Public input and capital tax competition in local jurisdictions in Brazil

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Resumo: Literatura anterior aborda o papel das alíquotas de imposto como variável chave para discutir competição fiscal. Este artigo discute como os governos locais consideram conjuntamente o nível de provisionamento público em infraestrutura e as alíquotas de imposto sobre serviços como os instrumentos para competir por capital. Com dados para aproximadamente 5000 municípios no Brasil para um período de sete anos, os resultados sugerem evidência robusta que a competição fiscal é influenciada tanto pelos gastos públicos em insumos de produção como pela escolha da alíquota do imposto. Com efeito, os resultados indicam que os governos locais reagem a cortes de alíquotas das localidades vizinhas de três formas possíveis: também cortando suas alíquotas de imposto, aumentando seus gastos em infraestrutura, ou combinando ambas as estratégias.

Palavras-chave: competição fiscal, transbordamento espacial, função de reação fiscal, gasto público local.

Abstract: Previous works emphasize the role of tax rates as the key feature of tax competition. This paper brings into attention how local jurisdictions jointly consider the level of public provision in infrastructure and the business tax rates as fiscal instruments to compete for capital. Using data for approximately 5,000 municipalities in Brazil over a seven-year period, we find strong evidence that tax competition is driven by both public input spending and tax rate choices. Our main findings indicate that local governments react to tax rate cuts from neighboring jurisdictions in three possible ways: also cutting their tax rates, increasing their public infrastructure spending, or combining both strategies.

Keywords: fiscal competition, spatial spillover, tax reaction function, local public spending.

JEL codes: H72, R12, R51.

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1. Introduction

There is a broad tax competition literature that approaches how local jurisdictions compete for business or corporate tax to attract mobile capital. This early literature emphasizes the role of government choices on tax rates as the key feature of tax competition. Most previous empirical work suggests that the tax differential across localities causes higher competition for capital and leads to lower business tax rates (see Devereux et al., 2008, for a comprehensive overview of the literature).

Differently, some recent literature has noted that local governments can explore several fiscal instruments to influence capital allocation. Specifically, some authors have emphasized that local governments affect capital allocation by strategically choosing the business tax rate and the level of public input provision. Hindricks et al. (2008), for example, develop a two-stage model in which tax rate choices are considered strategic complements of local public provision. In this setting, a local jurisdiction anticipates tax competition, and in equilibrium, localities voluntarily underinvest in public provision in the first stage to smooth tax rate competition in the next stage. This model contrasts with Keen and Marchand's (1997) simultaneous game framework in which local governments provide more investments to the more mobile agents (e.g., infrastructure for capital) in opposition to lower public spending for less mobile agents (e.g., local welfare services for residents).

Recently, Hauptmeier et al. (2012) extend the standard model of tax competition by including public input investment as another relevant fiscal instrument used by a local jurisdiction to attract capital. In their analysis, governments set both policy instruments strategically, such that the business tax rate is a function of the government's own level of input in public investment and vice versa.[1] The novelty in Hauptmeier et al.'s (2012) model is that now public infrastructure and business tax rate are jointly determined simultaneous variables. Empirically, this approach is very interesting since it also allows local governments to strategically interact with neighboring jurisdictions' choices over tax rate and public inputs.

In this paper, we apply the analytical framework developed by Hauptmeier et al. (2012) to investigate how local jurisdictions in Brazil jointly consider the level of public provision in infrastructure and the business tax rates as fiscal instruments to compete for capital. Using data for approximately 5,000 municipalities over a seven-year period, we find strong evidence that tax competition is driven by both public input spending and tax rate choices. The results suggest that municipalities mimic each other in business tax rate as well as in infrastructure spending. More interestingly, the results indicate that communities respond to neighboring tax rate cuts by increasing their own public infrastructure spending, or concurrently, municipalities respond to an increase in neighboring public input spending by cutting their own tax rates.

Considering that not only the dependent variable (business tax rate) but also some explanatory variables (public input expenditure) from neighboring observations can be spatially lagged, this paper tackles several econometric issues. Different from Hauptmeier et al. (2012), we control for spatial and time fixed effects and estimate a community's tax reaction function using a spatial Durbin model (SDM). This method allows us to control for community-specific

[1] This is true assuming that public consumption is also endogenous. See Hauptmeier et al. (2012) pp. 408 for a discussion. More recently, Han et al. (2017) argue that tax coordination does not eliminate infrastructure competition among local jurisdictions. The authors suggest that tax competition is "carried over" to infrastructure spending choices, which is in fact the only adjustment variable.

non-observable and invariant attributes, such as regional policies and institutional aspects, that can produce biased estimations in a cross-sectional approach (Elhorst, 2017). Additionally, we lag the dependent variable in a dynamic approach. Since previous literature on corporate tax suggests that tax rate does not change frequently, a dynamic model is more accurate to address high persistence over time (Redoano, 2007). Finally, we compare results from the dynamic panel data to the cross-sectional approach, and we provide evidence that our main findings are robust and conservative compared to Hauptmeier et al.'s (2012) findings.

To discuss capital competition in Brazil, this paper proceeds as follows. Section 2 briefly discusses some hypotheses regarding spatial interaction of public input provision and business tax rate based on previous literature. Section 3 depicts the empirical approach. Section 4 describes the Brazilian institutional framework. The results are shown in Section 5. Finally, Section 6 presents the conclusion.

