Fiscal competition over taxes and public inputs

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Abstract

Governments are widely perceived as competing for capital by choosing parameters in a multi-dimensional policy space. We consider the choice of a business tax rate as well as a productive public input by local governments and estimate a model of strategic interaction in both policy instruments. The estimations suggest that local governments use both the business tax rate and public inputs to compete for capital. We find that if neighbors cut their tax rates, governments try to restore competitiveness by lowering their own tax and increasing public inputs. If neighbors provide more infrastructure, governments react by increasing their own spending.

Keywords: Tax competition, public input competition, system estimation

JEL Classification: H72, H77, C72

1 Introduction

It is widely believed that national as well as local governments have powerful tools to affect the allocation of mobile capital, and that how these tools are used has significant consequences for the welfare of citizens. However, compared to the vast overall number of

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factors typically regarded as crucial for private investors when deciding where to invest, governments have mainly two sets of instruments at their disposal that directly affect investors' choices: the taxation of businesses and the provision of public inputs. When analyzing government behavior related to competition for capital, it thus seems natural to assume that governments make use of both available instruments, and that the choices affecting the taxation of firms and decisions on public input provision will typically be interdependent. Accordingly, a thorough analysis of how governments compete for mobile capital should be based on analytical tools treating the relevant business tax rates and infrastructure investments as jointly determined policy instruments.

The theoretical literature has pointed to the role of taxes and infrastructure investments as joint determinants of private investment early on. Extending the analysis of Zodrow and Mieszkowski (1986), Keen and Marchand (1997) have shown that in the presence of a productivity-enhancing public good the composition of public spending tends to be systematically biased towards a relative overprovision of public inputs compared to public goods which are consumed directly by residents. Focusing on the strategic choice of policy instruments, Büttner (1999) has suggested a model where governments optimize over tax rates and shares of income that are spent on productive public goods. More recently, Hindriks et al. (2008) have presented a framework in which the level of public inputs is chosen in the first stage of a game while the tax rate is determined in the second. This dynamic setting implies an incentive for governments to underinvest in public inputs in order to alleviate second-stage tax competition.

In contrast to the aforementioned contributions, the bulk of theoretical work on fiscal competition has treated the cases of pure tax competition and expenditure competition separately. While Mintz and Tulkens (1986), Wilson (1986), and Wildasin (1988) have discussed the issue of inefficiently low equilibrium tax rates and a corresponding underprovision of consumptive public goods, Taylor (1992) and Bucovetsky (2005) have dealt with the problem of overprovision of public infrastructure. The related empirical literature has been dominated by applications testing for the strategic choice of business tax rates, mostly ignoring the issue of public inputs.[1] Early contributions include Brueckner and Saavedra (2001), Büttner (2001), and Hayashi and Boadway (2001).

Building on the work mentioned above, we offer a theoretical as well as an empirical treatment of tax and public input competition, with a focus on the strategic behavior of governments in choosing both policy instruments. As a guideline to the empirical analysis, we provide a brief discussion of a theoretical model under suitable functional form assumptions. We then proceed to an empirical treatment of fiscal competition in business taxes and public inputs. Using a rich data set of local jurisdictions in Germany, we estimate a two-dimensional system of fiscal reaction functions. To the best of our knowledge, we provide the first empirical analysis of tax and public input competition that allows for taxes and spending on infrastructure to be jointly determined endogenous variables. Building on the approach suggested by Kelejian and Prucha (2004), we run a four-step systems estimation approach for spatially interrelated equations. Our approach is very general. First of all, it allows for both policy instruments to depend on tax rates and public inputs in neighboring jurisdictions. Secondly, we treat the business tax rate as a function of a government's own level of public input provision, and vice versa. Thirdly, it accounts for potential cross-sectional correlation in unobservables and potential cross-equation correlation of residuals.

[1] One of the few empirical studies acknowledging the joint impact of taxes and public infrastructure on the allocation of private capital is Bénassy-Quéré et al. (2007). They investigate FDI flows from the U.S. to several European countries and find that both the corporate tax rate and the stock of public capital are significant in explaining inward FDI. In contrast to their study, we take the responsiveness of investment to inter-jurisdictional differences in tax rates and public infrastructure as given and explore whether governments make use of taxation and public inputs as strategic instruments to attract private capital. A further study providing some related evidence on OECD countries is Gomes and Pouget (2008).

The picture of local government behavior that emerges from our estimations is much more complex than suggested by previous empirical work on fiscal competition. Across various specifications, our findings suggest that governments set both the business tax rate and the level of public input provision strategically, i.e. they set both instruments taking into account the respective choices of competing governments. In particular, we find that local governments tend to adjust their business tax rate towards levels chosen in neighboring jurisdictions. Moreover, if neighbors increase their spending on the local infrastructure, governments react by strongly increasing their own spending, too. Finally, our results suggest that a government's level of spending on public inputs is also affected by the tax rates of neighboring jurisdictions. Treating taxes and public inputs as alternative means to attract capital thus reveals that local governments react to competition by other jurisdictions in a rather flexible way: municipalities experiencing a boost in local infrastructure investment in neighboring communities will, on average, raise the level of public input provision, too. If neighbors choose to lower the tax burden on locally installed capital, municipalities will adjust both the tax rate and the spending on infrastructure to restore competitiveness.

The paper proceeds as follows. In Section 2, we present a theoretical model of tax and public input competition. Section 3 describes our estimation approach and presents evidence based on data on local jurisdictions in Germany. Conclusions are drawn in Section 4.

2 A Simple Model of Tax and Public Input Competition

To guide the empirical discussion, we present in the following the essence of a simple model of tax and public input competition. Our considerations build on the literature on strategic tax competition in the tradition of contributions such as Wilson (1991), Wildasin (1991) and Brueckner and Saavedra (2001). In these models, two governments compete for capital which is in fixed supply, and countries are large enough to have an influence on each other's optimal behavior. It is straightforward to extend this model of pure tax competition by public inputs as a second policy instrument and to characterize the reaction functions. Since our interest lies in the strategic interaction across instruments, we let governments set taxes and the level of spending on the public input simultaneously. This rules out commitment effects emerging in a setting with sequential moves. As pointed out by, e.g., Wildasin (1991) and Devereux et al. (2008), it is a common feature of models in this literature that analytical solutions and the signing of even basic effects tend to come at the cost of functional form assumptions. While such assumptions are certainly restrictive, we nevertheless think that our model is helpful to frame the empirical discussion.[2]

Consider a federation of two symmetric jurisdictions, labeled i, j. In each jurisdiction, production of a homogeneous consumption good takes place, using perfectly mobile capital k_i and a publicly provided input, g_i. The public input raises the marginal productivity of the primary input factor. Governments compete by choosing a mix of instruments capable of influencing the location of mobile capital. To keep the model tractable, we use a simple quadratic production function of the form

$$F_i(k_i, g_i) = (a + g_i)k_i - b\frac{k_i^2}{2}, \tag{1}$$

where a and b are parameters. Governments levy per unit taxes t_i on capital employed in their respective jurisdictions. With mobile capital, its net return across regions is equalized,

$$F_i'(k_i, g_i) - t_i = F_j'(k_j, g_j) - t_j, \tag{2}$$

where F_i' denotes the marginal product of capital. With the world capital stock denoted as k, we can solve (2) for the capital employed in i, to obtain $k_i = (kb + g_i - g_j - t_i + t_j)/2b$.

[2] In a working paper version of this study (Hauptmeier et al., 2008), we present a more detailed exposition of the theory.

Note that due to the symmetric setting and the specification of the production function, we have $\partial k_i/\partial g_i = -\partial k_i/\partial t_i = -\partial k_i/\partial g_j = \partial k_i/\partial t_j = 1/2b$. The governments are assumed to maximize welfare in their own jurisdictions. Assuming absentee ownership of capital, we define the objective function of the government in i to be

$$U_i = F_i(k_i, g_i) - F_i'(k_i, g_i)k_i + t_i k_i - \frac{(k_i g_i)^2}{2}, \tag{3}$$

where the first term captures total output, the second capital income of foreign owners, the third local tax revenue, and the fourth the cost of public input provision. The specification is close to the one used in Hindriks et al. (2008), but includes a congestion externality in the cost term. This simple framework captures all effects that are relevant to our question while still being fully analytically solvable.

Including the cost of public input provision in the welfare function instead of imposing a budget constraint warrants some discussion. First of all, this choice implies (realistically) that governments do not rely exclusively on capital taxes as the source of funding for public inputs. Secondly, the specification avoids the need for a further policy instrument. Otherwise, with two instruments and the requirement to balance the government's budget, only one policy instrument could be set strategically.[3] The convex cost of supplying the public input captures a congestion externality in its use. The presence of such externalities is a natural assumption with regard to common public inputs like road networks, telecommunication infrastructure or land for business parks.[4] The intuition for our specification of congestion is that, for any given level of g, the welfare costs of providing it are the higher the more it is used. Stated differently, we assume that governments trying to ensure an

[3] As first discussed by Wildasin (1991), equilibria in fiscal competition games with two instruments related via a budget constraint crucially depend on which instrument is set strategically. See Bayindir-Upmann (1998) for an exploration with taxes and public inputs as policy instruments.

