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Are Local Tax Rates Strategic Complements or Strategic Substitutes?†

By Raphaël Parchet*

The identification of strategic interactions among local governments is typically plagued by endogeneity problems. I exploit the fact that local jurisdictions located close to a state border have some neighbors in another state and instrument the tax rate of neighbor jurisdictions with the state-level tax rate of the neighboring state. I use this instrument to identify strategic personal income tax setting by local jurisdictions in Switzerland and find that tax rates are strategic substitutes. I then develop a residence-based personal income tax competition model and show that tax rates are strategic substitutes if the elasticity of the marginal utility of the public good with respect to the tax rate is above one. This is notably the case in the presence of economies of scale in the public good provision. (*JEL* H24, H71, H73, H77)

Tax competition is a hotly debated economic policy issue among as well as within nation states. The increasing mobility of firms and individuals is often seen as placing an ever more severe constraint on the revenue-raising power of independent jurisdictions and their ability to pursue redistributive policies. A policy response to the concern of "harmful" tax competition is to introduce tax coordination policies limiting the independence of jurisdictions. These can be found at all levels of government, from local to supranational entities such as the European Union. Importantly, these policies depend on whether tax rates are strategic complements or strategic substitutes.

The tax competition mechanism has been modeled formally in a well-established theoretical literature (see, e.g., Wilson 1999, and Keen and Konrad 2013, for a review). Empirically, it has become standard to interpret positive spatial correlations in tax rates at the subnational and international level as evidence for the "race-to-the-bottom" hypothesis, according to which competition for a mobile tax base is the cause of ever-falling statutory corporate tax rates in the United States and

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Europe. I argue that this approach faces two important challenges. First, identification of causal interactions is far from straightforward. Second, it implicitly assumes that tax competition implies strategic complementarity of competing jurisdictions' tax rates, even though this need not be the case in tax competition models. My contribution is twofold. First, I propose a new identification method based on an instrument that exploits multi-tier policy setting (Section I). Taking this estimation approach to data for local tax settings in Switzerland (Section II), I find that tax rates are strategic substitutes, except for large tax cuts (Section III). Second, I develop a simple, yet general, residence-based personal income tax competition model and show that tax rates are strategic substitutes if the elasticity of the marginal utility of the public good with respect to the tax rate is above one (Section IV). Tax rates are strategic substitutes, notably in the presence of economies of scale in the production of the local public good.

Regarding strategic complementarity, many tax competition models indeed predict that in an attempt to retain its mobile tax base, a jurisdiction will lower its tax rate when tax rates of neighboring jurisdictions fall. Tax reaction functions thus have a positive slope and tax rates are strategic complements. However, in a tax policy game, tax rates are strategic substitutes (complements) if the marginal payoff function in jurisdiction j decreases (increases) in the tax rate of another jurisdiction, that is, if jurisdiction j's best response to a less aggressive policy (higher tax rate) in another jurisdiction is to be more (less) aggressive (Bulow, Geanakoplos, and Klemperer 1985). This best response depends on two opposite effects: on the one hand, the tax policy of jurisdiction j is worth more in terms of marginal revenue because it is applied on a larger tax base. On the other hand, this larger tax base leads to an increase in the public good provision, which decreases its marginal utility. The best response of jurisdiction j therefore depends on whether by increasing its own tax rate, the decrease in marginal utility of the public good is less or more than proportional to the change in the tax rate.