2. Expected effects of local business tax and public input competition

Early contributions to the business tax competition literature consider tax rate choice the main fiscal tool used by communities to compete for capital. Differently, based on the works of Wildasin (1991) and Hindricks et al. (2008), Hauptmeier et al. (2012) suggest that local governments compete for mobile capital using a mix of fiscal instruments.

Assuming a federation with two homogeneous jurisdictions, Hauptmeier et al. (2012, pp. 408-409) build a model in which capital is perfectly mobile and fixed in supply and in which the public input improves the marginal productivity of the private factor of production. In this framework, the objective function of local governments is to maximize welfare, which depends on total output, capital income, tax revenue and public input provision. In equilibrium, capital net return is equalized across communities.

One interesting assumption of the model is that public input funding is not based on only capital taxes. Thus, governments can choose more than one policy instrument to compete for capital. In this context, the local decision on tax rate depends not only on the average tax rate but also on the public input spending of neighboring jurisdictions. Alternatively, local public input spending reacts concurrently to the average tax rate and the infrastructure spending of neighboring jurisdictions. The parameters of interest are the slope of the tax rate and public input reaction functions, as in the general functions $\tau_i = f_\tau(\tau_j, input_j)$ and $input_i = f_{input}(\tau_j, input_j)$.

Thus, the model of Hauptmeier at al. (2012) provides several insights on the strategic interactions of local communities to attract capital. The main implications are summarized in this section in four main hypotheses. Those hypotheses constitute the analytical foundation of our empirical analysis.

Hypothesis 1: If a neighboring community cuts its tax rate, the optimal reaction is to decrease local taxes as well.

The positive association between local tax rate and neighboring average tax rate has been noted by several authors in tax competition literature (See Brueckner, 2003 for a comprehensive discussion). In fact, this is the baseline hypothesis of tax mimicking literature.

Hypothesis 2: If the neighboring community increases its supply of public inputs, a region will respond by spending more in inputs.

Previous literature has approached public input competition separately from tax rate choice. Keen and Marchand (1997), for example, discuss how communities tend to privilege productivity-enhancing public spending compared to public goods associated with the welfare of their citizens. Bucovetsky (2005) suggests that public input competition is different from other fiscal variables because of agglomeration effects caused by skilled works and infrastructure quality. Differently, Hauptmeier at al. (2012) establish an interaction between neighboring input spending and local spending within a community. A positive slope is expected in the public input reaction function in a similar fashion to the tax mimicking literature.

Hypothesis 3: If the neighboring community increases (decreases) its tax rate, a region will respond by providing less (more) public input.

Hypothesis 4: If the opponent provides more (less) public inputs, it is optimal to cut (increase) the tax rate.

Hypotheses 3 and 4 are the main insights in Hauptmeier et al.'s (2012) model. The pioneering authors describe how local governments enact strategic behavior by simultaneously choosing tax rate and public input spending according to the decisions of neighboring jurisdictions concerning both instruments. In this framework, local jurisdictions compete for capital using tax and non-tax instruments. According to hypotheses 3 and 4, a negative association is expected between the tax rate (or public input) behavior of a community and that of a neighboring community. Thus, to compensate for a neighbor's tax rate cut, a community responds by increasing public input, or to counterbalance an increase in a neighbor's public input, the local community cuts its own tax rate. In the next sections, we detail the empirical approach to test these hypotheses and investigate the Brazilian institutional framework.

3. Empirical approach

In Hauptmeier et al. (2012), communities compete for capital considering tax rate and public input spending simultaneously. The strategic interactions between these fiscal instruments can be represented by two linearized reaction functions in a simultaneous system of equations as depicted below:

$$\tau_i = \gamma_\tau Input_i + \alpha_\tau \sum w_i \tau_j + \beta_\tau \sum w_i Input_j + \varphi_\tau X_i + u_i \quad (1.1)$$

$$Input_i = \gamma_I \tau_i + \alpha_I \sum w_i \tau_j + \beta_I \sum w_i Input_j + \varphi_I X_i + \vartheta_i \quad (1.2)$$

where τ and Input indicate, respectively, the business tax rate and the local public input spending from community i in the tax reaction function (1.1) and in the input reaction function (1.2). The subscript j indicates the community's neighboring jurisdictions. The parameters $\Sigma w_{ij}\tau_{jt}$ and $\Sigma w_{ij} Input_{jt}$ denote, respectively, the average neighboring tax rate and the average neighboring input spending excluding the local community and weighted by predetermined spatial matrix W. The term X represents the vector of control variables (including a constant) in both equations. Finally, μ and ϑ denote the residuals in the tax rate and input reaction function, respectively.[2]

The problem with the system of equations approach described in (1.1) and (1.2) is that to the best of our knowledge, as discussed by Klemm and Van Parys (2012, footnote 14 pp. 400), the only econometric approach available for spatial simultaneous relations is the cross-sectional estimator, developed by Kelejian and Prucha (2004) and used in Hauptmeier et al. (2012)

Another possible strategy considers a spatial panel model in which each reaction function (1.1 and 1.2) can be estimated separately. Thus, to investigate both the interaction effects of the neighboring jurisdictions on the tax rate and on the public input spending of jurisdiction *i*; it is possible to use the Spatial Durbin Model (SDM). In terms of the tax reaction function (1.1), we have the SDM specification (2.1):

$$\tau_{it} = \lambda \sum w_{it}\tau_{jt} + \beta Input_{it} + \theta \sum w_{it} Input_{jt} + \varphi X_{it} + \sigma_t + c_i + \varepsilon_{it} \qquad (2.1)$$

where the term *t* indicates the time period. The terms $\sum w_{it}\tau_{jt}$ (and $\sum w_{it} Input_{jt}$) capture the interaction effect of business tax rate (input spending) in jurisdiction i with respect neighboring jurisdictions j and own's jurisdiction (i) reaction to neighboring (j). Both terms are weighted by the spatial matrix W. Additionally, X_{it} indicates a vector of exogenous covariates, c_i indicates a spatial fixed effect and $\sigma_t$indicates a time fixed effect.

