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EXPENDITURE INTERACTIONS BETWEEN
MUNICIPALITIES AND THE ROLE OF
AGGLOMERATION FORCES:
A SPATIAL ANALYSIS FOR
NORTH RHINE-WESTPHALIA

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Expenditure Interactions between Municipalities and the Role of Agglomeration Forces: A spatial analysis for North Rhine-Westphalia

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May 2018

Abstract

This paper analyzes municipal expenditures in the light of horizontal fiscal interactions. I investigate total expenditures and a set of non-earmarked expenditure subcategories in the largest German federal state, North Rhine-Westphalia (NRW). The empirical analysis is based on a Spatial Durbin Model in a panel for the years 2009-2015. Using a two-regime spatial matrix, I also examine the impact of agglomeration on the intensity of public expenditure interactions, thus testing the hypothesis that an agglomerated region can decrease the amount of public goods without losing mobile factors to the periphery.

The findings indicate that significant municipal expenditure interaction effects do exist. The reaction functions also vary for different expenditure subcategories. Unlike spillover effects and fiscal competition, yardstick competition is an insignificant source of potential interactions. Expenditure interaction is fiercer if there is less agglomeration in a municipality. Urbanized and populous municipalities appear to benefit from agglomeration economies, a fact that enables them to spend less. Robustness checks confirm the findings.

JEL classification: C31, F12, F15, J31

Keywords: Local Government Expenditure, Spatial Regression Analysis, Expenditure Interaction

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INTRODUCTION

In the last two decades, increasing research attention has been dedicated to the empirical analysis of inter-governmental fiscal interactions, notably horizontal externalities (Case 1993; Foucault et al. 2008; Borck et al. 2015; Costa et al. 2015; Fossen et al. 2017, etc.). Interactions are a feature of multi-tiered governments where each jurisdiction sets its own tax or spending level and thereby influences the other jurisdictions in their level of spending or taxation. It is particularly interesting for the light it sheds on the implications of public and decentralization policies at the local level. Fiscal interactions occur for three major reasons that have been widely discussed in the literature. The first is public expenditure spillovers, the second centers around fiscal competition, and the last factor is yardstick competition (Revelli 2005).

A large body of literature focuses on tax interactions in particular, and most of it finds evidence for positive effects. Tax burdens in one jurisdiction are interdependent with those in neighboring jurisdictions. One of the first studies on tax mimicking in US counties identifies a positive interaction effect (Ladd 1992). Other studies on the US also point to positive coefficients (Case 1993; Besley and Case 1995; Frederiksson et al. 2004; Crowley and Sobel 2011). They investigate different tax variables such as sales tax, income or property tax, and total tax revenues. Similar papers focusing on the Eurozone are Büttner (1999, 2001), discussing all German counties as well as the municipalities of Baden-Wuerttemberg, Sollé-Ollé (2003), investigating selected Spanish municipalities, Bordignon et al. (2003) on Italian municipalities, Feld et al. (2003) on French regions, and Feld and Reulier (2009) on Swiss cantons. All these studies find positive tax externalities in neighboring jurisdictions.

Spatial interactions in the level and structure of expenditures have been given less attention in the literature than tax interactions. However, in the last two decades they have become noticeably more important because local governments very often do not have large tax competencies, and hence spending decisions gain much more weight. Where interactions do exist, they are relevant for investment decisions by municipalities and may influence the design of public policies. Recent studies on spending interactions, such as Case et al. (1993), Redoano (2007), Št'astná (2009), Frère et al. (2014), Costa et al. (2015), Qu et al. (2016) and Fossen et al. (2017) come up with ambiguous findings. Comparability

between these papers is limited. Only a few of them set their sights on municipal expenditure interactions between total expenses and non-earmarked subcategories at a local level, examples being Case et al. (1993), Št'astná (2009), Costa et al. (2015), or Fossen et al. (2017). As interactions are expected to be stronger at municipal-government level than at higher levels, this lack of research results is remarkable. Accordingly, an initial aim of the present paper is to investigate empirically whether expenditure interactions exist at the municipal level in NRW, in particular in non-earmarked subcategories.

From a theoretical point of view, local governments spend most of their money on guaranteeing the provision of public goods and services. These are not limited to the residents of the jurisdiction that supplies them, a fact referred to in the theory of pure public goods (Samuelson 1954) as “non-excludability.” As predicted by the Tiebout model of local public goods, governments provide public goods financed by local revenues. Residents are mobile, and in order to maximize utility, they will gravitate to those jurisdictions that enable them to profit from an optimal amount of public goods in conjunction with favorable tax rates (voting by feet) (Tiebout 1956). Jurisdictions will therefore be competing for mobile factors. Such theories suggest that local governments compare themselves with neighboring municipalities so as to stay competitive, under the proviso that they cannot limit domestic public goods and services to their own residents.

In the New Economic Geography (NEG) framework, hump-shaped agglomeration rents (Wang and Zeng 2013) may cause the results for the provision of public goods to differ from those found in classical competition models. NEG researchers Andersson and Forslid (2003) and Baldwin and Krugman (2004) state that such agglomeration rents do exist. They could be important for asymmetrical regions because an agglomerated region may conceivably decrease the amount of public goods without losing mobile factors to the periphery. The reason is that companies and employees gain extra profits from agglomeration economies. Other theoretical studies operating on this premise are Ludema and Wooton (2000), Baldwin et al. (2003, chs. 15 and 16), etc.

However, no study so far has considered local expenditures in the context of agglomeration economies. I claim that the combination of expenditure interactions at local levels and agglomeration rents may be of relevance and should therefore be examined. A negative relationship between the provision of public

goods and the indicators of agglomeration should be observed in case agglomeration rents exist. In this paper, I study the impact of agglomeration on the reaction function, i.e. the parameter that indicates whether the expenditure levels determined by a government have any effect on neighboring expenditures. In jurisdictions with agglomeration rents, the slope of the reaction function should flatten. To date, there are few studies that have looked into the impact of agglomeration forces in this context, and those that do so concentrate on tax interactions only (Charlot and Paty 2010; Fréret and Maguain 2017).

This paper thus investigates empirically whether high- or low-regime agglomeration municipalities are less or more responsive to horizontal expenditure interaction. The best measure of agglomeration economies is not obvious. I use population density, as it is both readily available and informative (other agglomeration indices are also applied) (Ciccone and Hall 1996; Hill 2008; Charlot and Paty 2010; Briant et al. 2010).

One of the possible mechanisms underlying interactions is yardstick competition. Should yardstick competition be responsible for interactions, the reaction function would decline as the municipal electoral margin increases – another hypothesis that is tested in this paper. As pointed out both by Costa et al. (2011) and Costa and Carvalho (2013), agglomeration economies can reduce the pressure from yardstick competition. Expenditure interaction in these municipalities is expected to be lower.

The ambiguous results produced by the literature discussed above and the existing research gap are reason enough to empirically analyze municipal expenditures in the light of spatial interactions. As a phenomenon, expenditure mimicking has important policy implications for the design of fine-tuned public policies and the identification of geographical disparities. The objective of this paper is threefold. First, I investigate spatial interdependencies between the expenditures of German municipalities in North Rhine-Westphalia (NRW) and their interaction behavior. To the best of my knowledge, this has not been done before. One contribution this paper makes is to focus not only on total expenditures but also on a complete set of non-earmarked expenditure subcategories. As suggested by theory and the literature, the reaction functions can vary for different expenditure subcategories. It is entirely possible that the expenditure subcategories will reveal that complementarity and substitutability neutralize each

other or lower the total interaction effect (Costa et al. 2015). At the municipal level, knowledge on fiscal interactions in different expenditure subcategories is limited.