[4] Bergstrom and Goodman (1973) provide evidence suggesting that most local public goods are congestible. Craig (1987) finds substantial congestion effects using the example of police services, and Fernald (1999) shows that after 1973, with the U.S. Interstate Highway system being well-established, an increase in total miles driven reduced road services to individual producers significantly.

adequate provision of g for any unit of k will see the costs of g rising with k. In anticipation of our empirical example involving jurisdictions providing a local road network, one might think of an increase in the number of vehicles as leading to a more than proportionate increase in the need for roads due to nonlinearities in congestion effects. Alternatively, one could argue that the maintenance costs of public infrastructure increase as it is being used more heavily. With respect to the specific functional form of the cost term, we again build on Hindriks et al. (2008) by using a quadratic form.

Using $k_i = (kb + g_i - g_j - t_i + t_j)/2b$ and (3), we derive the welfare level as

$$U_i(k) = \frac{\delta_i}{8b^2}[b^2k + g_i^2(g_j - g_i + t_i - t_j) + b(g_i - g_i^2k - g_j + 3t_i + t_j)], \quad (4)$$

where $\delta_i \equiv kb+g_i-g_j-t_i+t_j$. Our main interest lies in the slopes of the tax and public input reaction functions, $t_i = f_t(t_j, g_j)$ and $g_i = f_g(t_j, g_j)$, around the equilibrium. A government will generally find it optimal to respond to a marginal policy change by its competitor using both instruments. To obtain the slopes of the tax and public input reaction functions, we proceed by totally differentiating the governments' first order conditions with respect to t_i and g_i. Since we assume jurisdictions to be identical, we follow the common practice to focus on the symmetric equilibrium characterized by $t_i = t_j = t$ and $g_i = g_j = g$ (see the appendix for an exposition of this). Using the specific values of all the derivatives, it is straightforward to derive from (A.1) the four effects of interest as

$$\frac{dg_i}{dg_j} = -\frac{dg_i}{dt_j} = \frac{1}{|H|}\frac{gk-1}{4b^2} \quad (5)$$

and

$$\frac{dt_i}{dt_j} = -\frac{dt_i}{dg_j} = \frac{1}{|H|}\frac{k(bk + g(4-3gk))}{16b^2}, \quad (6)$$

where $|H|$ denotes the determinant of the Hessian (it is shown in the appendix that $|H|$ is positive). The symmetries in dt_i/dt_j and dt_i/dg_j as well as dg_i/dg_j and dg_i/dt_j are driven by the fact that the absolute values of the marginal changes in the tax base k_i are equal across instruments.

To sign the slopes of the reaction functions, we make use of the symmetric Nash equilibrium, which turns out to be $g^* = 2/k$ and $t^* = (bk^2 + 4)/(2k)$ (see the appendix for derivations).[5] Evaluating (5) at the symmetric equilibrium, we find unambiguous signs for the reactions in public inputs,

$$\frac{dg_i}{dg_j} = \frac{4}{3bk^2} > 0; \quad \frac{dg_i}{dt_j} = -\frac{4}{3bk^2} < 0. \tag{7}$$

The expressions in (7) show that if the opponent deviates from the symmetric equilibrium by increasing its supply of public inputs, a region will find it optimal to respond by supplying more g, too, and that a region will also react by providing more of the costly input if the opponent competes for capital by cutting its tax rate.

Evaluating (6) in equilibrium, we see that the signs of the reactions in taxes depend on b, the parameter measuring the curvature of the production function,

$$\frac{dt_i}{dt_j} = \frac{bk^2 - 4}{3bk^2}; \quad \frac{dt_i}{dg_j} = -\frac{bk^2 - 4}{3bk^2}. \tag{8}$$

Hence, the finding that the slope of the reaction function in a model of pure tax competition cannot be signed unambiguously (Brueckner and Saavedra, 2001) carries over to our setting. As long as we are willing to assume that b is larger than $4/k^2$, however, we find

$$\frac{dt_i}{dt_j} > 0; \quad \frac{dt_i}{dg_j} < 0. \tag{9}$$

Under the given restriction on b, the optimal reaction to a decrease in the opponent's tax rate is to decrease taxes as well. Similarly, if the opponent provides more public inputs, it is optimal to cut the tax rate.

[5] Note that capital has a participation constraint, namely that its net of tax return has to be positive, $F'(k_i, g_i) - t_i > 0$. This condition reduces to $a > bk$. This condition is also sufficient to ensure a positive marginal product of capital.

The rationale for requiring $b > 4/k^2$ can be seen from the components of a region's welfare, which, after substitution of the residual income, is

$$U_i = \frac{b}{2}k_i^2 + t_i k_i - \frac{(g_i k_i)^2}{2}. \tag{10}$$

Evaluating this expression at the symmetric equilibrium shows that the condition $b > 4/k^2$ is equivalent to the requirement that the residual income is larger than the cost of providing g. If this condition is not met, the welfare effect of attracting additional units of capital is negative once we net out the contribution of tax revenue. As b determines the curvature of the production function, thereby driving the residual income the country earns (after having paid the mobile factor its marginal product), imposing the condition $b > 4/k^2$ essentially means restricting attention to situations where fiscal policies are driven by a motive to attract investment as an income-generating factor (besides the motive to raise tax revenue): If b is very small, the production function is almost linear, rendering the residual income small.

Having discussed some key effects in a multi-dimensional model of fiscal competition, we now proceed to the empirical application. The analysis will focus on local governments setting a business tax rate and choosing the level of provision and maintenance of a local road network as a key public input to local production.

3 Empirical Analysis

3.1 Institutional Features of Municipal Finances in Germany

The German constitution, according to Art. 28 para 2, generally guarantees the right of municipal self-administration. This guarantee is also anchored in most state constitutions such as the one of Baden-Wuerttemberg (Art. 71) which is relevant for our analysis. As a result, German municipalities have significant autonomy in conducting their tasks. This holds true, in particular, for the so-called voluntary tasks as well as the mandatory tasks without instruction where the state level only has a legal control function.[6] The latter include the construction and maintenance of the local road network, which we focus on in this study, but also various other tasks such as the construction and maintenance of schools and kindergartens, the operation of the sewage system, the fire brigade, etc.

On the revenue side, German municipalities, besides transfers from the state level, depend to a significant degree on own tax revenues. On the one hand, they receive a share of the main federal taxes, i.e. VAT and income taxes. At the same time, they have rate setting autonomy for local business and property taxes. Most notably, revenues from the local business tax in 2009 accounted for around 40% of municipal tax revenues in the state of Baden-Wuerttemberg and around 15% of overall municipal revenues.

This institutional setup which is characterized by a significant degree of fiscal autonomy at the municipal level both on the spending and the revenue side makes Germany a very interesting case to study in the context of sub-national fiscal competition (see, e.g., Büttner 2001, Büttner 2006, and Egger et al. 2010). The existence of a sufficient degree of local discretion in the conduct of fiscal policies constitutes a crucial prerequisite for a convincing empirical analysis of the interaction of policy instruments both across and within municipalities. In this context our choice of policy instruments, i.e. the local business tax rate and expenditures on the local road network, appears well justified and suited with a view to testing sub-national fiscal policy interdependence.

[6]There are also so called mandatory tasks upon instruction which, however, are mostly limited to administrative responsibilities such as registration and passport issues or cooperative responsibilities related to statistics and the conduct of elections.

3.2 Estimation Approach

To accommodate strategic government behavior, our estimation approach must be flexible enough to allow for tax rates and public inputs to be determined simultaneously. Moreover, the design of the empirical model needs to account for the interdependence of all jurisdictions' choices regarding taxes and inputs, i.e. each jurisdiction's tax rate as well as the level of inputs provided to attract mobile capital should be allowed to depend on both taxes and inputs of all other jurisdictions.

Our empirical model builds on $t_i = f_t(t_j, g_j)$ and $g_i = f_g(t_j, g_j)$ as the general form reaction functions of the tax and public input competition model. To facilitate estimation, we make use of linearized versions of these functions and define the following system of equations,

$$\tau_i = \theta_\tau s_i + \lambda_\tau \tau_{-i} + \varphi_\tau s_{-i} + \beta_\tau X_{\tau i} + u_i \qquad (11)$$

$$s_i = \theta_s \tau_i + \lambda_s \tau_{-i} + \varphi_s s_{-i} + \beta_s X_{si} + v_i, \qquad (12)$$

where τ denotes the tax rate and s a jurisdiction's spending on the public input, $\tau_{-i} = \sum_j w_{ij}\tau_j$ and $s_{-i} = \sum_j w_{ij}s_j$ indicate the average tax rate and average inputs of other jurisdictions, weighted by the predetermined weights $w_{i1}, \ldots, w_{iN}$, and $X_{\tau i}$ and X_{si} denote vectors of control variables (including a constant) in the tax and input equation, respectively. The variables entering both $X_{\tau i}$ and X_{si} are subsets of a set of exogenous variables, $X_i = (x_{1i}, \ldots, x_{Ki})$.

Note that in specifying our system of equations, we include s_i among the right-hand side variables of the tax equation and τ_i as an explanatory variable in the input equation. In doing so, we deviate from the usual approach to use counterparts of reduced-form reaction functions when estimating models of fiscal competition with more than one choice variable (see Devereux et al., 2008). The reason for allowing a government's own policy instruments to appear as explanatory variables is that we want the empirical model to allow for the fact that governments are not always free to adjust both instruments to optimal levels. For instance, governments might face political costs when frequently changing the business tax rate, and prefer to keep the tax rate constant if the difference between the optimal rate and the rate actually implemented is sufficiently small. Taking into account the effect on the government's budget, the optimal choice of public inputs should then be modeled as being conditional on a given business tax rate. A similar argument can be made with respect to public inputs, where investments often require considerable planning effort. As a result, it may take some time until a government can adjust its stock of public capital to the desired level. Again, this may affect the government's budget and, thereby, the tax rate.