Similarly, function 2.2 brings the public input spending reaction function as:

$$Input_{it} = \lambda \sum w_{it} Input_{jt} + \beta\tau_{jt} + \theta \sum w_{it}\tau_{jt} + \varphi X_{it} + \sigma_t + c_i + \varepsilon_{it} \qquad (2.2)$$

As discussed in Elhorst (2014a), unlike non-spatial models, the coefficient estimate in the SDM is not exactly the marginal effects of a change in the explanatory variables. In terms of function (3.1), a change in a specific jurisdiction *i* associated with infrastructure spending affects the own community tax rate (direct effect) and can affect the tax rate in all other communities indirectly (spillover effect). The novelty here is that, compared to Hauptmeier et al. (2012), the direct effect includes feedback effects that arise as a result of impacts passing through neighboring units (units j) and back to the unit that the change originated from (unit i). These feedback effects are partly due to the coefficient of the spatially lagged dependent variable ($W_{it}y_{jt}$) and partly due to the coefficient of the spatially lagged value of the explanatory variable itself ($W_{it}X_{jt}$) (Elhorst, 2014a; LeSage and Pace, 2009). Thus, to obtain the marginal effect on the dependent variable, one should take the derivatives from the reduced form of function (3.1).[3]

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[2] We note that the simultaneous approach allows for cross-sectional interdependence in the residuals as described in R.1 and R.2:

$$u_i = \rho_u \sum_j w_{ij} u_j + \epsilon_i \qquad (R.1)$$

$$\vartheta_i = \rho_v \sum_j w_{ij} v_j + \varepsilon_i \qquad (R.2)$$

where ρ accounts for spatial correlation in each function and ε and ϵ are assumed to be error terms that are independently and identically distributed.

[3] In fact, someone should consider the matrix of partial derivatives of the expectation of the dependent variable, with respect to the k_{th} explanatory variable in unit 1 up to unit N. The diagonal and off-diagonal elements of this relation indicates the direct and spillover effects, respectively. In the SDM it follows $(I - \rho W)^{-1}[\beta_k + W\theta_k]$. Differently, the Ordinary Least Square (OLS) model does not tackle the spillover effect and the direct effect is

We also estimate fiscal a dynamic version of functions (3.1) and (3.2) including a lagged dependent variable (the term it-1) in the model, as also we run a standard spatial autoregressive (SAR) model, without the spatial lag of the explanatory variable. As the SAR model does not use the additional matrix W in the explanatory variable, the spillover effect is obtained from a common multiplier over the explanatory variables (LeSage and Pace, 2009). We estimate both SDM and SAR models using a maximum likelihood estimator (MLE). We discuss the robustness of our findings in Section 5.1 (Results). Next, subsection 3.1 describes the spatial weight matrix used in functions 1 to 3.

3.1 Spatial Matrix

To capture the effects of community j on the reaction function of community i, we consider a standard contiguity matrix (W_{ij}) in which the bordering communities are considered neighbors. The weight W_{ij} is uniformly distributed according to the number of total neighboring communities and standardized to create rows summing to one for each community i ($\sum_{i \neq j} W_{ij} = 1$) as depicted in function (4):

$$w_{ij} = \frac{V_{ij}}{\sum_{k \neq i} V_{ik}} \quad (4)$$

where V_{ij} indicates the j neighbor of community i and assumes the value of one if the communities are contiguous and zero otherwise. The contiguity matrix should capture spatial interdependence and potential spillover effect from tax rate choices and public input spending across the local community and its neighbors. In the next section, we describe the institutional framework and how we collect data from Brazilian municipalities.

4. Brazil Institutional Framework and Data

Brazil is a federation composed of three different levels of government, namely, federal, state and municipality. Municipalities are the lowest tier of government. There were 5565 municipalities in 26 states in the year 2015. Although municipalities are autonomous in political and administrative terms, they have weak fiscal autonomy. In fact, there is a great fiscal imbalance between the upper and lower tiers of government. Meanwhile, the federal budget accounts for approximately two-thirds of total public revenues, but it makes up less than half of total expenses on public services, such as health and education.

Local government depends strongly on non-conditional grants from the central government. Differently from most federations, there is not an equalization grant system that produces incentive effects in the tax base; e.g., an increase in communities' efforts to collect taxes tends to negatively affect how much they obtain from equalization grants. Non-conditional grant distribution across municipalities essentially follows demographic criteria. In approximately 97% of the municipalities, grant allocation depends on 17 populational cutoffs in which less populous communities obtain more resources per capita than more populous municipalities.

β_k. In the SAR model it follows the diagonal and off-diagonal elements of $(I - \rho W)^{-1}\beta_k$. See Halleck Vega and Elhorst (2015) pp. 345, for a discussion.