The second main contribution of the article is the exploration of yardstick competition as a possible explanation for expenditure interactions. Thirdly, there is no study so far that analyzes the effects of agglomeration on the intensity of public expenditure interactions. In contrast to previous studies on agglomeration and fiscal interaction, I shall not examine the effect of agglomeration on equilibrium tax rates but on expenditures across local jurisdictions. Studying the German case is also particularly interesting because German municipalities have a high degree of autonomy in planning their expenditure. The municipalities of NRW act within the same constitutional framework, thus simplifying the identification of fiscal interactions.

In my empirical analysis, spatial regression models are used to study fiscal interactions. This puts it in line with studies referred to earlier that either use an instrumental variables (IV) or the maximum likelihood (ML) model. In the main specification, I use a Spatial Durbin Model (SDM) in a panel framework. Due to the panel structure, and in contrast to the cross-sectional studies by Št'astná (2009) and Borck et al. (2007), I also control for spatial and time-fixed effects as ignoring them would lead to biases. The panel data set spans seven years from 2009 to 2015 in the municipalities of North Rhine-Westphalia (NRW). I test a large set of different spatial weighting matrices, also in assessing the robustness of my results. One robustness check contrasts the core results with instrumental variable/GMM estimations.

The remainder of the paper is structured as follows: The next section addresses theoretical considerations on fiscal interaction. The data is described in the third section. Section four specifies the empirical model, endogeneity issues, and the spatial weighting matrices. After that, the fifth section presents the results. The sixth section discusses subsequent robustness checks, and section seven concludes.

THEORETICAL CONSIDERATIONS ON FISCAL INTERACTION

Fiscal interactions occur due to public expenditure spillovers, fiscal competition, or yardstick competition (Revelli 2005; Št'astná 2009; Borck et al. 2015). I begin with a brief description of these factors.

Public expenditure spillovers occur when one local government's activities have an effect on the welfare function of another jurisdiction (Gordon 1983). In other words, the activity of a local government directly affects the preferences of another local government. Expenditure spillovers may be positive or negative, depending on whether the neighbors' expenditures are complements or substitutes. An example of expenditure spillovers would be the provision of a cultural good such as the construction of a theater, which due to higher welfare might lead to decreases in expenditure for cultural goods in the neighboring municipality. Free-riding by the neighboring government would be an optimal reaction.

The second possible explanation for fiscal interactions can be gleaned from the literature on fiscal competition (Zodrow and Mieszkowski 1986; Wilson 1999). Assuming spatial mobility, residents and businesses will move to those jurisdictions that meet their demand for public goods at lower prices in terms of taxation. Jurisdictions may increase expenditures or lower taxes in order to attract residents and firms (Št'astná 2009) and thus indirectly affect each other's policies, resulting in competition among governments for residents and businesses (Wilson 1999).

A third reason for fiscal interactions is yardstick competition, which is based on informational spillovers. Residents take the policies of a neighboring jurisdiction as a yardstick and compare them to the policies of their own government. Residents thus have (imperfect and asymmetric) information on which to evaluate the performance of their government. If the voters rate the achievements as poor, the politicians' chances of being re-elected decrease. Politicians have an incentive to mimic neighboring policies (Salmon 1987; Besley and Case 1995) to prevent this from happening.

The identification of the various driving forces behind fiscal interaction patterns is complex and difficult, not least because the spatial reaction functions are the same (Revelli 2005). However, some studies analyzing the causes of horizontal interactions suggest that yardstick competition is in fact the main

source (Allers and Elhorst 2005; Elhorst and Feret 2009; Wasserfallen 2014, etc.). This verdict will also be tested in this paper. Nevertheless, I do not intend to play off one theory against another. For an example of how to distinguish between underlying strategic interactions, see Baicker (2005). As Borck et al. (2007) have done, I intend to discuss spillovers and fiscal competition after testing for yardstick competition.

DATA

Descriptive statistics

I focus on the municipalities of NRW, the state with the highest population in Germany (about 22 % of Germany's inhabitants live there).

The data is a panel of the 396 German municipalities of the federal state of NRW. The panel spans a period from 2009 to 2015 in the core estimations. Accordingly, the final sample contains 2,772 observations in NRW. The data was obtained from the Genesis online (2016) statistical database of the Federal NRW Statistics Office. The investigation period is limited by data availability. Data before 2009 cannot be used due to the change from cameralistic to double-entry bookkeeping. This conversion enables NRW to make all expenditure subcategories available to the public. Data on the structure of expenditures is provided with a delay of two years. I have normalized all monetary values using the consumer price index based on the year 2010. A detailed description of the expenditure subcategories thus defined can be found in the Appendix (see Table A1). Table A1 displays the average structure of the eight expenditure subcategories in the municipalities of NRW. The categories follow the classification found in the Genesis database of the Federal NRW Statistics Office. This classification indicates that administrative expenditure is by far the largest category, followed by social system expenditures and transport/ infrastructure/ construction (TIC). The reason why the administration category is so large is that it also includes expenditures on transfers such as trade tax allocation or levies to the state.

The descriptive statistics can be found in Table 1, which gives an overview of the variables used in the empirical analysis. These were selected along the lines proposed by the tax and spending interaction literature, e.g. Case et al. (1993), Borck et al. (2007) etc., and in terms of what the control variables were expected to capture (as described in the following paragraph). The dependent variable is the total expenditure per capita variable and different expenditure subcategories per capita for each municipality.

To determine spending interactions, I distinguish between interaction effects and regional economic impacts. First, it is important to control for the composition of the population in municipalities because expenditures vary with different age structures (spending may be higher or lower). Accordingly, the age structure in the municipalities of NRW is included. I collect the GDP at county level (in domestic prices) to control for economic performance with an impact on municipal expenditures. In addition, a change in the debt level of municipalities could also influence municipal mimicking behavior, so it is important to control for the gross debt level per capita, including debts of the fiscal core and municipal companies and institutes. As a more densely populated municipality may also provide higher levels of public goods, I also include population density as a factor to control for. Given that population and population density are highly correlated, I do not include the population variable in the estimations. To control for temporal economic shocks in community development, I include unemployment per capita as a variable.¹

Institutional setting

Germany has a federal system with different levels of government: the central government, the state governments, and local governments with counties, districts (which only exist in four German states), and municipalities. At the local level, counties (*Landkreise*) are the most significant entities, in charge of such things as public safety, and construction as well as the maintenance of county roads. The more than 11,000 municipalities (*Gemeinden*) function at a subordinate level, largely entitled to handle local matters as they see fit (Article 28 (2), Constitutional Law). They decide on the level of the tax multipliers that have a direct impact on their business- and property-tax revenues and are responsible for general administration, infrastructure, cultural institutions, and sewage, as well as waste disposal, etc., etc.

¹ The unemployment rate, on the other hand, is not available at the municipal level.

Table 1. Summary Statistics.

	Obs.	Population-weighted mean	Mean	Std. dev.	Min.	Max.
<i>Expenditures (p.c.)</i>						
Total expenditure	2772	2619.6	2032.7	538.2	1056.5	7878.6
TIC	2772	326.4	272.4	131.9	0.3	1065.5
Administration	2772	1187.5	1147.2	321.4	509.8	6486.1
Business development	2772	38.5	31.5	56.1	0	1443.5
Public facilities	2772	104.6	70.9	44.2	3.8	427.3
Culture/ Sports	2772	107.9	62.6	43.7	0	356.5
Health system	2772	19.4	12.9	9.1	0	267.8
Social system	2772	670.9	285.7	276.5	8	2008.1
Education	2772	164.3	149.4	68.1	13.6	569.4
<i>Transfers (p.c.)</i>						
Formula-based transfers	2772	311.2	194.2	170.5	-38.4	1116.9
Transfers for present purposes	2772	102.5	105.2	47.8	0.2	665.7
Investment transfers	2772	126.5	83.6	58.4	0	336.1
<i>Tax multipliers</i>						
Property tax multiplier, %	2772	479.2	436.2	74.7	240	876
Business tax multiplier, %	2772	448	428.4	28.7	285	550
<i>Other indicators</i>						
Gross debt level p.c. (thousand Euros)	2772	3	1.9	1.5	0	9.4
% Age 0-65	2772	79.5	0.8	0.02	0.7	0.9
% Age 65+	2772	0.2	0.2	0.02	0.12	0.32
Population	2772		44694.3	87517	4116	1060582
Population density	2772	1246.2	504.9	533.3	43.2	3221.2
Gross domestic product (GDP)	2772	14319.9	10015	4639.4	2152.1	58047.3
Unemployed p.c.	2772	4.3	3.2	1.2	0.66	7.25

Notes: Statistics for pooled observations 2009-2015 by state. Monetary values in euros, prices as in 2010.

