	Maximum Likelihood		GS2SLS
		lag	error	
β	·	0.022^{**}	·	0.028^{***}
ρ	·	·	0.088^{***}	0.376^{**}
Population	0.016	0.007	0.009	0.001
Population density	-2.98^{***}	−0.515	−0.514	−0.244
Share of people 14–65	499.0^{*}	105.0	59.25	71.85
University education	−7.0	168.0	210.0	187.2^{**}
Workers travelling to jobs	94.45^{***}	0.102	2.12	3.42
Gross wage	−0.123	−0.115	−0.208	−0.051
Tax revenues	1.27^{***}	0.300^{***}	0.253^{**}	0.262^{**}
Subsidies	1.72^{***}	1.45^{***}	1.43^{***}	1.46^{***}
Left wing party	−487.7	−133.8	58.12	335.8
Party fragmentation	−1909	-2674.6^{**}	-3035.7^{**}	-2596.8^{**}
Constant	−31472	−8579	−9.15	1288
R^2	0.50	·	·	·
Sargan test	·	·	·	6.79 (0.43)

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

Analysis of determinants of total aggregate expenditures brings interesting results. Surprisingly, the size of the region in terms of its population does not matter, however population density does. The negative significant coefficient verifies hypothesis, that there are economies of scale of total expenditures with increasing population and there can exist fixed costs of operating a municipality. Additionally, the higher the proportion of people in productive age, higher the spending per capita. It can illustrate such a situation that municipality really cares of its population, because these people are exactly those who are mobile and decide where to live. On the other hand, we did not find any significant effect of share of university educated population. That can be explained by the fact that aggregate expenditures include such a various expenditures containing large share of social expenditures or expenditures on schooling which are not related to university educated population.

Furthermore, we get highly significant positive determinant - share of workers travelling to their jobs. These people can be those who are more willing to move to neighbouring regions, but still decided to stay in domestic region. On of the reasons why to stay in the domestic region can be better public services of local government. Strikingly, economic performance does not affect aggregate expenditures. However, it can be due to the fact that average wage is not so good approximation of richness of a municipality. Tax revenues and subsidies per capita represent a budget constraint so higher the revenues available, higher the spending. So municipalities mostly economize with balanced budget, with no surpluses.

In our analysis, we furthermore disregard political data as they do not have any significant effect on total aggregate expenditures. We did not find any evidence that communist or social democratic local governments spent more than others.

If we look at the analysis of capital aggregate expenditures, we can see that a lot of above mentioned significant determinants of total expenditures in OLS regression become insignificant. We found highly significant spatial lag and error dependence, therefore GS2SLS procedure is the most appropriate.

Compared to total expenditures, for capital expenditures we found significant and negative effect of party fragmentation. So the higher the party fragmentation, the lower capital aggregate expenditures. This effect can be easily interpreted; if there is higher number of parties in local government, they more hardly agree on huge investments projects requiring a lot of political and financial support. Moreover, we found positive effect of higher educated people in a municipality. People with university education may vote for politicians also with higher education who are more capable to carry some investment projects and get money for it.

Positive spatial lag means that local governments positively react to increase in neighbours' capital aggregate expenditures. Local governments may learn each from other how to apply for grants of various Ministries or of the European Union and how to get subsidies, or can cooperate and work on joint project. Further explanation can be some rivality and competition among governments, this can be illustrated by following reasoning: "If a neighbouring municipality builds new gym, we will built swimming pool." Positive spatial error dependence can be clarified by some common exogenous shocks, such as new grant competition announced.

5.3 Industry and infrastructure

This group includes expenditures on support of industry (e.g. building, water), trade and services, on roads, public transport and on networks (e.g. telephone, radio, post). These expenditures can be one of the determinants behind firms' locational decision. As we can see in Table 7, we expect positive spatial lag and error dependence caused by both, current and capital expenditures. Therefore, we analyze expenditures on industry and infrastructure in total. Table 9 presents results out of maximum likelihoood and GS2SLS estimation, because as suggested above OLS is not appropriate technique.