On average, resources from states and central government represent approximately two-thirds of municipalities' total revenues. [4]

Regarding local expenditures, budget allocation must respect legal rules on minimal spending (bottom limits). According to Brazilian legislation, municipalities should spend at least 25% of their budget (total revenues) on elementary and secondary educational services and at least 15% on health services.[5] Additionally, local public provision includes the maintenance of recreational areas, such as parks and squares, and public infrastructure investment, such as garbage collection, public transportation (excluding subway), street repair and lighting, as well as pavement, bridge and tunnel maintenance. According to Afonso et al. (2005, pp. 29), the local government is responsible for approximately 85% and 25% of total public spending in urbanism and transportation, respectively. Thus, we consider as public infrastructure spending per capita the total community expenditure in urbanism, transportation and energy. Those expenses should capture jurisdictions' investments in street and road maintenance, street lighting and public transportation.

With respect to local taxes, municipalities collect two main taxes: business tax and property tax. Municipality taxes represent on average only 20% of their total revenues. The local business tax is applied by local services that do not trade goods directly, such as restaurants, cafeterias, hairdressers, vehicle repair, travel agencies, private health care, financial and education services. Retailers such as gas stations and market chains collect VAT but not the business tax. The business statutory tax rate ranges from 2% to 5% and is set by federal law. Tax rates vary by economic sector.[6]

It is noteworthy that, different from most countries in Europe and North America, property tax in Brazil is not a very important source of revenues for municipalities. General statutory tax rate is very low (less than 2%), and there are many households that are tax exempt. According to Carvalho (2009), from 2002 to 2005, on average, only 30% of households paid property tax, and property tax accounts for less than 0.5% of gross domestic product (GDP). In our sample, revenues from business tax rate are two times larger than revenues from property tax.

Therefore, it seems appropriate to consider that the business tax constitutes the main tax that municipalities can choose to attract capital. Regarding public infrastructure, how public investment can be capital enhancing to small- and mid-sized firms is less straightforward. It is expected that local infrastructure is positively associated with commuting and that the demand of local services should benefit from better public input. Additionally, public urban structure can impact the costs of private services. Nevertheless, how capital location responds to public infrastructure spending in urbanization, such as street maintenance, sidewalks, lighting and public transportation, is an empirical question, as is Hauptmeier et al.'s (2012) analysis on German firms.

A problem with business tax (and for property tax in Brazil) is that there is not a systematic compilation of the tax rate across the 5,655 municipalities and by economic sector. To circumvent this problem, we follow Jacobs et al. (2010) and Hayashi and Boadway (2001), and we calculate the average effective tax rate (AETR) of the business tax. AETR is usually defined as the ratio of tax revenues to a firm's total revenues or profits. We calculate the business AETR

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[4] In Brazil, VAT and vehicle tax are states' duty. States return approximately 25% of total revenues to the communities where the taxes were collected. Additionally, there are categorical grants for education and health. For a comprehensive description in English of grants in Brazil, see Shah (1991).

[5] It follows, respectively, Law nº 9424 de 1996 (Lei das Diretrizes e Bases da Educação Nacional – LDB) and Emenda Constitucional 29/2000.

[6] It follows Lei Complementar 116/2003 and Emenda Constitucional 37/2002.

as the ratio of the total municipality revenue from business tax to the total direct value-added contribution of the services sector to municipality gross domestic product. We note that information on firms' revenues is available for only the state level in the Brazilian Bureau of Economics and Statistics (IBGE) dataset. Moreover, considering data on states, the direct value-added contribution presents a correlation above 80% with information on firms' revenues in the services sector. Thus, we assume that this variable is representative of firms' revenue.

There are some advantages in using AETR instead of statutory tax rates in our context. First, AETR changes more frequently and is less rigid across time than statutory tax rates. Second, AETR should present more tax salience than statutory tax rates (e.g., firms should be more concerned with the average tax burden between communities than with statutory rates). Third, AETR should capture the effect of the business tax rate over the fiscal base. Finally, data for calculating AETR are available on the IBGE.

Following previous literature on tax competition, we control for municipalities' additional sources of revenues. First, we collect data on unconditional grants that communities obtain from the central government. Additionally, we include municipalities' annual current account balance per capita. We expect that higher public debt should negatively impact investment spending, such as infrastructure. Finally, we also control for some demographic characteristics such as municipalities' share of young and elderly, population size (level and squared term) density and whether the municipality is inside a metropolitan area or not.

We obtain data from two main sources. Data on the public spending and revenue of municipalities are available at the Finanças do Brasil (FINBRA) dataset provided by the National Secretary of the Treasury. Information on number of firms in the services sector by municipality is available at the Cadastro Central de Empresas (CEMPRE) provided by the Brazilian Bureau of Economics and Statistics (IBGE). We also collect additional information on economic and demographic variables from the IBGE. All monetary variables are in Brazilian Reais (R$) and are deflated to their real values in 2010 using a national consumer index. Data are not available for all 5,565 Brazilian municipalities in the same number of time periods. For this reason, we build a balanced panel with information from 2006 to 2012 considering 5004 communities.