In the estimations I include the subcategories that mainly consist of non-earmarked expenditures. Municipalities are partly committed to passing on funds from the upper levels or implementing laws connected to expenditures. Possible interdependencies in these subcategories may not stem from neighboring interaction effects. This statement applies to the social system subcategory, where municipalities have smaller scope for decision-making. Though even in this category municipalities do have a degree of discretionary latitude, I exclude it from the estimations. Other subcategories also partly including earmarked expenditures are TIC, culture/ sport, and health. As earmarked expenditures represent a smaller share of these subcategories, I include them in the main results table. In the robustness section, I also present an estimation omitting these subcategories. Apart from that, the

robustness section refers to total expenditures only, as is the case with Costa et al. (2015) and others. Furthermore, cities with county status (*kreisfreie Städte*) combine county and municipal functions. I do not exclude them from the core estimations because this study focuses mainly on the investigation of interaction effects and the impact of agglomeration on spending, both of which also affect cities with county status. In this I follow the strategy of Borck et al. (2015) and others. However, in the section on robustness, I return to this point and present an estimation excluding cities with county status.²

EMPIRICAL STRATEGY

Model specification

One main aim of this paper is to estimate spatial interdependencies between the municipalities of NRW.³ As a starting point, an unconstrained Spatial Durbin Model (SDM) (equation 1) is set up, as it is a general specification and a test for various other spatial panel models such as Spatial Error Model (SEM), Spatial Autoregressive Model (SAR), and Spatial Autocorrelation Model (SAC) (Elhorst 2010a; Belotti et al. 2016).

$$y_{it} = \rho \sum_{j=1}^N w_{ij} y_{jt} + \mathbf{X}_{it} \beta + \sum_{j=1}^N w_{ij} \mathbf{X}_{jt} \theta + \mu_i + \delta_t + \epsilon_{it}, \quad i, j = 1, \dots, N, \quad (1)$$

with index i referring to the municipality and index t referring to the year. y_{it} indicates per-capita municipal expenditure. $\sum w_{ij} y_{jt}$ denotes the term that describes the impact on municipalities by their neighbors. W is a non-negative $N \times N$ weighting matrix, where w_{ij} is the i, j th element. ρ is the parameter that measures the response to neighboring municipalities. \mathbf{X}_{it} is a $1 \times K$ vector of other control variables in municipality i at time t that are important determinants of expenditure, and β is the $K \times 1$ vector of the

² Another possible concern that I take up in the section on robustness are municipalities subject to consolidation assistance. In 2011, the NRW state government initiated a program supporting indebted municipalities with extra consolidation assistance. Municipalities receiving such support may be forced to spend less and thus distort the core estimations.

³ Following Leprince et al. (2005) and Fréret and Maguain (2017), vertical effects (where the spending of a local government depends on expenditure at other levels) are not found to be relevant and are therefore not considered.

estimated parameter. $\sum w_{ij}X_{jt}$ represents the characteristics of the neighboring municipalities, while θ is the corresponding $K \times 1$ vector of the parameters estimated. μ_i and δ_t represent municipal and time-fixed effects. The fixed effects are space-specific, time-invariant variables that are difficult to measure but most likely have an impact on the dependent variable, such as location or attitudes. Excluding them would incur the risk of inconsistent results. ε_{it} is a normally, identically, and independently distributed error term.⁴ Robust inferences are provided through the clustering of standard errors. I apply a double-clustering strategy that takes the Jacobian matrix of all first-order partial derivatives of the log-likelihood function into account because the model specification does not control for spatial autocorrelation in the errors (Cameron et al. 2011; Atella et al. 2014).

As Elhorst (2011) points out, the best model irrespective of the spatial weights matrix applied is the one that includes spatial lags of the dependent and independent variables as well as exogenous and endogenous interaction effects, while excluding the autocorrelated error term. Such a model is the Spatial Durbin Model (equation 1). LeSage and Pace (2009) demonstrate that the cost of ignoring the spatial dependence of the dependent and/or independent variables is relatively high compared to the modest loss of efficiency incurred when spatial dependence in the error term is ignored.

Following Elhorst (2014), LeSage (2014), and Belotti et al. (2016), the SDM nests the SEM and the SAR. Accordingly, I test whether the SDM or SEM/ SAR are the preferred models in this case. I start from a general SDM. If I cannot reject the null hypothesis that the spatial lag of X is insignificant, $H_0: \theta=0$, then the SAR or a model without spatial dependence is preferable (in the case where $\rho=0$). In testing whether the SEM is the model of choice, the Common Factor hypothesis is $\theta=-\rho\beta$. Both can be tested using Wald-type tests (Angulo and Mur 2011). Likelihood Ratio (LR) tests are also performed.

SDM and SAC are non-nested models, so if both previous tests point to a SDM, Akaike's (AIC) and Schwarz's Bayesian (BIC) information criteria are drawn upon to test whether the appropriate model is a SAC instead. The best model will be the one showing a lower AIC (and BIC). Another possibility

⁴ Normally distributed error terms in Quasi Maximum Likelihood estimations are a strong assumption (Elhorst 2014). It has to be emphasized that in relatively large samples the Quasi Maximum Likelihood estimator is asymptotically consistent even without a normally distributed error term (Lee 2004). This also applies to my sample.

would be to use a Lagrange Multiplier (LM) test. Following Belotti et al. (2016), Wald and Likelihood Ratio (LR) tests are asymptotically near-equivalent and basically come to the same conclusion.

As can be seen from Table A2 in the Appendix, both Wald-tests and LR tests favor the SDM. The information criteria also point to an SDM rather than an SAC model. In addition, the Hausman test indicates that it is better to use a fixed-effects model than a random-effects model.

To obtain consistent results for equation (1), a bias correction procedure in accordance with Lee and Yu (2010) is also applied.⁵

Endogeneity

Two further issues need to be addressed. The first is the endogeneity of $\sum w_{ij}y_{jt}$, which denotes the term describing the impact on municipalities by their neighbors. Endogeneity in this context stems from the fact that the expenditures (y) appear on the left- and on the right-hand side of equation (1), so that own spending and neighbor spending are determined simultaneously. This violates the assumption of standard regression models that $E[\sum w_{ij}y_{jt}, \epsilon_{it}] = 0$, i.e. is uncorrelated. Ordinary least squares would therefore be inconsistent. The second issue is the spatial dependence between observations, which could also have an impact on the fixed effects (Elhorst 2010b).

Both issues are accounted for in the fixed-effects Spatial Durbin Model using a (Quasi) Maximum Likelihood (QML) estimator.⁶ The QML estimator accounts for spatial endogeneity via the Jacobian term of the transformation from ϵ to y (Anselin 1988).⁷ As pointed out by Fréret and Maguain (2017),

⁵ This bias correction can be applied in municipally fixed and time-fixed effect models and is referred to as the transformation approach. The time-fixed effects involve the incidental-parameter problem in addition to the individual effects (see Lee and Yu (2010) for a detailed description). The estimation procedure is performed using the Stata module XSMLE for spatial-panel data models via (Quasi) Maximum Likelihood as provided by Belotti et al. (2013). The XSMLE command is used with the "leeyu" option to perform inferences with the log-likelihood based on the transformation approach.