Table 9. Expenditures on industry and infrastructure - total

Regressor	Maximum Likelihood		GS2SLS
	lag	error	
β	-0.014	$\cdot$	-0.025
ρ	$\cdot$	0.016	0.215^{**}
Population	0.003	0.004	0.004
Population density	-2.11^{**}	-2.57^{**}	-2.55^{**}
Share of young people	239.5^{**}	212.6^{*}	302.5^{**}
Share of old people	22.93	17.91	35.4
University education	398.8^{***}	439.4^{***}	503.2^{***}
Workers travelling to jobs	-7.08	-5.46	7.04
Gross wage	0.028	-0.115	0.021
Tax revenues	0.392^{***}	0.396^{***}	0.434^{**}
Subsidies	0.235^{***}	0.229^{***}	0.203^{***}
Left wing party	-360.6	-407.4	-546.9^{*}
Party fragmentation	-690.4	-745.1	-993.5
Constant	1072.5	-5387.4	-8971.9
Sargan test	$\cdot$	$\cdot$	10.63 (0.28)

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

Surprisingly, the maximum likelihood estimation does not turn out significance of spatial error or spatial lag, however if we use GS2SLS procedure we get at least significant spatial error. This fact quite well corresponds to Table 7 which shows much stronger suspicion of spatial error than of spatial lag.

As for aggregate expenditures, we do not observe any evidence that size of the municipality matters. Similarly, we can see negative and significant effect of population density verifying economies to scale. If the municipality builds a road, then marginal costs of additional driver using this road are zero. Interestingly, positive significant effect was found for share of young, although there is no direct channel how children can benefit out of this expenditures. Maybe their parents are exactly those who can be attracted by this type of expenditures. They are just those people, young entrepreneurs running their own successful business.

Expenditures are also positively affected by the share of university educated people. These people can be again those who are running their business. Furthermore, increase in tax revenues and subsidies positively affects expenditures.

Notice interesting feature, although for capital aggregate expenditures subsidies were relatively more important than tax revenues, indicating that capital expenditures are payed mostly out of the subsidies, for expenditures on industry and infrastructure, we have opposite case.

Looking at political effects, party fragmentation does not play significant role, however we found significant negative effect for left wing parties. Thus, communist and social democratic representatives tend to support businesses less than other parties.

Finally, we did not prove any evidence of spatial lag dependence of expenditures on infrastructure and industry, so we do not observe that municipalities compete for businesses through this type of expenditures.

5.4 Culture, sports and recreation

Another expenditure group which we focus on includes spending on cultural activities, sports events and clubs and recreational services. As we seek evidence of spatial interdependence, we target only to capital expenditures as they are concerned as potential driver of spatial pattern in total expenditures on culture, sports and recreation (see Table 7).

Table 10. Expenditures on culture, sports and recreation - capital

Regressor	Maximum Likelihood		GS2SLS
	lag	error	
β	0.069***	·	0.089***
ρ	·	0.089***	0.428**
Population	0.004	0.004	0.003
Population density	−0.114	−0.128	0.127
Share of young people	−69.6	−65.58	−65.89
Share of old people	31.88	55.46	18.69
University education	−54.52	−33.22	−46.08
Workers travelling to jobs	−0.330	4.75	−3.14
Gross wage	−0.006	−0.021	−0.017
Tax revenues	0.017	0.025	0.000
Subsidies	0.058	0.046	0.058
Left wing party	424.3**	586.9***	539.7***
Party fragmentation	−242.6	−207.1	−342.7
Constant	−6978.4	−1.01	1403.9
Sargan test	·	·	15.11 (0.12)

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

As we can see from Table 10, we do not get very interpretable results. Probably, there will be some variables omitted which appropriately identify the model. These omitted variable can be moreover spatial dependent as is shown in highly significant coefficient ρ. The expenditures on culture, sports and recreation does not depend neither on tax revenues, nor on subsidies. No effect was found also for share of young people who are potential consumers of sporting services and for share of old people who are on the other hand those enjoying cultural events. The only significant effect was noticed for left wing party so we can conclude that communist and social democratic politicians spend more on cultural and sporting events.