TABLE 1
Descriptive Statistics

Variables	Average	Std. Dev.	Min.	Max.
Business Tax Rate (AETR)	0.016	0.041	0.00	2.65
Public Input spending per capita	243.4	240.4	0.00	13,224.9
Unconditional grants	874.0	786.5	-87.5	86,497.8
Current account balance (per capita)	35.6	421.9	-37,313.1	38,071.8
Share of young (<15 years)	0.27	0.06	0.03	0.86
Share of elderly (>60 years)	0.12	0.03	0.01	0.28
Pop. Density	114.27	598.52	0.08	13,347
Population	35,469.4	209,504.5	804.0	11,400,000
Metropolitan Area (=1)	0.14	0.35	0.00	1.00
Firms Density	3.19	20.31	0.00	878.42
Number of business firms (tax base)	996.49	8,906.32	2.00	599,434.00

Notes: number of observations is 35,028 (5,004 municipalities from 2006 to 2012); all monetary values are in year 2010 Brazilian Reais (R$).

Table 1 presents the descriptive statistics from the dependent and independent variables in our sample. On average, each municipality has 920 firms, and there are approximately 10 workers per firm. These results reinforce the idea that most of the business tax is levied on small- and medium-sized firms. Regarding demographic variables, municipalities present on average 34 thousand inhabitants, and of the total population, approximately 27% are under fifteen years old, and 11% are above sixty years old. It is important to note that the share of infrastructure spending is quite low compared to municipalities' total spending. On average, infrastructure spending per capita accounts for only 14% of the total local budget, but it represents 81% of public investment spending. Next, we present the results for the methodological approach for tax and public input interaction across communities in Brazil.

5. Spatial Panel Data Results

Table 2 shows the main results regarding Brazilian municipalities' reaction function on neighboring tax rate choice. Following function (3.1), columns I and II present the ML estimator results for, respectively, a static and a dynamic Spatial Durbin Model (SDM). The main difference between the two specifications is that the latter controls for higher persistence in the dependent variable, as also allows to estimate short-term effects of the lagged explanatory variable (public input spending). As a robustness check, column III brings the results of the SDM specification with two additional covariates: unconditional grants, and per capita public debt. Column IV brings the results for a dynamic spatial autoregressive (SAR) model without the spatial lagged explanatory variable in the public input variable.

As discussed in Section 3, the coefficients estimated in the SDM are not exactly the marginal effects of a change in the explanatory variables. We focus our discussion on the direct and indirect effect for our variables of interest. In addition to control for spatial and time fixed effects, we add demographic characteristics as size of population (also squared population), population density, share of young and share of elderly. All results bring the estimation outcomes for a row-standardized contiguity matrix.

We begin our analysis looking at the coefficients of the tax rate and public input spending variables. First, note that the estimated coefficients for neighboring tax rates are positive and significant for all specifications, ranging from 0.51 to 0.64. In fact, an estimated coefficient of 0.56 (column II) suggests that an average tax increase of one percentage point among neighboring municipalities is associated with a 0.56 percentage point increase in the local community tax rate. This result indicates a spatial spillover effect on communities' business tax rate, as discussed in hypothesis 1 from Section 2. Interestingly, the estimated coefficient for the spillover effect on tax rate is similar but a bit larger in the SDM specifications compared to the SAR model.

Additionally, we note that the coefficient on the lagged tax rate variable is positive and significant for all dynamic specifications (Columns II to IV). This finding suggests that business tax rate presents persistence over time or, similarly, that communities with a high tax rate in period t tend to set a high tax rate also in the next period.

TABLE 2

Spatial Tax Competition - Panel Data Estimation

Dependent variable: Business Tax Rate (AETR)	I	II	III	IV
Model	**SDM**	**SDM**	**SDM**	**SAR**
Lagged tax rate (l.AETR)		0.273***	0.294***	0.273***
		(5.30)	(7.44)	(5.26)
Neighbors' tax rate (AETR) - W	0.536***	0.560***	0.641***	0.513***
	(9.44)	(9.95)	(11.12)	(7.98)
Own public input per capita (in 100 Reais)	0.0067**	0.0074**	0.0027***	0.0072**
	(2.10)	(2.150)	(4.72)	(2.12)
Neighbors' public input per capita (in 100 Reais)	-0.0083**	-0.0102**	-0.0080***	
	(-2.04)	(-2.26)	(-6.24)	
Short Run				
Direct effect - Public input pc (in 100 Reais)		0.0072**	0.0026***	0.0071**
		(2.07)	(4.74)	(2.05)
Indirect effect - Public input pc (in 100 Reais)		-0.0017**	-0.0019***	0.0010**
		(-2.20)	(-5.15)	(2.21)
Total effect - Public input pc (in 100 Reais)		0.0054**	0.00075	0.0081**
		(1.97)	(1.26)	(2.08)
Long Run				
Direct effect - Public input pc (in 100 Reais)	0.0068**	0.0099**	0.0037***	0.0097**
	(2.08)	(2.07)	(4.70)	(2.05)
Indirect effect - Public input pc (in 100 Reais)	-0.0014*	-0.0019**	-0.0025***	0.0020**
	(-1.83)	(-2.11)	(-4.63)	(2.22)
Total effect - Public input pc (in 100 Reais)	0.0054**	0.0080**	0.0011	0.0117**
	(2.07)	(1.98)	(1.22)	(2.09)
Demographic covariates	yes	yes	yes	yes
Economic covariates	no	no	yes	no
R-squared	0.0416	0.1226	0.2030	0.1056
Log Likelihood	61,417	61,567	64,255	61,536