In addition, I manually adopt the double de-meaning procedure proposed by Lee and Yu (2010) and also estimate the model using XSMLE. This enables me to eliminate time-fixed and municipally fixed effects, too.

Both procedures produce very similar results and can be obtained from the author upon request.

⁶ LeSage and Pace (2009) state that even if a relevant variable (even though unobserved or unknown) is omitted, the SDM coefficient estimates are still unbiased.

⁷ Note that, due to the fact that the interaction parameter ρ enters the equation non-linearly, the optimization method must be non-linear, too.

only QML estimations, as employed in this paper, are efficient in dealing internally with spatial endogeneity.

Another possible approach that I apply in the robustness checks is the use of IV/ GMM, as suggested by Kelejian and Prucha (1998, 1999) and Arraiz et al. (2010). I instrument for W_y using the exogenous x variables and their spatially lagged counterparts. Both approaches yield consistent estimates and causal interpretations, but only the QML estimation is efficient when the model is correctly specified. This means that we require the exogeneity of the spatial weighting matrix. Compared to the IV estimator, the efficiency of ML is weakly dominant and in terms of unbiasedness its overall performance is good (Franzese and Hays 2007). Criticisms of ML estimations center around the fact that the Jacobian term becomes unstable if the number of spatial units is greater than 1000 (Anselin 2005). As I am dealing with 396 municipalities, this potential drawback is irrelevant in this case.

Spatial weighting matrices

To determine the correct weights matrix W , I consider various weighting matrices estimating the baseline SDM in equation (1). The literature proposes standard matrices based on exogenous geographical proximity (LeSage 2014). In line with this, I consider binary contiguity matrices, where W_{ij} is dichotomous, being one if i shares a border with j and zero otherwise. I also consider row-normalized matrices with municipalities assigned as neighbors within a certain radius around the center (15km, 20km, 25km and 30km). As a third type of weighting matrix I look at inverse distance matrices under different cut-off radii with the three normalization techniques row, spectral, and minmax – here W is a continuous function. In addition, I construct a weighting matrix based on district governments (*Regierungsbezirke*), which exist only in NRW and three other German federal states, i.e. all municipalities belonging to the same governmental district are assigned as neighbors.⁸

To choose the weighting matrix that suits the data best, I compare the log-likelihood values of the models as suggested by Elhorst (2010a). The model with the highest value is the model of choice.

⁸ There are five district governments in NRW, each having a district president and a regional council determined indirectly via municipal elections. Their tasks can play an important role for municipalities because they enforce municipal regulations, control regional/ urban planning and development, and are entitled to issue directives. Their influence may intensify fiscal expenditure interactions among municipalities.

Table A3 in the Appendix presents the spatial weighting matrices and their log-likelihood values. The row-normalized, inverse-distance matrix with a cut-off radius at 25 km performs best. The relative distance to other neighbors is crucial, and the closer the neighbors are, the higher they are weighted. In my main specifications I therefore employ this matrix as a standard matrix. In addition, the estimated total expenditure interaction coefficient is presented for all weighting matrices tested.

Non-standard matrices

Non-standard weighting matrices account for the special spatial characteristics of the municipal institutional setting and enable municipalities to weight the decisions of similar municipalities higher. Generally, the spatial weights matrices are assumed to be exogenous. With weights matrices based on socioeconomic distances, the assumption of exogeneity may be invalid. Weights based on variables such as population density or unemployment are endogenous because the dependent expenditure variable has an impact on them (Anselin and Bera 1998). As a consequence, I do not consider those non-standard weights matrices in selecting the standard matrix for my main specification but rather regard them as a confirmation and as a test for the robustness of the main results.

First, I construct a weighting matrix based on socio-economic variables (Št'astná 2009). It is based on geographical neighborhood or, more precisely, on the selected standard matrix as set out above but with different weightings due to mean municipal characteristics V , such as population, population density, population aged 65 plus, and unemployment per capita.⁹

Other non-standard spatial weights matrices that I construct are based on the paper of Janeba and Osterloh (2013) and were also applied by Borck et al. (2015). Core centers are assumed to mainly compete with other core centers and direct neighboring municipalities. By contrast, the periphery, and especially small municipalities, compete with municipalities at short distances only. To take such weighting matrices into account, I allocate those municipalities as neighbors that both have a mean population (period 2009-2015) above a defined ceiling and are located within the 25-km radius. The remaining municipalities consider the municipalities within a 25-km radius as their neighbors.

⁹ The x^k variables are normalized from 0 to 1. The weight is then given by $w_{ij} = \frac{1}{V} \sum_V (1 - |x_i^V - x_j^V|)$.

A general note of caution is in order here. To identify causal effects, a number of restrictions need to be made to the weighting matrices. Some of the literature contends that for IV estimations the spatial lags of x are neighbor averages that are often mutually correlated and therefore cannot be suitable instruments. Hence the exogeneity assumption is most likely violated when IV/ GMM methods are applied. I follow Elhorst and Feret (2009), Borck et al. (2015), Fréret and Maguain (2017), etc. by rejecting IV/ GMM as my preferred estimation method. Instead, I adhere to the QML method, where the Jacobian term purges the endogeneity problem of the interaction effect, given that the weights matrix W is known and depicts real-world linkages. The latter aspect is an object of criticism, too, because it is a strong assumption that is very difficult to bear out (Gibbons and Overman 2012). I construct more than twenty different weighting matrices W to address these concerns. In addition, I include spatial as well as time-fixed effects and add independent control variables. The interaction coefficient is significant in all of the estimations, which is an initial proof of the validity of the results (see Table A3). When I apply inverse distance matrices under different cut-off radii with the three normalization techniques row, spectral, and minmax, the fiscal interaction coefficient increases with the number of municipalities included (as distance increases). This is plausible because the definition of neighborhood then becomes less restrictive (Costa et al. 2015; Borck et al. 2015).

MAIN RESULTS

Key estimates

In this section I present the main results for fiscal expenditure interactions in total expenditures and in the expenditure subcategories. Later in the section I also present empirical findings on the impact of agglomeration economies on expenditure interactions. I apply the SDM from equation (1) and use a QML estimator.

The main results are presented in Table 2. The evidence indicates that expenditure interactions do exist. I find significant fiscal expenditure interactions (ρ) between the municipalities of NRW in total expenditures p.c. (column 1) and in four expenditure subcategories. For the total expenditures p.c., the

estimated spatial effect is positive and significant at the 1 % level, i.e. spatial effects play a role in explaining neighboring government expenditures, which suggests that an OLS model would be biased and inconsistent. The coefficient of 0.124 means that a 1-euro increase in expenditures by the neighboring municipalities will increase the municipality's own spending by 12.4 eurocents. This confirms the complementary characteristics of total municipal spending levels. The comparison of this coefficient across models applying different definitions of contiguity (Table A3) indicates that the coefficient has a similar size and is both positive and significant in all specifications.¹⁰

Among the expenditure subcategories, the fiscal interaction coefficient is insignificant for the administration category as well as for public facility and education. Administration mainly comprises expenditures on regulatory affairs, general transfers, and levies. These expenditures are to some extent fixed and thus do not strongly depend on neighbor spending, which may explain the insignificant coefficient. The same goes for the education subcategory, which consists of material and general expenditures that display only minor deviations. Effectively, construction expenses in the education subcategory are subject to a superordinate strategy determined by the state. By contrast, public facility has both expenditures that are fixed (like spending on emergency services) and those that vary (like spending on environmental measures). It appears, however, that municipalities do not interact with their neighbors with regard to these expenditures.