Apart from modeling tax rates and inputs to be interrelated both within and across jurisdictions, we also allow for cross-sectional dependence in the disturbances u and v,

$$u_i = \rho_u u_{-i} + \epsilon_i \quad \text{and} \quad v_i = \rho_v v_{-i} + \varepsilon_i, \tag{13}$$

where $u_{-i} = \sum_j w_{ij} u_j$ and $v_{-i} = \sum_j w_{ij} v_j$. The innovation vectors ϵ and ε are assumed to be identically and independently distributed with zero mean. Hence, we require that the innovations are free of spatial correlation. Note, however, that we allow for contemporaneous cross-equation correlation among innovations of the same cross-sectional unit.

Following most of the literature on tax competition among local jurisdictions, we choose a spatial metric which accounts for the physical distance between jurisdictions. Moreover, we also want the weights to reflect differences in the jurisdictions' size. We therefore use the metric

$$w_{ij} = \frac{n_{ij}\, pop_j}{\sum\limits_{k \neq i} n_{ik}\, pop_k},$$

where n_{ij} is an indicator for neighbors of i (with $n_{ii} = 0$) and pop_j is j's population. To determine which jurisdictions are 'neighbors' of a given community, we either use a maximum great circle distance between the centroids of jurisdictions, or we apply an mth-nearest-neighbors criterion, defining as neighbors the m nearest jurisdictions in terms of physical distance. Note that the spatial metric defines an environment for each municipality that is assumed to be the relevant local market for mobile investment. Although all municipalities in our sample are part of an integrated capital market, it nevertheless seems reasonable to assume such a local environment. One reason is that the population of firms in almost all municipalities is dominated by small and mid-size firms with limited management capacity. Imposing a spatial metric based on geographical proximity essentially means that these small and mid-size firms are assumed to consider only a 'local environment' of municipalities as alternative locations.

While our specification of the empirical reaction functions is more general than the commonly employed reduced-form version, it also makes the estimation of the parameters of interest more involved. In fact, allowing the choice variables to appear as explanatory variables means that we have to deal with a total of four endogenous explanatory variables: s_i, τ_{-i}, and s_{-i} in the tax equation, and τ_i, τ_{-i}, and s_{-i} in the public input equation. To account for all endogeneity problems and to achieve efficient estimation, we use the spatial system estimator proposed by Kelejian and Prucha (2004). In the following, we briefly outline the four step estimation procedure.

As the initial step, we run a two-stage least squares (2SLS) procedure separately on the tax and the input equation, treating τ_i, s_i, τ_{-i} and s_{-i} as endogenous regressors. We use the same set of instruments in both estimations, containing $x_{1i}, \ldots, x_{Ki}$ as well as the corresponding first and second order spatial lags. In matrix notation, they can be written as $WX_1, \ldots, WX_K, WWX_1, \ldots, WWX_K$, where W denotes the N-dimensional square matrix of weights. The fact that τ_i as well as s_i appear as explanatory variables in our system requires some of the exogenous characteristics to be used as instruments for these variables. Technically, this is achieved by imposing exclusion restrictions with respect to a subset of the exogenous variables on both equations. We comment on the specific exclusion restrictions imposed in a separate subsection below. Using the residuals of the first stage, in the second step of the procedure the spatial auto-regressive parameters ρ_u and ρ_v are estimated by the generalized moments method originally suggested by Kelejian and Prucha (1999). The estimates of the spatial auto-regressive parameters are then used in the third step to perform a Cochrane-Orcutt-type transformation of the original equations to remove the spatial error correlation and to re-run 2SLS on the transformed system. While the third-step estimation takes into account potential spatial correlation, it does not take into account the cross equation correlation in the innovation vectors. To utilize the full system information, in the fourth step we apply a systems instrumental variable estimator, which is efficient relative to the first and third stage single-equations estimators.

For several reasons, the systems estimation approach outlined above seems to be the ideal choice for estimating our tax and public input competition model. First of all, the procedure takes account of the fact that both taxes and public inputs are determined simultaneously. Secondly, it allows for contemporaneous interaction between jurisdictions in a very general way. In addition, it is easy to implement even in large samples, a distinctive advantage over maximum likelihood procedures.

The evidence reported in this study is derived from cross-sectional estimations. While we would like to run panel estimations accounting for fixed municipality effects, there is, unfortunately, no straightforward way to do so. The systems estimator of Kelejian and Prucha (2004) is not designed for panel data, and we are unaware of an alternative estimation procedure that combines the features of a systems estimator with general cross-sectional interdependence with ways to account for unobserved heterogeneity.[7] Moreover, variation

[7]Note, however, that Baltagi and Pirotte (2011) consider estimators for seemingly unrelated regressions

in tax rates over time is rather limited, and estimating a model with fixed municipality effects would thus require data covering more periods than we have at our disposal. However, as a robustness check regarding potential period-specific effects, we report the results of systems estimations using the municipality-level data after a between-transformation, i.e. we run cross-sectional regressions using variables after taking averages over time.

3.3 Data

The data used to estimate our empirical model of tax and public input competition come from a sample of 1100 German municipalities in the state of Baden-Wuerttemberg, covering the period 1998-2004. Note that we exclude independent cities from the sample (10 cross-sectional units), which face different incentives within the municipal system of fiscal equalization.[8] As we will see, the treatment within this redistributive grant system exerts a strong impact on local tax and spending decisions. In the following, we briefly comment on the data which are summarized in Table 1.

As already pointed out, German municipalities have taxing autonomy with respect to the business tax (Gewerbesteuer), essentially a tax on local business earnings. In the time period under consideration, the statutory tax rate in the state of Baden-Wuerttemberg averaged 0.167 and varied between 0.145 and 0.21. Besides revenues from the local business tax, grants and federal tax revenue sharing play an important role in municipal financing. In our context of tax and public input competition, fiscal equalization grants deserve special attention, as redistributive grant systems affect the incentive of local governments with

with spatial error correlation in a panel data framework.

[8]According to constitutional law, the independent cities are treated as municipalities. However, beyond the functions of municipalities these cities also fulfil additional county-related tasks which are, in turn, reflected in a different treatment within the municipal fiscal equalization system. In particular, independent cities are not involved in the redistribution via the county contribution which results in different taxation incentives.

respect to tax and expenditure policies. The theoretical literature on the internalizing effects of fiscal capacity based equalization suggests that the implementation of redistributive grant systems tends to weaken tax and public input competition (e.g., see Koethenbuerger, 2002 and Bucovetsky and Smart, 2006). Recent empirical evidence for Germany (Büttner, 2006; Egger et al., 2010) supports the view that tax rates tend to rise when the degree of equalization increases. Following Büttner (2006), we therefore include two control variables in our regressions to account for substitution and income effects of equalization grants. The marginal contribution rate describes to which extent an increase in the tax base reduces the equalization transfers received. For the period between 1998 and 2004 the average rate was 13.2% with a maximum value of 14.5% and a minimum of 8.8%. Relating the marginal contribution rate to the tax rate reveals an average equalization rate of around 80%. As a means to control for pure income effects we include unconditional transfers capturing the amount of transfers a municipality would receive if its tax base were actually zero. This includes equalization transfers and the municipal share of statewide income and value added taxes.

Furthermore, since differences in taxing capacity may affect local tax and expenditure policies, we account for a municipality's relative fiscal capacity. This variable is calculated by relating a municipality's fiscal capacity (comprising the local business tax base as well as other revenue sources, in particular the share of statewide income and value added taxes) to its fiscal need, calculated by multiplying a predefined per capita spending need with the municipality's population size. Hence, controlling for a municipality's relative fiscal capacity essentially captures the local budget constraint. The relative fiscal capacity shows values between 28% and 635% with an average value of 71.4%, indicating that the average municipality in the state of Baden-Wuerttemberg is not able to cover its spending needs though own resources and depends on intergovernmental transfers.[9]

In our analysis, public input provision is defined as spending on the municipal road network. This choice is straightforward since it seems reasonable to assume that the quality of the local road infrastructure is of substantial importance for all types of firms. Moreover, the construction and maintenance of local roads is one of the most important autonomous municipal responsibilities in Germany. More than 60% of the road network falls under the municipal domain.[10] Between 1998 and 2004, municipalities spent, on average, 130 Euros per capita (in prices of 2000) on the construction and maintenance of local roads. A standard deviation of 93 Euros per capita indicates substantial variation in this expenditure category. As municipalities receive grants in order to fulfill their self-administrated spending responsibilities, we explicitly control for specific transfers in the spending category 'local roads'. This includes grants within the so called 'traffic and transport burden sharing' (Verkehrslastenausgleich), which depend on the length of the road network and the size of the municipal area. In addition, we include other specific grants independent of the tax base in order to control for the corresponding income effects. Other conditioning variables capturing local characteristics include debt service, population size and population density as well as the population share of the young (less than 16 years) and the elderly (above 65 years). Furthermore, we also include the unemployment rate as a proxy for the general demand for spending on social services. Finally, drawing on Büttner (2001), we include the share of the population that is affiliated with one of the three major Christian churches (Catholic, Protestant State, and Protestant Free Church) as well as two variables that interact this proportion with the rate of unemployment and the share of elderly peo-

[9]See Büttner (2006) for further details on the municipal system of fiscal equalization in the state of Baden-Wuerttemberg.