*Notes: Number of observations is 35,028. In parentheses are robust t-statistics. All regressions include municipality and time fixed effects.We use the variation of 500 simulated parameter combinations drawn from the multivariate normal distribution implied by the ML estimates. *** Significant at 1%, ** significant at 5%, * significant at 10%.*

Regarding direct impacts, observe that in Column II (Dynamic SDM), the long run coefficient estimate of 0.0074 on public input spending per capita (per $ 100 Reais) is different from the direct effect estimate of 0.0099. Considering this difference, that suggests that local tax rate would increase by approximately 0.025 percentage points due (positive) feedback effects, which amounts to approximately 25% of the direct effect. LeSage and Pace (2009) notes that these occur since the municipality is considered a neighbor to its neighbor, thus the effects passing through neighboring jurisdictions will generate an influence (feedback effect) on the jurisdiction itself. Importantly, these feedbacks effects originated from the own tax rate are not so small (in our sample, the average tax rate is approximately 1.6%) and suggest a significant impact passing through to neighboring municipalities and back to the own jurisdiction. In the SAR model (Column IV), the feedback effect presents a similar magnitude of approximately 26% of the direct effect. Differently, in the static SDM (Colum I) the difference between the direct effect estimate and the coefficient estimate is very small, approximately only 0.0001 (we come back to this finding below).

However, whereas results in Table 2 suggest that a change in infrastructure spending in a municipality presents a positive effect in the business tax rate in the municipality itself, we also find that the neighboring public input spending presents a negative spillover (indirect) effect in municipality's tax rate in both SDM specifications. In particular, those results indicate that an increase of 1000 Reais per capita in the neighboring jurisdiction infrastructure causes a 0.02 percentage points decrease on business tax rate of municipality i. Again, the spillover effect is larger in the dynamic specification.

Thus, in Column II, results for the total effect (summing up direct and indirect effect) indicate that for each additional investment of 1000 Reais per capita in local public input, local tax rate would increase (in the long run) by approximately 0.08 percentage points. Results suggests that indirect effect reduces the direct impact around 20%. Moreover, the spillover effect is around four times smaller than the direct effect. According to (Elhorst, 2014b), it is expected that the impact of a change will probably be larger in the jurisdiction that provoked the change.

Regarding short term, our estimations for direct effects of infrastructure spending are smaller than long term counterparts. It seems reasonable to assume that that takes time to the municipality's infrastructure spending fully influence own tax rate. Surprisingly, the short-term spillover effect is similar to the long term estimated effect (-0.0017 and -0.0019, respectively). These results suggest that while municipality takes longer to increase its own tax rate, own jurisdictions reacts faster to an increase in neighboring infrastructure spending by cutting their tax rate. Additionally, the long-term effects (both direct and indirect) are greater in the dynamic SDM compared to the static model. This result points out that the static model underestimates long term effects, and the potential bias is more severe for the direct effect than for the spillover effect for this case.

On the other hand, it is noteworthy to point out that in the SAR model, although the estimated direct effect is very close to the SDM model, the indirect effect is not. In fact, results in Column IV reveals a positive and significant spillover effect for an increase in neighboring public input spending on own tax rate. This result contradicts hypothesis 4 from our analytical framework as also the SDM results. In fact, it seems that the SAR model fails to proper estimate the spillover effect because it does not consider the spatial lagged term in its functional form. Compared to the SDM model, the main drawback of the SAR specification is that it does not consider the heterogeneous impact from a change in the explanatory variable (public input) in total effects (see discussion in Section 3).

Finally, as in previous works on tax competition, Column III brings the results for the SDM regression with two additional covariates: grants and current account balance. Compared to our baseline model, results indicate a significant decrease in the direct long run effect estimate (from 0.099 to 0.035), although there is still a positive feedback effect. Interestingly, results in Column III suggest that the spill-over effect represents around 70% of the direct effect (versus 20% in Column II). It is important to note that in all three SDM specifications the spillover effect is solid: it presents the expected sign, is significant and similar. Moreover, the inclusion of covariates associated to jurisdictions' revenues increases the explanatory power of the model (R squared increases from 0.12 to 0.20).

Elhorst (2014a) notes that, in general, several researches fail to reject the null hypothesis that the coefficients of the spatially lagged explanatory variable are not significant, and concurrently, do not obtain a significant estimate of spillover effect, because they do not observe a large number of cases over time or have only cross-sectional data. However, one contribution of this paper is the number of units in our sample is quite large and leads us to estimate both direct and spillover effect in the dynamic SDM significantly at 5% level.

Overall, results in the SDM (Columns I to III) specifications suggest two forces at work that affect jurisdictions' tax rate choice. First, there is a positive effect of infrastructure spending on own tax rate that is exacerbated by feedback effects. This result shows that, in some manner, further spending in infrastructure allows the community to increase the local tax rate without damaging capital competition. Second, whereas an increase in infrastructure spending present a positive impact on own municipality tax rate, it causes a tax rate cut in neighboring jurisdictions. This last result suggests that the municipality can try to counterbalance an improvement in neighboring infrastructure conditions by cutting its own business tax rate.[7] As predicted in hypothesis 4 from our analytical framework, if the neighbor municipality increases the public provision of inputs, the local jurisdiction reacts by cutting its tax rate.