I find a positive and significant spatial effect for business development, which partly confirms the empirical investigations on expenditure interaction undertaken by Borck et al. (2007) at the German county level. Although the coefficient on business development in the present paper is smaller, it still indicates fiscal competition between municipalities. In order to stay competitive, municipalities increase their expenditures on business development to attract companies or boost economic activity. On the other hand, I find negative but significant coefficients in the subcategories TIC, Culture/ Sport, and Health. They range between 8 and 11 eurocents. If the neighboring municipalities increase their

¹⁰ I also test whether the SDM eliminates spatial autocorrelation of the residuals. To this end, I construct the Moran's I statistic of the residuals of the total expenditures. This can only be done for each cross-section in the seven years. The Moran's I shows that the autocorrelation is close to zero in all seven cross-section estimates and significantly different from zero in only two of them, which indicates that the SDM almost completely eliminates spatial autocorrelation of the residuals. The result is confirmed in the other expenditure subcategories.

expenditures by 1 euro, the municipality will decrease spending in these subcategories. As discussed similarly by Borck et al. (2007), this decline can be explained by public expenditure spillovers. It is associated with free-riding behavior on the part of municipalities. Municipalities take advantage of the spill-in and reduce expenditure e.g. for passenger transport (TIC), sport/ culture funding (Culture/ Sport) or health care (Health). The residents of the given municipality benefit from amenities provided by neighboring municipalities. The expenditures in these subcategories are strategic substitutes.

Table 2. Main results - Fiscal expenditure interactions between the municipalities of NRW

	QML							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total	Admin	TIC	Pub Fac	Bus Dev	Cul/ Spo	Health	Educ
ρ	0.124*** (0.0475)	0.071 (0.0514)	-0.107** (0.053)	0.047 (0.0482)	0.239** (0.1012)	-0.105** (0.0529)	-0.076* (0.0438)	0.046 (0.056)
GDP	-0.013 (0.0364)	-0.0045 (0.0218)	-0.004 (0.0072)	0.001 (0.0029)	-0.002 (0.0024)	0.002 (0.0021)	-0.00001 (0.0005)	0.002 (0.0032)
Population density	-3.89* (1.92)	-2.33 (1.4254)	-0.62** (0.2399)	-0.112* (0.0656)	-0.061 (0.0854)	-0.128 (0.0942)	-0.0003 (0.008)	-0.259** (0.1135)
Unemployed p.c.	41.54 (37.75)	31.45 (29.32)	-1.242 (10.18)	1.203 (2.864)	-10.05 (6.83)	1.57 (2.925)	-0.851 (0.5296)	-5.14 (5.77)
Share aged 65+	-44.43** (21.78)	-10.64 (15.9)	-4.72 (6.622)	1.796 (2.18)	-0.922 (2.932)	1.64 (1.979)	1.166** (0.5817)	-2.99 (3.296)
Level of debt p.c.	-37.14 (64.33)	-50.36 (54.41)	7.69 (8.346)	0.406 (1.835)	9.11* (5.106)	-2.86* (1.66)	-0.136 (0.2864)	0.494 (3.053)
Spatial Lag of X								
<i>GDP</i>	-0.013 (0.0548)	0.0244 (0.0373)	-0.008 (0.016)	-0.014*** (0.0052)	0.008 (0.0092)	-0.005 (0.0046)	-0.003* (0.0013)	-0.006 (0.0079)
<i>Population density</i>	3.8 (2.8)	1.81 (2.24)	1.124** (0.4953)	0.285** (0.1326)	0.095 (0.274)	0.238 (0.1616)	0.064** (0.0292)	0.32 (0.2189)
<i>Unemployed p.c.</i>	99.3 (69.51)	11.03 (52.2)	7.55 (22.41)	5.12 (5.47)	17.79 (11.56)	10.71* (5.86)	-0.13 (1.255)	10.25 (10.3)
<i>Share aged 65+</i>	-75.55 (70.51)	-75.81 (52.63)	-6.74 (20.24)	2.334 (5.24)	-0.533 (7.82)	4.77 (7.203)	-1.907 (1.44)	5.47 (9.96)
<i>Level of debt p.c.</i>	88.34* (48.98)	104.05** (42.76)	-6.87 (11.57)	0.657 (3.356)	-6.54 (6.271)	-2.98 (4.982)	0.293 (0.9644)	15.37** (6.999)
Log-Likelihood	-16259.39	-15799.93	-13417.04	-10655.1	-12428.32	-10655.54	-7970.46	-11861.64
N	2376	2376	2376	2376	2376	2376	2376	2376

Note: ρ denotes the spatial interaction effect. All models are estimated using the bias correction procedure proposed by Lee and Yu (2010) with maximum likelihood. Robust standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Comprehensive interpretation of the estimates also requires the consideration of direct, indirect, and total effects (marginal effects) (LeSage and Pace 2009). I concentrate on the total expenditure category

because it is the sum of all expenses per capita in a municipality. The interpretation of all marginal effects is not a major focus in this paper.

The change in an explanatory variable in municipality i has not only a direct effect on that municipality but also an indirect effect on all other municipalities. Thus the direct effect describes how the variable of interest in municipality i changes in the case of a change in the k^{th} regressor in that municipality. The indirect effect describes how a change in the independent variable in municipality i changes the dependent variable in municipality j . Every diagonal element in the $N \times N$ matrix of total effects represents the direct effects and every off-diagonal element represents the indirect effects (Elhorst 2010a). The sum of the direct and the indirect effects is the total effect.

The direct, indirect, and total effects from the total main specification of Table 2, are shown in Table 3. Demand-side variables seem to be more important for direct effects. In particular, the higher the population density and the share of people aged 65 plus, the lower are the expenditures per capita. Economic factors are not significant at conventional levels. Expenditures mainly depend on population structure and its concentration in space and not on the economic development of that municipality. For the indirect effects, on the other hand, it suffices that the level of debt p.c. be positive and significant, i.e. an increase in debt levels of nearby municipalities increases the expenditures in the municipality of interest by way of a feedback process. As for the total effects, Table 3 shows that the variables unemployed p.c. and share of people aged 65 plus are significant. This means that a typical region will react with an increase in expenditures when unemployment p.c. increases in all other municipalities. On the other hand, this typical region would decrease its expenditures if the share of people aged 65 plus increased everywhere else.

Table 3. Average direct, indirect, and total effects from fixed-effects SDM estimates

	Total expenditures		
	Direct effects	Indirect effects	Total effects
GDP	-0.012	-0.016	-0.028
Population density	-3.92**	3.8	-0.011
Unemployed p.c.	46.11	124.52	170.63**
Share aged 65+	-45.88**	-98.53	-144.41*
Level of debt p.c.	-39.03	97.55*	58.52

Note: *Significant at 10 % level, ** significant at 5 % level, *** significant at 1 % level.

Yardstick competition

For the total expenditures I also analyze whether yardstick competition can be made responsible for fiscal interactions. This has formerly been done by Allers and Elhorst (2005), Elhorst and Fréret (2009), Delgado et al. (2014) and others in their analyses of tax rates. If yardstick competition is the driving force behind mimicking behavior, the interaction effect should be smaller and significantly different in municipalities governed by a large majority than in those governed by a small majority or by a party with no absolute majority. If the electoral margin is high, the majority party's reelection will be relatively certain. I envisage interaction between neighboring expenditures and a dummy variable that equals one if majorities in the councils are larger 55 %, 60 %, 65 % or 70 % for the governing coalition and zero otherwise.

As Allers and Elhorst (2005) have pointed out, mimicking behavior may also be different when right-wing parties (CDU, FDP, REP) rule the roost (with a majority larger than 50%) instead of left-wing parties (SPD, Alliance 90/The Greens, The Left, The Pirates). The dummy variable interacting with neighbor expenditures equals one if the municipality is controlled by a right-wing government and zero otherwise. The results are presented in Appendix Table A4 and show that in neither case is the interaction effect significantly different for varying majorities. Also, municipalities with right-wing party majorities are not concerned with different fiscal expenditure interaction. Yardstick competition or dependence on party affiliation in the council cannot be made responsible for fiscal expenditure interactions in NRW.