Strategic complementarity or substitutability of tax rates has been mainly discussed in the literature with respect to the choice of the payoff function.[1] Tax rates have been shown to be strategic substitutes if, for example, the utility function of the representative agent is linear and the private good is valued at the margin more than the public good (Brueckner and Saavedra 2001); if public and private goods are close complements (Vrijburg and de Mooij 2016); or if the income elasticity of public goods is lower relative to private goods, that is, public goods are necessity goods (Chirinko and Wilson 2017). My model includes these existing explanations as special cases. It also extends the literature by showing that besides the utility function, economies of scale in the production of the public good play a key role in the elasticity of the marginal utility of the public good and therefore in the determination of the

[1] Another explanation relates to the choice of the policy variable by the governments, i.e., to compete over tax rates or expenditure levels. Standard models assume governments optimize over tax rates with expenditures adjusting through the budget constraint. As Wildasin (1988, 1991) shows, if governments instead optimize over expenditure levels with tax rates adjusting residually, tax reaction functions have a negative slope, and tax rates are strategic substitutes.

slope of the tax reaction functions.[2] As Ross and Yinger (1999) notes, the standard assumption of constant per unit cost in public good provision is unlikely to hold in reality. Indeed, many services provided locally, such as the local road network, sanitation, education, fire, and police protection typically require large infrastructure investment (Fisher 2016).

Empirical evidence has thus far pointed toward positively-sloped tax reaction functions (see, e.g., Allers and Elhorst 2005 on local tax competition; and Devereux, Lockwood, and Redoano 2008 on international tax competition over corporate tax rates).[3] These empirical studies apply spatial regression models where the tax rate in one jurisdiction is regressed on the average tax rate of neighboring jurisdictions. However, the identification of strategic interactions in these models is plagued by two-way causality (see, e.g., Brueckner 2003). The main challenge consists in disentangling endogenous strategic interactions from unobserved and spatially correlated characteristics such as preferences, topographical features, or institutions. The standard estimation method is either to assume that the estimated equation fully describes the true data-generating process and to apply maximum likelihood methods or to use an instrumental variable approach taking average characteristics of neighboring jurisdictions as instruments (Kelejian and Prucha 1998). As noted by Gibbons and Overman (2012), these methods generally do not offer reliable identification of causal relations. The first approach assumes implausibly that the true data-generating process is known. With the second method, instruments are likely to be invalid due to endogenous population sorting and the existence of spatially correlated local shocks. The key for identification is to isolate variations in the tax rate of competing jurisdictions that can be plausibly considered as exogenous.

This paper proposes making use of a multi-tier federal system. Fiscal reforms at the (upper-tier) state level provide an arguably exogenous source of variation in the tax rate levied at the (lower-tier) local level. Moreover, state borders create spatial discontinuities in state-level fiscal policies across areas that are otherwise highly integrated. I thus propose identifying strategic interactions among local jurisdictions using the fact that jurisdictions located close to a state border have some immediate neighbors in another state. As long as individual local jurisdictions do not significantly affect state-level tax setting and mobile taxpayers react to the consolidated state plus local tax rate regardless of its composition, the state-level tax rate of the *neighboring* state is a valid instrument for the average tax rate of neighboring local jurisdictions. I use this new instrument to identify strategic personal income tax setting by local jurisdictions (municipalities) in Switzerland. I find that once I instrument properly in this way, tax rates are strategic substitutes. Decomposing this result according to the sign and magnitude of the exogenous tax change suggests that tax rates are strategic complements only for large tax cuts. I also make use of

[2] Standard capital tax competition models feature immobile labor and thus typically abstract from economies of scale in public good provision. There are two notable exceptions. Wilson (1995) discusses the efficiency pattern of local public good provision in a tax competition model featuring mobile residents and economies of population scale. Matsumoto and Feehan (2010) shows that public inputs enhancing the production of private goods are under-provided under capital tax competition if there are economies of production scale.

[3] A notable exception to the prevailing empirical results is the analysis by Chirinko and Wilson (2017) who find that tax reaction functions for capital taxes among US states have a negative slope.

my proposed identification strategy to estimate the elasticity of the tax base with respect to local income tax rates. I find an elasticity of 0.4. Informed by my theoretical model, I compare this elasticity to the share of tax revenue that one can plausibly consider as "fixed" or "committed." This comparison suggests that the empirical results of the paper are indeed plausible in my setting.