5.1 Cross Section Results and Robustness[8]

In order to provide additional comparison, we present the results for a simultaneous equation model for cross-sectional data as in Hauptmeier et al. (2012). Thus, we take the average from our seven-year data and build a cross-section version. With this data, we re-estimate the original model (functions 1.1 and 1.2) using a spatial system estimator as suggested by Kelejian and Prucha (2004). The generalized spatial two stage least squares (GS2SLS) approach consists of three steps (See Hauptmeier et al. (2012), Section 3.2 for details). We use again a normalized spatial contiguity matrix.

Results using cross section data (GS2SLS) are on Table 3[9] The main difference here is that the cross-sectional approach considers that the effect of the neighboring tax rate and local public inputs on own fiscal decisions are jointly determined. In fact, LeSage and Pace (2009) emphasize that spatial cross-sectional model and spatial panel data model can produce quite different estimates coefficients, even if both approaches are properly specified. Meanwhile cross-sectional data tend to underline spatial dependence, spatial panel model could indicate relatively greater temporal dependence than spatial temporal dependence.[10]

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[7] We note that inter-jurisdiction investments in infrastructure are federal or state responsibilities. Thus, potential externality effects should not be driven by communities' own spending.

[8] In the Appendix, we provide the results with infrastructure spending as dependent variable, as described in function (2.2). Overall, we note that our main findings are maintained.

[9] We note that Hauptmeier et al. (2012) use as instrumental variable for the averaged values of neighboring tax rate and public input spending, the share of communities' church members and specific grants for roads, respectively. We use as instrumental variable for the averaged values of neighboring business tax rate and infrastructure spending, respectively: the share of local workers and the share of elderly; and the share of workers and per capita sales tax grants (from States). The 2SLS approach is done in Stata using the spivreg command as developed by Drukker et al. (2013).

[10] Since a cross-sectional spatial model does not provide an explicit role for the passage of time, it emphasizes the change in the relationship between independent and dependent variable moving to a new steady-state equilibrium. See Lega and Pace (2009) Section 7.2 for a discussion.

TABLE 3

Tax Rate and Public Input Competition -Cross Section - 3 SLS Estimator

Dependent Variable	**Tax Rate**	**Public Input**
Neighbors' tax rate (AETR) - W	0.664***	-6,095.7***
	(3.690)	(-3.630)
Own tax rate		4,839.6***
		(9.850)
Neighbors' public input per capita (in 100 Reais) - W	-0.0033***	0.706***
	(-3.070)	(5.140)
Own public input per capita (in 100 Reais)	0.0074***	
	(17.010)	
Grants per capita		0.110***
		(14.390)
Current account balance (per capita)	0.000	
	(5.110)	
Annual average wage (per capita)		5.494***
		(2.610)
Pop. Density	0.000	0.001
	(0.380)	(0.140)
Population	-0.000	0.000*
	(-0.730)	(1.850)
Population^2	0.000	-0.000
	(0.540)	(-1.350)
Share of young (<15 years)		808.531***
		(4.460)
Share of elderly (>60 years)		167.1421
		(0.920)
F-tests of excluded IV's	123.26	99.920
(first stage of the 2SLS estimation)	(0.000)	(0.000)
R-squared	0.0970	0.6239

*Notes: Number of observations is 5,004. In parentheses are robust t-statistics. Regression includes 5 regional binary variables. The averaged values of neighboring business tax rate and infrastructure spending are instrumentalized by, respectively, the share of local workers and the share of elderly; and the share of workers and per capita sales tax grants*** Significant at 1%, ** significant at 5%, * significant at 10%.*

Overall, estimated coefficients on neighboring tax rate are similar to the estimations in Table 2. On the tax rate function, results indicate a positive and significant coefficient of 0.66 for the tax interaction parameter. Since the cross-sectional approach does not control for the persistence overtime, it is expected a higher coefficient estimation for this variable in a static approach compared to its dynamic counterpart (0.66 against 0.56, respectively).

More important, Table 3 shows that an increase of 1000 Reais per capita in local infrastructure spending would rise local tax rate around 0.074 percentage points. Moreover, results suggest that a rise on spending in neighboring infrastructure by 1000 Reais per capita would cause a 0.033 percentage point fall in community's own tax rate.

Comparing results from cross-section estimations to Table 2, one notes that cross-section model results indicate a larger estimated spillover effect regarding neighboring spending on community' tax rates (0.003 versus 0.002) but a lower total effect (0.007 versus 0.008) for own community's public spending on business tax rate. Those differences (positive and negative bias, respectively) could be associated to time effects or feedback effects that are not captured in the cross-section approach.

However, it is important to point out that all the estimated coefficient for fiscal interaction parameters present the signal as predicted by Hauptmeier et al. (2012) model as discussed in Section 2. The own input spending is positively associated to tax rate (column I) as well vice versa (column II). Overall, our results reinforce the idea that strategic interaction in capital competition, different from previous research, depends not only on tax rate interaction among communities but also on fiscal variables related to capital investment, such as local spending on public infrastructure.

6. Conclusion

There is much theoretical and empirical literature on capital tax competition. However, only recently has this literature incorporated the idea that tax competition between localities depends on several fiscal variables such as tax rate and the provision of public input. In this paper, we explore Hauptmeier at al.'s (2012) framework to investigate spillover effects in tax rate and public infrastructure across local communities in Brazil. Our data include information on approximately 5000 municipalities for a seven-year period.