Another issue I explore is whether the spending behavior of municipalities controlled by an absolute majority of right-wing parties differs from those with other majority structures (left-wing majorities or no absolute majorities).¹¹ I introduce a dummy that is one if the local government has a right-wing majority and zero otherwise. This produces interesting results for spending behavior in several subcategories. Right-wing parties may tend to be more rigorous about saving than left-wing parties.

¹¹ The argument is that left-wing majorities are in favor of redistribution and stand for a more active role by the state, leading to an increase in public spending (Tellier 2006).

The results are presented in Table A5 in the Appendix. The coefficient for total expenditure is about 72 and significant. In contradiction to the theory discussed above, this means that in total municipalities with a right-wing majority spend about 72 euros more per capita than municipalities with left-wing or no majorities. Accordingly, there is no confirmation for their reputation for being more rigorous savers. Most of the sum (approx. 52 euros) is spent on the administration subcategory. This can partly be explained by higher spending on administration management and service as well as on regulatory matters. Right-wing majorities spend about 6 euros per capita more on the public facility subcategory, most of it on fire protection, emergency services, and disaster control.

Agglomeration effects

This section assesses the role agglomerations play in fiscal expenditure interactions. The agglomeration measure applied is average population density.¹² I test whether expenditure interactions are stronger or weaker in more agglomerated municipalities, i.e., whether neighbor spending plays a larger or a smaller role in more densely populated municipalities.

Following Charlot and Paty (2010) and Fréret and Maguain (2017) on the subject of taxes, –I interact neighbor expenditures with an agglomeration index based on population density. I define two agglomeration regimes (strong and weak agglomeration) with two interaction coefficients and once again concentrate on total expenditures.

$$y_{it} = \rho \sum_{j=1}^N w_{ij} y_{jt} + \rho_u \sum_{j=1}^N w_{ij} y_{jt} * Agglo_i + X_{it} \beta + \sum_{j=1}^N w_{ij} X_{jt} \theta + \mu_i + \delta_t + \epsilon_{it}, \quad (2)$$

where $Agglo_i$ is the agglomeration measure, a binary variable equal to one if municipality i is characterized by high agglomeration and zero otherwise. Five alternative definitions of agglomeration

¹² In the literature, different agglomeration indices are applied. I follow Ciccone and Hall (1996), Charlot and Paty (2010), Briant et al. (2010), etc. and use population density to determine the size of urbanization economies. Localization economies on the other hand measure externalities that indicate attributes of industry (Combes and Gobillon 2015). Other agglomeration indices capturing local urbanization economies include the total sum of salaried jobs in municipality i divided by the area of that municipality (Fréret and Maguain 2017). Applying the latter agglomeration indicator to our model does not significantly change our findings. The results can be obtained from the author upon request.

are used, with high agglomeration being defined as whether population density is above the 50 %, the 60%, the 70 %, the 80 % or the 90 % quantile. ρ_u measures the additional effect on fiscal interactions if the agglomeration level is high.¹³

If agglomeration economies have an effect on fiscal expenditure interactions, then there should be a significant coefficient for ρ_u whatever the sign is. As in equation (1), X_{it} is a $1 \times K$ vector of control variables in municipality i at time t that are important expenditure determinants, and β is the vector of the estimated parameter. μ_i and δ_t again represent municipal and time-fixed effects. I apply the same row-normalized, inverse-distance weights matrix with a cut-off radius at 25 km as in the main results.¹⁴

Table 4. Main results - Fiscal expenditure interactions in the light of agglomeration between the municipalities of NRW

	QML				
	(1)	(2)	(3)	(4)	(5)
	Total	Total	Total	Total	Total
Cut-off point of the agglomeration index	50% Quantile	60% Quantile	70% Quantile	80% Quantile	90% Quantile
ρ	0.365*** (0.0605)	0.354*** (0.0544)	0.325*** (0.0503)	0.319*** (0.0471)	0.313*** (0.0443)
ρ_u	-0.226** (0.1004)	-0.263** (0.1071)	-0.216* (0.116)	-0.25* (0.1363)	-0.41** (0.1908)
Municipal fixed effects	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Log-likelihood	-17689.98	-17690.87	-17693.51	-17696.96	-17696.03
N	2772	2772	2772	2772	2772

Note: The dependent variable is the total expenditure per capita, ρ denotes the spatial interaction effect. All models are estimated using the bias correction procedure proposed by Lee and Yu (2010) with maximum likelihood. Robust standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

¹³ The model has been calculated using the SPM command written by Atella et al. (2014) in Stata and applying a two-way clustered variance–covariance matrix.

¹⁴ The way I introduce the two-regime matrix has many parallels in the literature, e.g. in the studies by Allers and Elhorst (2005), Elhorst and Fréret (2009), Charlot and Paty (2010), Fréret and Maguain (2017), etc. LeSage and Pace (2011), however, criticize this way of extending spatial regression models although they focus on an SAR-type model. One of their remarks is that the specification relies on the assumption that parts of the combination of different weight matrices vanish, which is only possible if W is zero. They also note that the model acts in a way that contradicts the hypothesis it sets out because it does not take into account the feedback effects of all interacting regions.

A possible solution that has been advanced in the recent literature but has not yet been completely implemented involves the calculation of a QML model with heterogeneous coefficients (Aquaro et al. 2015). Nevertheless, in awareness of these distortions and fully cognizant of the fact that comprehensive solutions are not available, the specifications applied provide an indication of the magnitude of interactions under agglomeration regimes of the kind referred to in the studies quoted.

As from Table 4 shows, the coefficient of the interaction between neighboring expenditures and population density is significant in all columns. Fiscal expenditure interactions (ρ) below the respective quantile are significant in all columns and range from 31 to 36 eurocents for every 1-euro increase in neighboring municipal spending. By contrast, the coefficient of municipalities with high agglomeration is significantly smaller, ranging between -9.7 and +13.9 eurocents. Especially interesting is the interaction coefficient for municipalities above the 90 % quantile with the negative sign (-9.7). It indicates that those municipalities (10 % most agglomerated) lower total expenditures in response to an increase by their neighbors. The results show that in more agglomerated municipalities expenditure interactions are weaker and may even be negative.¹⁵ The results confirm the findings by Fréret and Maguain (2017) proving that neighbors' taxes play less of a role in highly agglomerated regions. It seems fair to assume that agglomeration provides advantages for capital and thus reduces incentives to leave.

ROBUSTNESS CHECKS

In this section I perform a number of robustness checks, assessing other specifications to establish whether the main results are stable and the main SDM estimation results can be confirmed. To save space, the checks will be applied to total expenditure p.c. only because it covers all expenditure subcategories.

Including, excluding, and lagging other potential control variables

I begin by including three variables that may influence per capita expenditures - and vice versa. These are total transfers (1), earmarked transfers plus total revenues p.c. (2), and property and business tax rates (3). I use lags of these variables to reduce endogeneity issues. As can be seen from the relevant rows in Table 5, the point estimates of the interaction effect are still significant and positive. The coefficient in row (1) changes slightly compared to the main results. In row (2) the coefficient is larger

¹⁵ Since yardstick competition is not responsible for fiscal expenditure interactions in NRW, there is no connection between agglomeration economies and yardstick competition, although both Costa et al. (2011) and Costa and Carvalho (2013) suggest the contrary.

but the point estimates are not significantly different. The same applies to the coefficient in row (3), where I include both the property and the business tax rate. In row (4) I exclude the gross debt level p.c. from the estimation because it is largely determined simultaneously with total expenditures and could thus be endogenous. Here again, the point estimates are significant, positive, and very similar to the main results (not significantly different). This can be considered a substantial confirmation of robustness in the main results. From the first four rows I conclude that the estimates for ρ are robust to the inclusion or exclusion of additional control variables. In row (5) of Table 5, I apply lagged independent variables because it is possible that their impact on expenditures may be deferred. This estimation shows no significant difference in the point estimate for the spatial interaction effect either.