5.5 Environmental protection

Finally, we explore expenditures on environmental protection. Capital expenditures are very low, that is why we deal only with current expenditures. Following table presents the estimation results.

Table 11. Expenditures on environmental protection - current

Regressor	Maximum Likelihood		GS2SLS
	lag	error	
β	-0.017	$\cdot$	-0.030^{**}
ρ	$\cdot$	0.059^{***}	0.176^{***}
Population	-0.001	-0.002	0.000
Population density	-0.041	-0.039	-0.050
Share of people 14-65	59.20^{**}	10.62	53.94^{*}
University education	57.52^{***}	60.62^{***}	47.58^{*}
Workers travelling to jobs	0.007	-2.11	0.794
Gross wage	0.017	0.026	0.004
Tax revenues	0.027	0.033	0.019
Subsidies	-0.024	-0.023	-0.025
Left wing party	-16.32	-41.61	-1.10
Party fragmentation	-171.4	-189.8	-82.34
Constant	-3726.4^{*}	-1.01	-3014.2
Sargan test	$\cdot$	$\cdot$	13.23 (0.15)

Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level

As in previous case, we cannot infer too much from the results shown in Table 11. We observe spatial error dependence which again can be cause by some spatial dependent omitted variable. For the spatial lag, we got negative parameter β. So the higher the expenditures on environmental protection in neighbouring municipalities, the lower in domestic municipality. This result can be evidence of positive spillover effect. Higher environmental protection abroad increase welfare of domestic residents, thus they can decrease their environmental protection and spend money a different way.

Additionally, we found positive and significant effect for share of people in productive age and share of university educated people. These people care more about environment protection, therefore they can be either those who decide n environmental policy in local government or those who vote for politicians with higher preference for good environment.

6 Conclusion

In this paper, we seek evidence of spatial interdependence between local public expenditures in the Czech Republic. We test hypothesis that Czech municipalities compete for residents and businesses via higher spending, focusing mainly on expenditures on infrastructure and industry support, culture, sports and recreation and environmental protection. Higher expenditures on infrastructure and higher support of firms improve conditions for doing business and thus can potentially attract firms into the region. Additionally, rich people who value high-quality environment, cultural and sport services are virtually more mobile, therefore can be attracted by better services. If this hypothesis is valid, the spatial interdependence must be positive. Increase in expenditures in neighbouring regions increases expenditures in domestic region.

We construct various neighbourhood matrices and test the relevancy of them. Diagnostic tests of spatial lag and spatial error indicated the highest spatial dependence for a neighbourhood weighting matrix in which region takes into account expenditure decisions not only of its own neighbours, but also of neighbours of its neighbours. Furthermore, we take into account the fact that municipality's decision is more affected by municipality which has similar socioeconomic characteristics.

Technically, we estimate municipality's reaction function and use two different techniques, maximum likelihood and generalized two-stage least squares. In case the spatial error and lag dependence occur, the latter one is more appropriate.

Concerning total aggregate expenditures, we do not find any spatial dependence. However, if we decompose it and analyze only aggregate capital expenditures, we get significant positive spatial dependence. Therefore, municipalities can compete in their investment projects. Moreover, among other significant effects the party fragmentation decreases these expenditures, so the higher is disagreement among parties in local governments, the lower amount is spent on investment projects.

Additionally, we analyzed expenditures on industry and infrastructure. If municipalities compete for businesses, they should compete also via these expenditures. However, we do not find any evidence validating this hypothesis. Therefore, our analysis does not support the hypothesis that municipalities compete for firms via these expenditures. On the other hand, we get significant spatial lag dependence for culture, sports and recreation, but this effect has to be interpreted with caution, because we are suspicious of omitted variables which can be possibly spatial dependent. Finally, for environmental expenditures we observe negative spatial lag which may indicate positive spillover effect from neighbouring regions.

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