[10]Due to strong interlinkages of municipal and state responsibilities, other spending categories potentially capturing inputs to production, most notably educational expenditure, cannot be considered as independently provided at the local level. Our empirical analysis therefore focuses on the local road network and captures other expenditures as a residual category.

ple, respectively.[11] The inclusion of these variables is warranted as the religious orientation of the population may indicate preferences regarding the provision of social services and welfare. The interactions account for the possibility that, depending on the strength of religious orientation, an increase in the number of potential welfare recipients may have different effects on the socially preferred level of social services. For instance, we would expect a higher preferred spending on social services (and, thus, a higher business tax rate) in municipalities where the population is firmly attached to religious communities, whereas in places where religious orientation is weak, we expect a lower preferred spending level.

3.4 Exclusion Restrictions

The fact that both the tax rate and public inputs appear as explanatory variables in our system of equations requires to use some of the exogenous characteristics as instruments for these variables. Technically, this is achieved by imposing exclusion restrictions with respect to a subset of the exogenous variables on both equations. An exclusion restriction for the tax equation is suggested by the system of specific grants. As specific grants for the construction and maintenance of local roads amount, on average, to only 1.2% of overall expenditures, the business tax rate should be independent of the level of these grants. To the contrary, we expect grants for local roads to significantly affect actual spending on the local road network. Consequently, we include specific grants in the public input equation, but exclude it from the tax equation.

The fact that infrastructure spending as well as specific grants for local roads depend on the length of the existing network might give rise to concerns regarding the exogeneity of

[11]Data on religious affiliation is available only for 1987. The slight imprecision in the count of church members relative to overall population (10 municipalities with a reported share of church members higher than one) is known from other studies using the same data. Excluding municipalities with implausible figures does nothing to our estimation results.

the grants variable. While we do not have data on the pre-existing road network, we believe that the inclusion of population and population density captures most of the variation in expenditures driven by this unobserved factor.[12] Note that other specific grants amount to 57.4 Euros per capita, twice as much as specific grants for local roads. We therefore include other specific grants in both equations to account for potential income effects.

Regarding the exclusion restrictions for the public input equation, note first that local roads are not only used as public inputs by firms, but are also consumed by private households. A change in infrastructure spending will therefore have direct as well as indirect effects on the utility of residents. In contrast, a change in the business tax rate will affect households only indirectly. This suggests to exclude the variables describing the religious orientation of the local population and related preferences regarding spending on social services from the input equation. We thus assume that a stronger preference for spending on social services and welfare may affect the preferred level of local taxation, but that the level of municipal spending on physical infrastructure is independent of residents' religious orientation.

Of course, the quality of the instruments obtained from imposing our exclusion restrictions is also an empirical question. In particular, to identify public inputs in the tax equation, we need the specific grants for local roads to be sufficiently strongly partially correlated with spending on local roads. Furthermore, the identification of the local business tax rate in the input equation rests on the partial correlations between the tax rate and the proportion of church members as well as the related interaction terms. We will discuss the quality of the instruments when turning to the estimation outcomes.

[12] We also checked whether population density might serve as an alternative instrument for local road expenditures. We obtain very similar results, but face the problem that, compared to specific grants, population density is a much weaker instrument for infrastructure spending.

3.5 Results

Table 2 and 3 present estimation results for a first set of system estimations on tax and public input competition. The spatial metric is $W^{15\text{km}}_{\text{pop adj}}$, defining as neighbors of a given community all municipalities with a physical distance of up to 15 km. As discussed above, the metric also gives higher weight to larger municipalities in terms of population size.[13] We show results from cross-sectional estimations and check for the robustness across years by reporting regressions for different years.

After excluding the 10 independent cities from the sample, we are left with 1100 cross-sectional observations. Note that the sample restriction is applied after taking spatial lags. Hence, while all municipalities are included in the computation of τ_{-i}, s_{-i} and the spatial lags of the exogenous variables, the estimation of coefficients is based on the restricted sample.

Table 2 reports two columns for each year, where the left one shows coefficients and standard errors for the tax equation and the right one depicts the results for the public input equation. First of all, we note that the coefficient of neighbors' taxes is positive and highly significant in the tax equation in all reported cross-sections, ranging from 0.20 to 0.31. These results suggest that the municipalities in our sample react to tax policies of their neighbors by adjusting their own business tax rate towards the level chosen in nearby jurisdictions.[14] Note that this finding is well in line with the evidence presented in Büttner (2001). However, our results also reveal that there are several other effects at work, suggesting that the behavior of local governments is much more complex than described in the earlier empirical tax competition literature. In particular, we find a positive and sta-

[13] We use population figures from the year 1997 to avoid possible endogeneity problems.

[14] In the following, we sometimes interpret the estimates of the strategic effects in terms of reactions of governments to changes in other municipalities' policy instruments. Such interpretations always refer to the partial effects in our static empirical model, and not to any sort of dynamic adjustment.

tistically significant effect of neighbors' spending on infrastructure on a community's own spending level in three out of four cross-sections. The coefficients indicate that a one-Euro increase in neighbors' average spending per capita triggers an increase in a municipality's own per-capita spending on infrastructure between 18 and 51 Cents. Hence, our findings suggest that the municipalities engage in simultaneous tax and public input competition for mobile capital.[15] A second effect that has not been considered in previous work is that of neighbors' taxes on a municipality's own level of spending on public inputs. In two out of four cross-sections, we find a negative and statistically significant effect, pointing to local governments increasing their per-capita spending on infrastructure by about 7 to 11 Euros per capita in reaction to a one percentage point decrease of their neighbors' average tax rate. It is worth noting that for all these effects, the sign of the estimated coefficient is in line with the corresponding prediction of our theoretical model.

Interestingly, our results also point to direct interaction between fiscal variables within a community: a one percentage point increase in the statutory tax rate triggers an increase in spending per capita of 32 Euros in 1998 and of 24 Euros in 2000, while in the 2002 cross-section we find a negative effect of about 22 Euros. Moreover, for 1998 and 2000 there is a positive partial effect of public inputs on taxation, indicating that an increase of spending by 100 Euros per capita would result in a tax rate increase of 0.1 to 0.2 percentage points. All these findings support the notion that it is important to account for the fact that not all policy instruments might be adjustable to optimal levels at all points in time.

Besides the evidence on tax and public input competition, there are additional findings that are worth mentioning. Confirming our expectations, the marginal contribution rate

[15] The positive impact of neighbors' spending on a municipality's own spending is unlikely to be driven by technological externalities since the construction and maintenance of major interconnecting roads and highways falls into the responsibility the federal government and the states. Our measure of local public input provision thus includes only spending on roads with a very limited potential impact on the productivity of capital invested in other municipalities.

positively affects the tax rate, while unconditional transfers exert a negative impact on local taxes. Both findings are in line with Büttner (2006) and support the view that a higher degree of redistribution within a system of fiscal equalization alleviates business tax competition. In addition, there is evidence for a negative impact of the marginal contribution rate on public input provision in two out of four cross-sections. This suggests that fiscal equalization counteracts both tax and public input competition. Furthermore, unconditional transfers are found to positively affect public inputs. An increase of these transfers by one Euro per capita brings about an increase in infrastructure spending per capita of 0.18 to 0.24 Euros. Regarding relative fiscal capacity, our expectations are also confirmed: municipalities with higher capacity set lower tax rates and spend more on public inputs. With respect to the characteristics used as instruments in either the tax or the public input equation, we note that spending on local roads strongly reacts to the amount of specific grants received for that purpose. In addition, we find at least two highly significant variables capturing the religious orientation of the population in all cross-sections.[16] Finally, we note a positive impact of debt service on local taxes and a negative impact on public input provision, and a negative (positive) effect of unemployment (population) on the tax rate.

Regarding the quality of the instruments, we first note that τ_{-i} and s_{-i} are identified by a strong partial correlation with first and second-order spatial lags of exogenous community characteristics, resulting in F-statistics of the excluded instruments in the corresponding first-stage regressions larger than 50 in general.[17] With respect to a community's own tax rate and public input as endogenous explanatory variables, we first checked the performance of the instruments in the first stage regression in terms of statistical significance. The

[16] Note, however, that this finding is not sufficient to rule out a potential problem of weak identification. We comment on this below.

[17] We refer to the 2SLS estimation that is performed as the third step of the estimation procedure.

specific-grants variable is always highly significant in the first-stage regression of public inputs on the set of instruments, with t-statistics around 10. In the first-stage regression of the tax rate, both the proportion of church members and the interaction with the rate of unemployment are generally significant at the 1% level. However, since the F-statistics for a community's own tax rate and public input are relatively small, we also checked the critical values for the Stock-Yogo weak identification test. We were able to reject the null that the bias of our IV estimation exceeds 20% of the bias in the corresponding OLS estimation in all cases, lending further support to our identification strategy.

The spatial metric used in the estimations reported in Table 2 assigns 23 neighbors on average to each municipality. In addition, there is substantial variation in the number of neighbors, ranging from one to 54. As a first robustness check of our findings with respect to the definition of neighborliness among municipalities, Table 3 reports results of the same estimations as before, with the metric $W^{\text{10 nearest}}_{\text{pop adj}}$ based on the definition of the 10 nearest communities (in terms of physical distance) as neighbors, weighted by population.