Changes in model features and estimation period

In row (6) I exclude both municipal and year-fixed effects. The unobserved effects that I control for by the inclusion of fixed effects are probably correlated with the dependent and independent variables, so not controlling for them produces biased estimates. The point estimate of spatial interaction increases significantly. Hence, an upward bias is apparent. Furthermore, in row (7), I estimate equation (1) without Lee and Yu's bias correction (2010). In row (8), I employ the difference in per capita expenditures as the dependent variable. As can be seen in both rows, the point estimates are larger but still not significantly different from the main result. In row (9), I add a linear trend instead of year-fixed effects. The estimate is 0.072 points larger but still not significantly different from the interaction effect in the main results.

Varying the sample

Shortening the estimation period (data before 2009 is not applicable due to the change from cameralistic to double-entry bookkeeping) does not change the interaction effect significantly (row 10). Although mean expenditures are higher per capita in cities with county status, I still include those municipalities in my main results. I now return to this issue and in row (11) present the interaction effect of a sample that excludes cities with county status. Another concern that I take up is the question of municipalities subject to the 2011 consolidation assistance. Municipalities receiving such assistance may be forced to spend less and thus distort my main estimations. The interaction effect of a sample without

municipalities receiving consolidation assistance is shown in row (12). In row (13) I subtract all partly earmarked subcategories, i.e. social system, TIC, culture/ sport, and health. In all three rows, the interaction coefficient is positive and significantly different from zero.

Additionally, I perform an estimation with a placebo weighting matrix. Following Borck et al. (2015), I apply a weighting matrix that determines random neighbors. As shown in row (14), the interaction coefficient becomes insignificant and negative, thus no longer displaying mimicking behavior.

The robustness checks of Table 5 largely confirm the interaction effect in the main results: it is positive, significant, and not substantially different.

Table 5. Robustness results - Fiscal expenditure interactions between the municipalities of NRW

Specification	QML		
	ρ	Standard Error	N
1) Including total transfers	0.102**	0.0589	1980
2) Including earmarked transfers and total revenues p.c.	0.192***	0.0441	1980
3) Including property and business tax multiplier	0.114**	0.057	1980
4) Excluding gross debt level p.c.	0.118***	0.0488	2376
5) Using lagged independent variables	0.14***	0.0529	1980
6) No fixed effects	0.306***	0.0402	2772
7) No Lee and Yu (2010) bias correction	0.153***	0.0437	2772
8) Difference in y	0.163***	0.046	1980
9) Trend instead of year FE	0.196***	0.0516	2376
10) Changed period (2010-2015)	0.143***	0.0534	1980
11) Excluding cities with county status	0.142***	0.048	2238
12) Excluding municipalities subject to consolidation aids	0.102**	0.049	2010
13) Subtracting partly earmarked subcategories	0.099*	0.0509	2376
14) Placebo weighting matrix (random neighbors)	-0.009	0.0493	2376

Note: The dependent variable is the total expenditure per capita, ρ denotes the spatial interaction effect. All models are estimated using the bias correction procedure proposed by Lee and Yu (2010) with maximum likelihood. Independent variables in the specifications are: population-density, gross domestic product on county levels, share of people aged 65+, unemployed per capita and the gross debt level p.c. The averaged neighboring equivalents are included as well as independent variables. Municipal and year fixed effects are included. Robust standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Alternative spatial regression model specifications

In this section I shift my attention away from the sole application of the Spatial Durbin Model and home in on other spatial regression models. Although the SDM nests the SEM and SAR models and the SDM

is model of choice, I use columns (1 and 2) of Table A6 to present the results of the two models most commonly applied in the literature. The point estimates are somewhat higher, but not significantly different.

Another potential approach I draw upon here focuses on instrumental variables/ GMM. It has been shown by Kelejian and Prucha (1998, 1999). Drukker et al. (2013) show that IV/ GMM estimators can be very useful when one or more endogenous explanatory variables are instrumented. Consequently, I instrument for W_y by applying x and Wx , the independent and the spatially lagged independent variables that are natural instruments in this context and include the spatially auto-correlated error term (Elhorst 2010a). This also takes account of the spatial dependence in the error terms.

Column (3) of Table A6 in the Appendix depicts a positive and significant fiscal expenditure interaction point estimate that is very similar in range to QML estimations. Again, the robustness of the main findings is confirmed.

CONCLUSION

This paper is an empirical analysis of municipal expenditures in the light of fiscal interactions. I investigate spatial interdependencies between the German municipalities of North Rhine-Westphalia (NRW) in the years 2009-2015, focusing not only on total expenditures but also on a complete set of non-earmarked expenditure subcategories.

For the total expenditures I find a positive and significant spatial interaction effect of about 12 eurocents when neighbors increase their expenditures by 1 euro. This is confirmed by the robustness checks. Reaction functions also vary for different expenditure subcategories. For reasons discussed above, the fiscal interaction coefficient in those subcategories is insignificant for administration, public facility, and education. I also find a positive and significant spatial effect for business development, which indicates that fiscal competition is present and confirms the empirical investigations by Borck et al. (2007) on expenditure interaction at German county level. On the other hand, I find negative and significant coefficients in the subcategories TIC, Culture/ Sport, and Health, which can be explained as

expenditure spillovers. Residents benefit from amenities provided by neighboring municipalities. The empirical evidence thus indicates that municipalities do not ignore their neighbors when making expenditure decisions.

I also analyze whether yardstick competition, where the reaction function declines as the municipal electoral margin increases, can be a source of such interactions. I find no evidence for this.

In addition, I analyze the effects of agglomeration on the intensity of public expenditure interactions using a two-regime matrix in an SDM model. A major finding of the paper is the evidence suggesting that expenditure interaction is fiercer if a municipality is less agglomerated. Urbanized and populous municipalities benefit from agglomeration economies, a circumstance that enables them to spend less than their neighbors.

The identification of the expenditure mimicking phenomenon is valuable in designing fine-tuned public policies for local municipalities and ensuring efficient expenditure planning. Spending and investment decisions in the subcategories business development, TIC, culture and sport, and health are affected strongly by spatial interactions. The fiscal interaction changes detected in more agglomerated municipalities prove that theoretical considerations on agglomeration rents also apply to expenditure interactions. More highly agglomerated municipalities are indeed less dependent on their neighbors, which is another useful indication for the design of local governmental policies, for instance in allocating financial benefits such as transfers that mostly depend on population size. As agglomeration rents exist urban regions in particular have a higher chance to attract residents and firms. This issue should not be overlooked even in considerations of the national budget.

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Appendix

Table A1. The expenditure subcategories.

Expenditure subcategory	Type of expenditure	Share	Mainly earmarked/ non-earmarked
Transport, infrastructure, construction (TIC)	Spatial planning and development, geo-information, construction and property regulation, housing-construction funding, electricity, gas, water, district heat supply, waste management, sewage disposal, municipal-roads, district-roads, state-roads, federal-roads, road cleaning, parking facilities, public transport, other passenger and goods transport, ports	13-14 %	Mainly non-earmarked
Administration	Administration management and service, statistics and elections, regulatory affairs, funeral and cemetery services, taxes, general transfers and general levies, general financial economy	54-56 %	Mainly non-earmarked
Business development	General institutions and companies, business development, tourism	1-2 %	Mainly non-earmarked
Public facilities	Fire protection, emergency services, large-scale emergencies, disaster control, public green areas, nature and rural conservation, agriculture and forestry, environmental measures, immission protection, landscaping, public waters, water supply plants, monument conservation and care	3-4 %	Mainly non-earmarked
Culture/ Sport	Museums, exhibitions, zoological and botanical gardens, theater, public music culture, music schools, adult education center, libraries, other adult education, cultural education, national education, clerical affairs, sport funding, sport facilities	3-4 %	Mainly non-earmarked
Health system	Health administration, hospitals, health care, recreational facility, spas and bath houses	1 %	Mainly non-earmarked
Social system	Primary care, basic social benefits, benefits for asylum seekers, social facilities, war victim welfare, benefits under the Federal Pensions Act, benefits for severely disabled persons, funding of welfare carriers, benefits for living, inclusion of disabled persons, help with care, advances on maintenance payments, assistance services, funding for returnees and political prisoners, other social services, funding for children, youth work, services for young people and families	12-14 %	Mainly earmarked
Education	Primary schools, secondary schools, combined primary and secondary schools, high schools, comprehensive schools, vocational schools, special schools, other formal school tasks, science and research	6-7 %	Mainly non-earmarked

Source: own calculations based on Genesis online (2016).