The novelty here is that we consider a panel data approach in which it is possible to control for local fixed effects and to incorporate a dynamic component. Using separated regressions with business tax rate and public input spending as dependent variables confirm Hauptmeier at al.'s (2012) hypothesis. In fact, the Spatial Durbin Model (SDM) produces greater spillover effect compared to the cross-section model. Our main findings indicate that local governments adjust their tax rate based not only on the tax rate of the neighboring communities but also on the neighbors' public input spending. Importantly, this paper presents strong evidence that local governments react to tax rate cuts from neighboring jurisdictions in three possible ways: also cutting their tax rates, increasing their public infrastructure spending, or combining the two strategies. The results confirm that, in Brazil, local public infrastructure seems to be very important in fiscal competition. This new evidence is probably valid for other regions with similar characteristics.

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APPENDIX

Table A.1 presents regressions on public input spending per capita as the dependent variable. Although, the analytical reference in tax competition suggests that infrastructure spending leads to tax rate changes, we also test the opposite to verify the robustness of our findings.
Different from previous estimates on tax rate, results in Table A.1 suggests less evidence of persistence over time. In fact, the lagged public input spending is significant (columns II and III), but the magnitude of the coefficient is lower than the coefficient for the lagged tax rate (estimated average of 0.17 against 0.27 in Table 2). This finding suggests that public input spending is more volatile (less persistent) over time compared to business tax rate.
Additionally, Table A.1 points out that a change in business tax rate in a municipality is positively associated to the public input spending in that jurisdiction. Regarding direct impacts, we note that in Column II (Dynamic SDM), the long run direct effect estimate of $ 1417 Reais on business tax rate is somewhat different from the coefficient estimate of $ 1203 Reais. Since our effect estimate is superior to the coefficient estimate, this result indicates that the direct effect on local infrastructure spending is approximately $ 200 Reais larger due to (positive) feedback effects.
Regarding indirect effects, similarly to our previous results (on business tax rate as dependent variable), results in the SDM regression also indicate a negative spillover effect, but in this case, the indirect effect is not significant. According to results in column II, one percentage point increase in neighboring's tax rates leads to a decrease of about $ 116 Reais on infrastructure on own municipality. This result is an evidence in favor of hypothesis 3, if the opponent cuts its tax rate, it is optimal to the own community to provide more public inputs.
Thus, in Column II, results for the total effect (summing up direct and indirect effect) indicate that for an additional increase of one percentage point in local tax rate, public input spending would rise around $ 1301 Reais per capita. Interestingly, compared to the regressions in Table 2, the spillover effect here is much smaller and not significant: approximately 12 times smaller than the direct effect (in the regressions with tax rate as dependent variable, the indirect effect is four times smaller than the direct effect). These results reinforce the idea that the causal relationship is stronger from public input to tax rate than the opposite.
As in the case with the business tax rate as dependent variable, in the SAR model, although the estimated direct effect is similar to the SDM model, the indirect effect suggests the opposite. Results in the SAR model in Column III indicates a positive and significant spillover effect on public input spending. This result contradicts SDM results and hypothesis 3 from our analytical framework.
Interestingly, results on Column II suggest that short term spillover effects are fair greater than long term effects. Similarly to our findings in Table 2, one possible interpretation to this result is that neighboring jurisdictions reacts faster to an increase in business tax rate than the own tax jurisdiction.
Finally, comparing Table A.1 to Table 3, we find that coefficients for the tax rate parameters in the spatial panel regressions are fairly different from the GS2SLS regression. Coefficients are approximately four to five times greater in cross-sectional approach compared to SDM. These differences suggest that infrastructure spending is more susceptible to time effects.

TABLE 3

Spatial Tax Competition - Panel Data Estimation

Dependent variable: infrastrucutre spending per capita	I	II	III
Model	**SDM**	**SDM**	**SAR**
Lagged infrastructure spending		0.176***	0.177***
		(4.83)	(4.84)
Neighbors' infrastructure spending - W	0.678***	0.702***	0.668***
	(14.02)	(13.33)	(10.11)
Own business tax rate	1,125.1*	1,203.1*	1,188.0*
	(1.88)	(1.94)	(1.93)
Neighbors' business tax rate	-1,235.5*	-1,306.2*	
	(-1.90)	(-1.86)	
Short Run			
Direct effect - business tax rate		1,166.4*	1,161.4*
		(1.85)	(1.84)
Indirect effect - business tax rate		-143.4	2,207.0**
		(-1.31)	(2.04)
Total effect - business tax rate		1,023.0*	1,382.1*
		(1.82)	(1.88)
Long Run			
Direct effect - business tax rate	1,142.9*	1,417.3*	1,414.9*
	(1.87)	(1.85)	(1.84)
Indirect effect - business tax rate	-150.8*	-116.4	3,407.5**
	(-1.44)	(-0.96)	(2.05)
Total effect - business tax rate	992.2*	1,300.9*	1,755.6*
	(1.79)	(1.82)	(1.89)
Demographic covariates	yes	yes	yes
Spatial Fixed effects	no	no	no
R-squared	0.1550	0.3950	0.3944
Log Likelihood	- 217,900	- 187,556	- 187,987

*Notes: Number of observations is 35,028. In parentheses are robust t-statistics. All regressions include municipality and time fixed effects. We use the variation of 500 simulated parameter combinations drawn from the multivariate normal distribution implied by the ML estimates. *** Significant at 1%, ** significant at 5%, * significant at 10%.*