All effects discussed before are robust to this change in the metric. The effect of neighbors' taxes on a municipality's own tax rate is somewhat smaller than before, ranging from 0.16 to 0.21. The impact of neighbors' spending on infrastructure on the local provision of public inputs is of similar size as before, with estimated coefficients ranging from 0.22 to 0.39. The results also confirm the finding that the municipalities take into account the level of taxes among neighbors when choosing their level of spending on the local road network. Even with respect to the strength of the interaction, we do not find any significant difference compared to the results reported in Table 2.

To some extent, the evidence on tax and public input competition depends on which cross-sections are used for estimation. This applies in particular to the public input equation.

While we do not have evidence on the forces behind these changes over time, we believe that general economic conditions are affecting the degree of fiscal competition. With our analysis covering the sharp economic downturn between 2000 and 2003, such changes in general economic conditions are particularly strong in our sample. Of course, with cross-sectional estimations we cannot control for such effects, and it might therefore be useful to have a look on average effects. Table 4 reports the results of a system estimation after applying a between-transformation, i.e. after taking averages of all variables over time. Using $t = 1, \ldots, T$ as the index of time periods, the transformed system reads

$$\bar{\tau}_i = \theta_\tau \bar{s}_i + \lambda_\tau \bar{\tau}_{-i} + \varphi_\tau \bar{s}_{-i} + \beta_\tau \bar{X}_{\tau i} + \bar{u}_i \tag{14}$$

$$\bar{s}_i = \theta_s \bar{\tau}_i + \lambda_s \bar{\tau}_{-i} + \varphi_s \bar{s}_{-i} + \beta_s \bar{X}_{si} + \bar{v}_i, \tag{15}$$

where $\bar{\tau}_i = T^{-1} \sum_t \tau_{it}$, $\bar{X}_i = T^{-1} \sum_t X_{it}$, $\bar{\tau}_{-i} = \sum_j w_{ij} \bar{\tau}_j$, etc. The between-estimations confirm the presence of direct strategic interaction in the choice of taxes and public inputs. Using $W^{15\text{km}}_{\text{pop adj}}$ as the spatial metric, we find an average direct tax competition effect of 0.263 and a direct public input competition effect of 0.328. With $W^{10\,\text{nearest}}_{\text{pop adj}}$, the corresponding point estimates are 0.211 and 0.215, respectively.

The result regarding the impact of neighbors' taxes on own spending on infrastructure is mixed: the null of no interaction cannot be rejected under the metric $W^{15\text{km}}_{\text{pop adj}}$, but it is rejected under $W^{10\,\text{nearest}}_{\text{pop adj}}$ at the 10% level of significance. However, the magnitude of the estimated effect is rather small.

3.6 Robustness

In the following, we discuss some robustness checks regarding the choice of the spatial metric, spatial error dependence, border effects, and the exogeneity of WX and WWX.

The results discussed so far have been derived under specific assumptions with respect to spatial metrics. In related applications it has been shown that the choice of the metric may be of critical importance (Baicker, 2005), and it therefore seems to be warranted to discuss the issue in more detail. While choosing a metric based on some geographical definition of neighborliness seems to be accepted as a general rule in applications involving local jurisdictions (Büttner, 2001, 2003), no consensus has evolved how to exactly specify the weights. However, as argued by Conley (1999), in many cases the application itself suggests a certain strategy. In our case, for instance, the significant differences in the jurisdictions' size together with the fact that the key issue driving local governments into strategic interaction is a fiscal externality warrant to include some measure of size. Moreover, there are also technical aspects that need to be considered. As shown in the descriptive statistics (Table 1), the cross-sectional variation of the tax rate is rather limited. Taking averages over neighboring jurisdictions' tax rates will, of course, give a variable with even smaller variation. This problem can be expected to become the more severe the more municipalities are, on average, defined as neighbors for a given community. In fact, with sufficiently many communities included in the calculation of neighbors' taxes, τ_{-i} will quickly converge towards the regional (or even the statewide) average of taxes. Defining many municipalities as neighbors for a given community will thus result in τ_{-i} becoming a poor measure for the tax effort of nearby municipalities.

To exemplify the last point, we have assembled in Table 5 some descriptive statistics for neighbors' average tax rates (τ_{-i}) and neighbors' expenditures on infrastructure (s_{-i}) according to different spatial metrics (based on data for the year 2000).

The first four rows depict statistics for spatial metrics that take either the municipalities within a distance of up to 15km or the 10 geographically closest municipalities to be neighbors of a given municipality. Irrespective of whether we take the weights of neighbors to be uniform or to be defined based on the inverse of the great circle distance, the variable capturing the average tax rate of neighbors shows very limited variation. With uniform weights assigned to municipalities within a distance up to 15km, for instance, the variation in neighbors' average tax rate is actually modest, with a minimum of 0.16 and a maximum of 0.177. However, if we account for asymmetries in population size (last two rows), the variation in the resulting series is significantly higher. Note that, due to higher variation in local expenditures per capita, the computation of neighbors' spending on infrastructure does not seem to be affected by the problem of quick convergence towards regional or statewide averages.

Based on the preceding discussion, we expect the estimates regarding the impact of τ_{-i} to critically depend on the choice of the spatial metric. In contrast, the estimates regarding the coefficient of s_{-i} should be more robust to the definition of neighbors. To check to what degree this presumption is supported by our data, we estimated our system of reaction functions using the different spatial metrics. Table 6 gives an overview on the estimated coefficients of interest for a number of cross-sections.

We note that using $W^{\text{15km}}_{\text{uniform}}$, $W^{\text{15km}}_{\text{inverse}}$, $W^{\text{10 nearest}}_{\text{uniform}}$ and $W^{\text{10 nearest}}_{\text{inverse}}$ results in very large estimates of λ_τ compared to $W^{\text{15km}}_{\text{pop adj}}$ and $W^{\text{10 nearest}}_{\text{pop adj}}$. This is well in line with our expectations, as the variation in τ_{-i} tends to be low (recall that, with the weight matrix approaching a matrix of uniform weights for *all* other municipalities, τ_{-i} becomes a constant measuring the average tax rate among all communities).[18] It is worth mentioning that the estimate for the interaction effect in public input provision, φ_s, is much more robust to changes regarding the spatial metric. Noting that the variation in spending on infrastructure is

[18]Note that for our system of equations to be stable, λ_τ is required to be smaller than one in absolute value. There are two estimations based on the 2004 cross-section where this requirement is barely met, adding further doubt about the appropriateness of spatial metrics that define 'large' sets of neighbors and that do not account for the municipalities' relative population size.

much higher than the variation in tax rates, and that defining a composite neighbor from a large set of communities should therefore be less of a technical problem, it is reassuring that the conclusions regarding public input competition are not critically affected by the choice of a spatial metric that defines either smaller or larger sets of neighbors.

Another issue deserving some more discussion is spatial error dependence. If the way we model this dependence in eq. (13) is not correct, this may cause correlation between the residuals and the instruments WX and WXX. A straightforward robustness check is to re-estimate the model without accounting for spatial error correlation. However, when setting ρ_u and ρ_v to zero, we obtain very similar results (see Table 7 for findings using $W^{15\text{km}}_{\text{pop adj}}$). While the estimates for λ_τ are now somewhat smaller, φ_s is now larger in two out of four estimations. We conclude that the correction for spatial error dependence is unlikely to cause problems with the specification of the instruments.

Finally, we test for the impact of border effects and possible endogeneity of variables used as instruments. As in many applications using local data, it is difficult to study local tax and expenditure competition because competition is not confined to a specific, well defined area. For instance, it may be that municipalities located at the border to France compete with French municipalities, too, but this is not captured by our model. Moreover, our exclusion of independent cities may create similar problems. While there is no perfect solution to this issue, we can at least test for border effects in tax setting and infrastructure spending. We do this by including in our model two dummy variables for municipalities sharing a border with France and Switzerland, respectively. In addition, we account for border effects in municipalities located at a border to a different German state. This gives three additional dummies for shared borders with Bavaria, Hesse, and Rhineland-Palatinate. Finally, we include a dummy for municipalities located at the shore of Lake Constance (where other parts of the shore belong to Austria and Switzerland, respectively), and a dummy for localities sharing a border with an independent city. We have assembled the key coefficients from some estimations (again using $W^{15\text{km}}_{\text{pop adj}}$ as spatial metric) including these dummy variables as additional regressors in Table 8. Comparing this with Table 2 shows that our key findings are unchanged.[19]

Another concern that could be raised relates to the exogeneity of WX and WWX. The prime candidate for such concerns is certainly our measure of community size, i.e. population. For instance, if neighbors' population captures the potential for cross-municipality commuting, spending needs for the local road network could directly depend on this variable. A model using neighbors' population as an IV would then be misspecified. The final four columns in Table 8 therefore report results from estimations including neighbors' population as an ordinary regressor in both equations.[20] We find that the additional regressor is insignificant in all cases, supporting the view that cross-community mobility is mainly achieved through major interconnecting roads and highways financed by the federal government and the states. Moreover, the robustness of our key findings is again confirmed.

4 Conclusion

This study offers a comprehensive treatment of tax and public input competition, with a focus on the strategic interaction between governments in simultaneously choosing both policy instruments. Using a systems estimator for spatially interrelated equations, we find strong fiscal policy interdependencies among local jurisdictions in Germany, consistent with intense multi-dimensional fiscal competition.