Table A2. Specification tests for spatial panel 2009-2015

	NRW
Wald Test SDM vs. SAR	21.87***
LR Test SDM vs. SAR	94.24***
Wald Test SDM vs. SEM	19.31***
LR Test SDM vs. SEM	89.23***
Information criteria SDM vs. SAC	SDM: AIC: 32593 BIC: 32662; SAC: AIC: 32661 BIC: 32707
Spatial Hausman Test Fixed vs. Random Effect	129.68***

Notes: All models are estimated with population-density, gross domestic product, share of old people (65+), unemployed per capita and debt level per capita as independent variables. Year and municipality fixed effects are taken into account by a double demeaning procedure. W is a row normalized Inverse Distance Matrix with a cut-off point after 25 km. Test statistics are significant at: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: own calculations.

Table A3. Spatial weight model comparison

Weight specification W	ρ	Log-likelihood
Binary contiguity second order (row standardized)	0.069* (0.0371)	-16267.43
Binary contiguity third order (row standardized)	0.132** (0.0578)	-16265.93
Binary Neighbors within 15 km	0.13*** (0.0001)	-16659.94
Binary Neighbors within 20 km	0.068*** (0.0001)	-16469.52
Binary Neighbors within 25 km	0.121*** (0.0001)	-16647.69
Binary Neighbors within 30 km	0.29*** (0.0001)	-17624.21
Inverse Distance 15 km (row standardized)	0.059* (0.0303)	-16259.43
Inverse Distance 20 km (row standardized)	0.097** (0.0392)	-16261.47
Inverse Distance 25 km (row standardized)	0.124*** (0.0475)	-16259.39
Inverse Distance 30 km (row standardized)	0.147*** (0.0512)	-16260.88
Inverse Distance 15 km (spectral standardized)	0.093** (0.0466)	-16267.03
Inverse Distance 20 km (spectral standardized)	0.121** (0.0566)	-16264.34
Inverse Distance 25 km (spectral standardized)	0.153** (0.0641)	-16262.57
Inverse Distance 30 km (spectral standardized)	0.183** (0.0708)	-16263.17
Inverse Distance 15 km (minmax standardized)	0.126** (0.0636)	-16267.03
Inverse Distance 20 km (minmax standardized)	0.152** (0.0713)	-16264.34
Inverse Distance 25 km (minmax standardized)	0.185** (0.0774)	-16262.57
Inverse Distance 30 km (minmax standardized)	0.226** (0.0874)	-16263.17

Same district government	0.178*** (0.0635)	-16267.78
Socio-Economic	0.128*** (0.047)	-16259.60
25 km radius, binary, population>20000 (row standardized)	0.19*** (0.0696)	-16267.73
25 km radius, binary, population>30000 (row standardized)	0.182*** (0.0545)	-16264.74

Notes: The dependent variable is the total expenditure per capita, ρ denotes the spatial interaction effect. All models are estimated using the bias correction procedure proposed by Lee and Yu (2010) with maximum likelihood. Independent variables in the specifications are: population-density, gross domestic product on county levels, share of people aged 65+, unemployed per capita and the gross debt level p.c. The averaged neighboring equivalents are included as well as independent variables.

According to Drukker et al. (2013): Row standardized matrices - Each element in row i is divided by the sum of row i 's element. Spectral normalized matrix – each element is divided by the modulus of the largest eigenvalue of the matrix. Minmax normalized matrix – each element is divided by the minimum of the largest row sum and column sum of the matrix.

Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: own calculations.

Table A4. Yardstick competition - Fiscal expenditure interactions between the municipalities of NRW depending on political majorities

QML					
	(1)	(2)	(3)	(4)	(5)
	Total	Total	Total	Total	Total
	Seat shares >55 %	Seat shares >60 %	Seat shares >65 %	Seat shares >70 %	Right-wing >50 %
ρ	0.252*** (0.0636)	0.266*** (0.0513)	0.255*** (0.0459)	0.277*** (0.0435)	0.199*** (0.0704)
ρ_y	0.055 (0.1124)	0.057 (0.1312)	0.187 (0.1789)	-0.09 (0.3149)	0.139 (0.1043)
Municipal fixed effects	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Log-Likelihood	-17691.57	-17683.94	-17693.56	-17686.77	-17691.35
N	2772	2772	2772	2772	2772

Note: The dependent variable is the total expenditure per capita, ρ denotes the spatial interaction effect. All models are estimated using the bias correction procedure proposed by Lee and Yu (2010) with maximum likelihood. Independent variables in the specifications are: population-density, gross domestic product on county levels, share of people aged 65+, unemployed per capita and the gross debt level p.c. The averaged neighboring equivalents are included as well as independent variables. Robust standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A5. Results including right-wing dummy - Fiscal expenditure interactions between the municipalities of NRW

	QML							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total	Admin	TIC	Pub Fac	Bus Dev	Cul/ Spo	Health	Educ
ρ	0.118** (0.0471)	0.065 (0.0514)	-0.107** (0.053)	0.046 (0.048)	0.238** (0.1004)	-0.105** (0.0529)	-0.076** (0.0438)	0.047 (0.0559)
Right-wing	72** (29.51)	52.87** (24.16)	5.74 (8.43)	6.12** (2.52)	4.61 (4.4)	-0.458 (2.85)	0.893 (0.8611)	3.46 (5.86)
Municipal fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log-Likelihood	-16254.96	-15796.42	-13416.73	-10651.51	-12427.86	-10655.52	-7969.73	-11861.23
N	2376	2376	2376	2376	2376	2376	2376	2376

Note: The dependent variable is the total expenditure per capita, ρ denotes the spatial interaction effect. All models are estimated using the bias correction procedure proposed by Lee and Yu (2010) with maximum likelihood. Independent variables in the specifications are: population-density, gross domestic product on county levels, share of people aged 65+, unemployed per capita and the gross debt level p.c. The averaged neighboring equivalents are included as well as independent variables. Robust standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A6. Further spatial regression results - Fiscal expenditure interactions between the municipalities of NRW

Estimation methods	QML		IV/ GMM
	(1)	(2)	(3)
	SAR	SEM	SAR
ρ	0.132*** (0.0501)	0.157*** (0.0476)	0.106** (0.0431)
GDP	-0.008 (0.0267)	-0.009 (0.0288)	0.003 (0.0019)
Population density	-3.42** (1.55)	-3.58** (1.65)	0.4*** (0.0244)
Unemployed p.c.	65.50 (37.91)	64.26* (37.9)	168.95*** (11.12)
Share age 65+	-44.86** (20.26)	-44.6** (20.33)	2.97 (4.23)
Level of debt p.c.	-29.19 (63.29)	-30.87 (65.15)	-0.47 (0.0613)
Spatial Lags of X	NO	NO	YES, as instruments
Municipal fixed effects	YES	YES	YES
Year dummies	YES	YES	YES
Log-Likelihood	-16270.28	-16269.08	-18868.61
Number of obs.	2376	2376	2772

Note: The dependent variable is the total expenditure per capita, ρ denotes the spatial interaction effect. Spatial lags of the independent variables are Instruments in the IV/ GMM estimations: population-density, gross domestic product on county levels, share of people aged 65+, unemployed per capita and the gross debt level p.c. The averaged neighboring equivalents are included as well as independent variables. Robust standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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