In particular, the estimation results show a positive and significant direct interaction effect in the local business tax rate. Municipalities facing competition by low-tax jurisdictions

[19] The coefficients of the dummy variables are not significantly different from zero in all cases.
[20] At the same time, *WW population* is dropped from the list of IVs.

thus set lower taxes than municipalities with high-tax neighbors. Secondly, the local governments also adjust their level of spending on infrastructure towards the average level among neighboring jurisdictions. For our preferred specifications, the direct interaction effect in public input provision is statistically different from zero in 10 out of 14 cross-sections, and it tends to be larger than the direct interaction effect in taxes. Moreover, treating taxes and public inputs as alternative means to attract capital reveals that the municipalities react to competition in a rather flexible way: if neighbors lower their taxes, a municipality not only adjusts its own tax rate, but also increases its level of public input provision. All our findings pass a number of robustness tests.

As regards lines of further research, it would be interesting to compare our results to evidence regarding tax and expenditure competition from other countries. Depending on the institutional environment, taking into account different policy instruments could yield further insights into the rather complex process of fiscal policy decision making at the local level. For instance, with respect to the US, our findings suggest to treat local property taxes and local expenditures for public schools as well as public safety as jointly determined endogenous variables.

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Appendix

Total differentiation of the FOCs

The system of equations resulting from total differentiation of the first order conditions, invoking symmetry, reads

$$\begin{pmatrix} -\frac{g^2+3b}{4b^2} & \frac{g^2+2bkg+b}{4b^2} \\ \frac{g^2+2bkg+b}{4b^2} & -\frac{g^2+b^2k^2+b(4gk-1)}{4b^2} \end{pmatrix} \begin{pmatrix} dt_i \\ dg_i \end{pmatrix} = \begin{pmatrix} -\frac{g^2+b}{4b^2} & \frac{g^2+b}{4b^2} \\ \frac{g^2+2bkg-b}{4b^2} & \frac{-g^2-2bkg+b}{4b^2} \end{pmatrix} \begin{pmatrix} dt_j \\ dg_j \end{pmatrix}. \quad \text{(A.1)}$$

The symmetric equilibrium

Forming the first order conditions of (4) with respect to the tax rate, invoking symmetry in g, and proceeding analogously for public inputs yields

$$t^o = \frac{1}{2}(b+g^2)k, \qquad g^o = \frac{\sqrt{b^2k^4+4bk^2+8tk}-bk^2}{2k}. \quad \text{(A.2)}$$

Combining these two terms provides us with the Nash equilibrium values of

$$g^* = 2/k, \quad t^* = (bk^2+4)/(2k). \quad \text{(A.3)}$$

Sufficient conditions

The second derivatives of the welfare function with respect to own instruments are negative at the symmetric equilibrium. To see this, note that

$$\left.\frac{\partial^2 U_i}{\partial t_i \partial t_i}\right|_{g=g^*} = -\frac{3b+\frac{4}{k^2}}{4b^2} < 0 \quad \text{(A.4)}$$

and

$$\left.\frac{\partial^2 U_i}{\partial g_i \partial g_i}\right|_{g=g^*} = -\frac{b\,(bk^2+7)+\frac{4}{k^2}}{4b^2} < 0. \quad \text{(A.5)}$$

Note furthermore that the Hessian determinant evaluated at the Nash equilibrium is

$$|H|\,|_{g=g^*} = \frac{3k^2}{16b}. \tag{A.6}$$

Since this expression is positive, all sufficient conditions for a maximum are met.

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Statutory tax rate, τ	0.167	0.006	0.145	0.210
Spending for local roads per capita, s	130	92.8	0.815	1739
Marginal contribution rate	0.132	0.011	0.088	0.145
Unconditional transfers per capita	300	50.3	96.5	447
Fiscal capacity	0.714	0.272	0.276	6.35
Specific grants for local roads per capita	27.3	53.7	-76.5	1730
Other specific grants per capita	57.4	33.0	-3.92	282
Debt service per capita	10.6	35.2	-858	280
Population (1,000s)	7.81	10.7	0.101	112
Population density^a	0.300	0.302	0.017	2.50
Unemployment	0.062	0.013	0.025	0.127
% population $<$ 16 years	0.181	0.022	0.101	0.300
% population $>$ 65 years	0.155	0.027	0.071	0.347
% church members	0.891	0.053	0.706	1.04

^{a} (total population)/1000 per square kilometer; Nob=7700 (1100 municipalities from 1998 to 2004, independent cities excluded); Fiscal variables in Euros (prices of 2000). Source: Statistical Office of Baden-Wuerttemberg and own calculations.

Table 2: Tax and public input competition, system estimation using $W^{15\text{km}}_{\text{pop adj}}$

Cross section	1998		2000		2002		2004	
Dependent variable	τ	s	τ	s	τ	s	τ	s
Neighbors' tax rate	0.196***	-731**	0.207***	-1055**	0.278***	68.4	0.314***	60.0
	(0.049)	(350)	(0.049)	(427)	(0.055)	(559)	(0.058)	(480)
Neighbors' public input	-0.000	0.178*	-0.000	0.507***	0.000	0.237**	0.000	0.148
	(0.000)	(0.095)	(0.000)	(0.096)	(0.000)	(0.124)	(0.000)	(0.108)
Own tax rate	-	3190***	-	2396***	-	-2176**	-	-171
		(801)		(924)		(1057)		(772)
Own public input	0.00002***	-	0.00001***	-	0.000	-	-0.000	-
	(4D-06)		(4D-06)		(0.000)		(0.000)	
Marg. contr. rate	0.098***	-810***	0.091***	-523	0.065**	342	0.088***	-469*
	(0.029)	(302)	(0.026)	(318)	(0.030)	(426)	(0.030)	(276)
Uncond. transfers	-0.00002***	0.241***	-0.00002***	0.175**	-0.00002***	0.199**	-0.00004***	0.215***
	(7D-06)	(0.070)	(6D-06)	(0.075)	(7D-06)	(0.097)	(8D-06)	(0.075)
Fiscal capacity	-0.001	46.0***	-0.002*	87.7***	-0.002*	95.7***	-0.004***	52.8***
	(0.001)	(13.5)	(0.001)	(14.4)	(0.001)	(15.7)	(0.001)	(10.5)
Specific grants for local roads	-	0.995***	-	1.05***	-	1.30***	-	1.12***
		(0.044)		(0.051)		(0.047)		(0.037)
Other specific grants	0.00001*	-0.005	0.000	0.025	0.000	0.010	0.00002**	0.004
	(7D-06)	(0.071)	(0.000)	(0.073)	(0.000)	(0.078)	(7D-06)	(0.060)
Debt service	0.00005***	-0.112	0.00004***	-0.153**	0.00004***	-0.100	0.00002***	-0.116**
	(6D-06)	(0.072)	(6D-06)	(0.074)	(5D-06)	(0.078)	(5D-06)	(0.049)
Unemployment	-1.01***	194	-1.27***	265	-1.50***	-70.3	-1.23***	166
	(0.266)	(147)	(0.316)	(200)	(0.344)	(280)	(0.337)	(186)
Population (1,000s)	0.0002***	0.119	0.0002***	0.309	0.0002***	1.02**	0.0002***	0.625**
	(0.00002)	(0.272)	(0.00002)	(0.308)	(0.00002)	(0.418)	(0.00002)	(0.274)
Pop. density	0.000	-22.1**	0.001	-18.1*	0.000	-6.59	0.000	-7.80
	(0.000)	(9.25)	(0.001)	(10.1)	(0.000)	(11.6)	(0.000)	(8.17)
% pop. < 16 years	-0.005	-42.8	-0.004	25.6	-0.005	40.6	-0.015	212*
	(0.012)	(120)	(0.012)	(138)	(0.012)	(165)	(0.014)	(127)
% pop. > 65 years	-0.272**	-37.8	-0.187*	-112	-0.075	50.4	-0.089	140
	(0.111)	(98.3)	(0.111)	(109)	(0.111)	(124)	(0.118)	(88.2)
% church members	-0.132***	-	-0.114***	-	-0.115***	-	-0.109***	-
	(0.028)		(0.026)		(0.029)		(0.032)	
% church members× unemployment	1.07***	-	1.32***	-	1.57***	-	1.28***	-
	(0.295)		(0.352)		(0.383)		(0.374)	
% church members× % pop. > 65 years	0.308**	-	0.219*	-	0.108	-	0.107	-
	(0.123)		(0.123)		(0.123)		(0.130)	
F-tests of excluded IVs:								
τ_{-i}	110.3	215.7	105.4	199.6	73.6	133.9	94.1	115.0
s_{-i}	77.7	91.2	95.6	104.1	68.0	65.4	49.8	54.7
Own tax rate	-	5.0	-	5.8	-	6.9	-	5.4
Own public input	7.3	-	8.7	-	7.7	-	16.6	-

Sample includes all municipalities up to independent cities, Nob=1100. Spatial metric for constructing τ_{-i} and s_{-i} is $W^{15\text{km}}_{\text{pop adj}}$ (see notes in Table 5 for details). Standard errors in parentheses. F-tests of excluded IVs are from first-stage regressions of the 2SLS estimation in the third step of the estimation procedure. Significance levels: * 10%; ** 5%; *** 1%.

Table 3: Tax and public input competition, system estimation using $W^{10\,\text{nearest}}_{\text{pop adj}}$

Cross section	1998		2000		2002		2004	
Dependent variable	τ	s	τ	s	τ	s	τ	s
Neighbors' tax rate	0.158***	-678*	0.177***	-796*	0.212***	-604	0.213***	-1412***
	(0.041)	(398)	(0.040)	(481)	(0.040)	(503)	(0.044)	(373)
Neighbors' public input	-0.000	0.086	0.000	0.389***	0.00001*	0.134	-0.000	0.217***
	(0.000)	(0.072)	(0.000)	(0.075)	(7D-06)	(0.086)	(0.000)	(0.080)
Own tax rate	-	3039***	-	1276	-	-560	-	3283***
		(821)		(923)		(1066)		(800)
Own public input	0.00002***	-	0.00001*	-	0.000	-	0.000	-
	(4D-06)		(4D-06)		(0.000)		(0.000)	
Marg. contr. rate	0.089***	-774**	0.080***	-470	0.089***	120	0.098***	-763***
	(0.028)	(303)	(0.025)	(323)	(0.029)	(433)	(0.029)	(289)
Uncond. transfers	-0.00002***	0.225***	-0.00002***	0.170**	-0.00002***	0.265***	-0.00004***	0.304***
	(7D-06)	(0.071)	(6D-06)	(0.073)	(7D-06)	(0.09)	(8D-06)	(0.080)
Fiscal capacity	-0.001	45.7***	-0.003**	85.2***	-0.003**	100***	-0.004***	62.4***
	(0.001)	(13.4)	(0.001)	(14.2)	(0.001)	(15.5)	(0.001)	(10.6)
Specific grants for local roads	-	0.999***	-	1.05***	-	1.30***	-	1.10***
		(0.045)		(0.051)		(0.047)		(0.038)
Other specific grants	0.00001*	-0.004	0.00001*	0.064	0.00001*	0.003	0.00001*	-0.060
	(7D-06)	(0.071)	(6D-06)	(0.073)	(6D-06)	(0.078)	(7D-06)	(0.062)
Debt service	0.00004***	-0.096	0.00004***	-0.089	0.00003***	-0.153**	0.00002***	-0.194***
	(6D-06)	(0.072)	(6D-06)	(0.074)	(5D-06)	(0.077)	(5D-06)	(0.048)
Unemployment	-0.961***	189	-1.10***	187	-1.18***	93.7	-0.913***	425***
	(0.264)	(140)	(0.312)	(183)	(0.334)	(248)	(0.316)	(157)
Population (1,000s)	0.0002***	0.169	0.0002***	0.315	0.0002***	0.585	0.0002***	0.027
	(0.00002)	(0.267)	(0.00002)	(0.275)	(0.00002)	(0.3759)	(0.00002)	(0.272)
Pop. density	0.000	-26.8***	0.000	-22.8**	-0.000	-12.7	-0.000	-12.3
	(0.000)	(8.45)	(0.000)	(9.29)	(0.000)	(10.5)	(0.000)	(7.56)
% pop. <16 years	-0.003	-9.84	-0.000	51.8	-0.001	80.9	-0.007	241*
	(0.012)	(118)	(0.011)	(136)	(0.012)	(163)	(0.014)	(128)
% pop. >65 years	-0.248**	-7.39	-0.198*	-52.5	-0.094	77.1	-0.025	115
	(0.110)	(97.0)	(0.110)	(107)	(0.109)	(120)	(0.112)	(87.8)
% church members	-0.124***	-	-0.106***	-	-0.100***	-	-0.077**	-
	(0.027)		(0.026)		(0.028)		(0.030)	
% church members× unemployment	1.02***	-	1.16***	-	1.25***	-	0.965***	-
	(0.294)		(0.349)		(0.372)		(0.351)	
% church members× % pop. >65 years	0.280**	-	0.229*	-	0.126	-	0.037	-
	(0.122)		(0.122)		(0.121)		(0.124)	
F-tests of excluded IVs:								
τ_{-i}	77.0	76.1	76.3	63.2	69.0	63.4	88.6	93.7
s_{-i}	72.6	78.7	67.1	63.9	38.9	33.7	37.5	36.8
Own tax rate	-	4.9	-	5.8	-	5.7	-	4.1
Own public input	6.9	-	9.5	-	7.1	-	14.7	-

Sample includes all municipalities up to independent cities, Nob=1100. Spatial metric for constructing τ_{-i} and s_{-i} is $W^{10\,\text{nearest}}_{\text{pop adj}}$ (see notes in Table 5 for details). Standard errors in parentheses. F-tests of excluded IVs are from first-stage regressions of the 2SLS estimation in the third step of the estimation procedure. Significance levels: * 10%; ** 5%; *** 1%.

Table 4: Tax and public input competition, system estimation after between-transformation

Spatial metric	$W^{15\text{km}}_{\text{pop adj}}$		$W^{10\,\text{nearest}}_{\text{pop adj}}$	
Dependent variable	τ	s	τ	s
Neighbors' tax rate	0.263***	-387	0.211***	-505*
	(0.050)	(352)	(0.039)	(263)
Neighbors' public input	-0.000	0.328***	-0.000	0.215***
	(0.000)	(0.081)	(0.000)	(0.060)
Own tax rate	-	1658***	-	1591**
		(568)		(632)
Own public input	0.00002***	-	0.00001***	-
	(5D-06)		(5D-06)	
Marginal contribution rate	0.098***	-372	0.093**	-438
	(0.037)	(278)	(0.036)	(282)
Unconditional transfers	-0.00003***	0.261***	-0.00003***	0.259***
	(7D-06)	(0.054)	(7D-06)	(0.057)
Fiscal capacity	-0.002	87.7***	-0.003**	84.7***
	(0.002)	(11.7)	(0.001)	(11.8)
Specific grants for local roads	-	1.17***	-	1.17***
		(0.044)		(0.044)
Other specific grants	0.00001*	0.016	0.00001*	0.019
	(7D-06)	(0.047)	(6D-06)	(0.048)
Debt service	0.00004***	-0.166***	0.00004***	-0.153***
	(6D-06)	(0.050)	(6D-06)	(0.050)
Unemployment	-1.41***	179	-1.15***	232*
	(0.314)	(147)	(0.306)	(134)
Population (1,000s)	0.0002***	0.133	0.0002***	0.198
	(0.00002)	(0.203)	(0.00002)	(0.228)
Pop. density	0.000	-8.43	0.000	-15.8**
	(0.000)	(6.38)	(0.000)	(6.19)
% pop. $<$ 16 years	-0.010	90.6	-0.004	109
	(0.013)	(94.7)	(0.013)	(94.6)
% pop. $>$ 65 years	-0.141	-4.47	-0.135	25.8
	(0.108)	(70.3)	(0.107)	(69.6)
% church members	-0.127***	-	-0.109***	-
	(0.028)		(0.027)	
% church members$\times$unemployment	1.47***	-	1.21***	-
	(0.349)		(0.340)	
% church members$\times$% pop. $>$ 65 years	0.165	-	0.158	-
	(0.120)		(0.118)	
F-tests of excluded IVs:				
τ_{-i}	108.2	149.1	81.2	91.1
s_{-i}	124.0	123.8	83.5	79.9
Own tax rate	-	6.3	-	6.0
Own public input	15.9	-	16.5	-

Sample includes observations for all municipalities up to independent cities after between-transformation using years 1998, 2000, 2002, and 2004, Nob=1100. Standard errors in parentheses. F-tests of excluded IVs are from first-stage regressions of the 2SLS estimation in the third step of the estimation procedure. Significance levels: * 10%; ** 5%; *** 1%.

Table 5: Neighbors' tax rates and infrastructure spending for different spatial metrics, year 2000

	Mean		Std. Dev.		Min		Max	
Spatial metric	τ_{-i}	s_{-i}	τ_{-i}	s_{-i}	τ_{-i}	s_{-i}	τ_{-i}	s_{-i}
$W^{15\text{km}}_{\text{uniform}}$	0.167	140	0.0030	31.3	0.160	76.3	0.177	253
$W^{15\text{km}}_{\text{inverse}}$	0.167	139	0.0032	33.6	0.159	68.8	0.182	329
$W^{10\,\text{nearest}}_{\text{uniform}}$	0.167	139	0.0034	37.4	0.157	66.0	0.181	332
$W^{10\,\text{nearest}}_{\text{inverse}}$	0.167	139	0.0036	40.6	0.156	66.9	0.182	465
$W^{15\text{km}}_{\text{pop adj}}$	0.171	147	0.0068	28.9	0.160	83.7	0.198	281
$W^{10\,\text{nearest}}_{\text{pop adj}}$	0.169	146	0.0066	35.4	0.156	72.0	0.204	326

$W^{15\text{km}}_{\text{uniform}}$: Municipalities with distance <15km defined as neighbors, weights uniform. $W^{15\text{km}}_{\text{inverse}}$: Municipalities with distance <15km defined as neighbors, weights based on inverse distance. $W^{10\,\text{nearest}}_{\text{uniform}}$: 10 geographically closest municipalities defined as neighbors, weights uniform. $W^{10\,\text{nearest}}_{\text{inverse}}$: 10 geographically closest municipalities defined as neighbors, weights based on inverse distance. $W^{15\text{km}}_{\text{pop adj}}$: Municipalities with distance <15km defined as neighbors, weights based on relative population size. $W^{10\,\text{nearest}}_{\text{pop adj}}$: 10 geographically closest municipalities defined as neighbors, weights based on relative population size. All weight matrices are row-standardized.

Table 6: Selected parameter estimates for different spatial metrics

			$W^{15km}_{uniform}$				Year			$W^{15km}_{inverse}$			
Year	λ_τ	φ_τ	θ_τ	λ_s	φ_s	θ_s	Year	λ_τ	φ_τ	θ_τ	λ_s	φ_s	θ_s
1998	0.68***	-	0.00001***	-3643***	0.22**	5307***	1998	0.73***	-	0.00001***	-2497*	0.20**	3584***
1999	0.72***	-	-	-	0.32***	-	1999	0.73***	-	-	-	0.31***	-
2000	0.77***	-	0.00001*	-3225**	0.53***	4127***	2000	0.74***	-	-	-	0.53***	-
2001	0.72***	-	-	-3389*	0.38***	4194**	2001	0.75***	-	-	-	0.32***	3105*
2002	0.85***	-	-	-	0.38***	-	2002	0.87***	-	-	-	0.31***	-
2003	0.71***	0.00001**	-	-7091***	-	6658***	2003	0.77***	0.00001**	-	-10092***	-	9554***
2004	0.94***	-	-	-6560***	0.21**	7378***	2004	0.93***	-	-	-7963***	-	8549***

			$W^{10\,nearest}_{uniform}$							$W^{10\,nearest}_{inverse}$			
Year	λ_τ	φ_τ	θ_τ	λ_s	φ_s	θ_s	Year	λ_τ	φ_τ	θ_τ	λ_s	φ_s	θ_s
1998	0.57***	-	0.00001**	-	-	-	1998	0.55***	-	0.00001**	-	-	-
1999	0.54***	-	-	-	0.19***	-	1999	0.53***	-	-	-	0.17***	-
2000	0.54***	-	-	-	0.46***	-	2000	0.53***	-	-	-	0.42***	-
2001	0.56***	0.00001*	-	-	0.24***	-2505*	2001	0.57***	0.00001*	-	-	0.20***	-
2002	0.70***	0.00001**	-	-	0.22***	-	2002	0.71***	0.00001**	-	-	0.21***	-
2003	0.58***	0.00001**	0.00001*	-	-	-2765*	2003	0.60***	0.00001*	-	-	-	-
2004	0.77***	-	0.00001*	-6812***	0.18**	7703***	2004	0.78***	-	0.00001*	-8853***	0.13*	9613***

			$W^{15km}_{pop\,adj}$							$W^{10\,nearest}_{pop\,adj}$			
Year	λ_τ	φ_τ	θ_τ	λ_s	φ_s	θ_s	Year	λ_τ	φ_τ	θ_τ	λ_s	φ_s	θ_s
1998	0.19***	-	0.00001***	-731**	0.17*	3190***	1998	0.15***	-	0.00001***	-678*	-	3039***
1999	0.20***	-	0.00001***	-741*	0.25***	-	1999	0.14***	-	0.00001**	-	0.14*	-
2000	0.20***	-	0.00001***	-1005**	0.50***	2396***	2000	0.17***	-	0.00001*	-796*	0.38***	-
2001	0.22***	-	-	-862**	0.37***	1702*	2001	0.15***	-	-	-	0.25***	-
2002	0.27***	-	-	-	0.23*	-2176**	2002	0.21***	0.00001*	-	-	-	-
2003	0.22***	-	-	-	0.40***	-	2003	0.18***	-	-	-	-	-
2004	0.31***	-	-	-	-	-	2004	0.21***	-	-	-1412***	0.21***	3283***

For definitions of spatial metrics, see Table 5. Bars (-) indicate that the coefficient is not statistically different from zero at the 10% level of significance. * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Table 7: System estimation using $W^{15km}_{pop\,adj}$, no correction for spatial error correlation

Cross section	1998		2000		2002		2004	
Dependent variable	τ	s	τ	s	τ	s	τ	s
Neighbors' tax rate	0.099***	-596*	0.138***	-920**	0.144***	-211	0.174***	-466
	(0.031)	(332)	(0.033)	(422)	(0.034)	(490)	(0.038)	(358)
Neighbors' public input	-0.000001	0.139	0.000006	0.479***	0.000004	0.253**	0.00001	0.209**
	(9.8D-06)	(0.099)	(8.8D-06)	(0.099)	(9.0D-06)	(0.120)	(0.00001)	(0.100)
Own tax rate	-	3732***	-	2558***	-	-2561**	-	-369
		(857)		(979)		(1008)		(728)
Own public input	0.00001***	-	0.00001**	-	-0.0000007	-	-0.000001	-
	(4.0D-06)		(3.8D-06)		(2.6D-06)		(3.6D-06)	
Marg. contr. rate	0.111***	-946***	0.104***	-607*	0.124***	471	0.138***	-319
	(0.028)	(307)	(0.025)	(323)	(0.030)	(427)	(0.029)	(277)
Uncond. transfers	-0.00003***	0.298***	-0.00003***	0.213***	-0.00003***	0.162*	-0.00005***	0.148*
	(6.4D-06)	(0.072)	(5.9D-06)	(0.077)	(6.6D-06)	(0.097)	(7.3D-06)	(0.076)
Fiscal capacity	-0.001	46.8***	-0.002**	88.9***	-0.001	95.3***	-0.003***	50.9***
	(0.001)	(13.5)	(0.001)	(14.5)	(0.001)	(15.7)	(0.001)	(10.5)
Specific grants	-	1.00***	-	1.06***	-	1.30***	-	1.11***
for local roads		(0.045)		(0.051)		(0.047)		(0.037)
Other specific	0.00001**	-0.005	0.00001*	0.028	9.3D-06	0.024	0.00001	-0.004
grants	(6.9D-06)	(0.071)	(6.2D-06)	(0.073)	(5.7D-06)	(0.078)	(6.9D-06)	(0.061)
Debt service	0.00004***	-0.123*	0.00003***	-0.155**	0.00003***	-0.090	0.00002***	-0.119**
	(6.2D-06)	(0.074)	(5.6D-06)	(0.076)	(5.1D-06)	(0.077)	(5.2D-06)	(0.048)
Unemployment	-0.847***	178	-0.980***	255	-0.937***	-31.8	-0.574*	247
	(0.255)	(155)	(0.299)	(210)	(0.320)	(267)	(0.317)	(167)
Population	0.0002***	-0.297	0.0002***	0.052	0.0002***	1.12***	0.0002***	0.775***
(1,000s)	(0.00002)	(0.311)	(0.00002)	(0.347)	(0.00002)	(0.396)	(0.00002)	(0.276)
Pop. density	-0.0002	-18.1*	-0.00007	-14.5	-0.001	-8.01	-0.0009	-10.4
	(0.0009)	(9.50)	(0.0008)	(10.36)	(0.0008)	(11.5)	(0.0009)	(8.061)
% pop. <16 years	0.0007	-64.0	-0.0008	13.1	-0.002	37.3	-0.012	205
	(0.011)	(121)	(0.011)	(139)	(0.012)	(164)	(0.014)	(126)
% pop. >65 years	-0.256**	-34.4	-0.212**	-112	-0.099	57.4	-0.130	135
	(0.109)	(99.1)	(0.109)	(110)	(0.108)	(123)	(0.115)	(87.3)
% church members	-0.120***	-	-0.103***	-	-0.087***	-	-0.072**	-
	(0.027)		(0.025)		(0.027)		(0.030)	
% church members$\times$	0.912***	-	1.031***	-	0.990***	-	0.597*	-
unemployment	(0.284)		(0.334)		(0.358)		(0.352)	
% church members$\times$	0.293**	-	0.247**	-	0.133	-	0.153	-
% pop. >65 years	(0.122)		(0.121)		(0.120)		(0.128)	

Sample includes all municipalities up to independent cities, Nob=1100. Spatial metric for constructing τ_{-i} and s_{-i} is $W^{15km}_{pop\,adj}$ (see notes in Table 5 for details). Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 8: System estimation using $W^{15\text{km}}_{\text{pop adj}}$, additional regressors: border dummies and neighbors' population

Cross section	2002		2004		2002		2004	
Dependent variable	τ	s	τ	s	τ	s	τ	s
Neighbors' tax rate	0.273***	-132	0.309***	93.5	0.229***	273	0.362***	-410
	(0.057)	(615)	(0.002)	(483)	(0.072)	(1019)	(0.078)	(726)
Neighbors' public input	0.000	0.216**	0.000	0.131	0.000	0.245**	0.00002**	0.126
	(0.00001)	(0.109)	(0.000)	(0.109)	(0.000)	(0.123)	(0.00001)	(0.111)
Own tax rate	-	-1443	-	-332	-	-2988***	-	-303
		(1072)		(765)		(1091)		(776)
Own public input	0.000	-	-0.000	-	-0.000	-	-0.000	-
	(0.000)		(0.000)		(0.000)		(0.000)	
Neighbors' population	-	-	-	-	0.000	0.040	-0.000	0.096
					(0.000)	(0.104)	(0.000)	(0.076)

Sample includes all municipalities up to independent cities, Nob=1100. Spatial metric is $W^{15\text{km}}_{\text{pop adj}}$ (see notes in Table 5 for details). All estimations include additional dummy variables for municipalities sharing a border with France, Switzerland, Bavaria, Hesse, and Rhineland-Palatinate, a dummy for municipalities located at the shore of Lake Constance, and a dummy for municipalities sharing a border with an independent city within Baden-Wuerttemberg. Estimations showing a coefficient for neighbors' population use this variable as an ordinary explanatory variable (in all other estimations, neighbors' population is used as an IV). Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.