This paper contributes to the emerging literature that departs from estimating a spatial regression model. Lyytikäinen (2012) uses a fiscal reform in Finland that raised the minimum property tax rate, affecting only a subset of municipalities to identify tax competition. He finds no evidence of strategic interactions, whereas standard instrumental variables techniques indicate a strong and positive interaction. This conclusion is shared by Isen (2014), who uses close elections of local referenda in Ohio as a source of exogenous increase in taxation, and by Baskaran (2014), who exploits a reform of the fiscal equalization scheme in one German state to study tax mimicking by municipalities in the neighboring state. I contribute to this literature by proposing an instrument that is not tied to a specific reform or context. Other studies exploit border discontinuities. Agrawal (2015) explores the spatial pattern of local sales tax rates in the United States at state borders where state sales tax rates change discontinuously. His results suggest that local sales taxes are set as a function of the distance to state borders and of state tax differentials. Eugster and Parchet (2019) uses a cultural border to identify strategic interactions among municipalities in Switzerland. Exploiting a discrete and measurable discontinuity in voter preferences between the French-speaking and the German-speaking regions in Switzerland, they find that tax competition does constrain income taxation of municipalities at the language border. These papers provide evidence for the existence of strategic interactions among local jurisdictions in their tax setting. I complement them by investigating the nature of these strategic interactions.

I. Identifying Strategic Interactions at State Borders

I exploit two features of a prototypical federal system. First, different levels of governments—with full or partial fiscal autonomy—share the same tax base. Second, state borders create spatial discontinuities in state-level fiscal policies across areas that are otherwise highly integrated. Consider, for simplicity, a federation with two levels of sub-federal governments that both levy a tax on personal income: states ("cantons" in Switzerland) levy a tax at rate t_c, and municipalities independently levy a tax on the same base at rate t_{ic}. The consolidated state plus municipal personal income tax rate in municipality i belonging to state c is therefore $T_{ic} \equiv t_c + t_{ic}$. With mobile tax bases, this setting gives rise to two classical externalities studied in the literature: a vertical externality between the different levels of government that share the same tax base and a horizontal externality among neighboring jurisdictions with separate but interdependent tax bases (Keen 1998). Formally, assuming linearity,

$$t_{ic} = at_{-i} + bt_c, \tag{1}$$

that is, the tax rate of municipality i depends on the tax rate of neighboring municipalities t_{-i} (horizontal externality) and on the state tax rate t_c (vertical externality). If municipality i is located close to a state border, its tax rate also depends on the state tax rate of the neighboring state, t_{-c}.[4] Hence,

$$t_{ic} \;=\; at_{-i} + bt_c + ct_{-c}. \tag{2}$$

Consider, again for simplicity, that municipality i lies at the state border and has only one neighboring municipality located in the neighboring state. To the extent that taxpayers care only about their total tax bill regardless of its composition, municipality i should react equivalently to a change in t_{-i} or in t_{-c} (i.e., $a = c$). In other words, the tax rate of municipality i depends on the consolidated state plus municipal tax rate in the neighboring municipality as well as on its own state tax rate, such that

$$t_{ic} \;=\; aT_{-ic} + bt_c. \tag{3}$$

In this paper, I propose using t_{-c} as a source of exogenous variation in the taxation of neighboring municipalities (T_{-ic}). Moreover, if t_{-c} affects t_{ic} only through T_{-ic}, it can be used as an instrument to identify horizontal strategic interactions among municipalities in their tax setting.

More specifically, I estimate the following linear regression model:

$$T_{ic,t} \;=\; \alpha\overline{T}_{-i,t} + \beta'\mathbf{X}_{ic,t} + \gamma_i + \delta_{c,t} + \varepsilon_{ic,t}, \tag{4}$$

where $\overline{T}_{-i,t}$ is the weighted average of neighboring municipalities' consolidated tax rates, possibly located in different states, $\mathbf{X}$ is a vector of controls, and γ_i and $\delta_{c,t}$ are municipality and state-year fixed effects, respectively; α is the coefficient of interest, designed to measure horizontal strategic interactions among municipalities in their tax setting. Note that in contrast to equation (3), the dependent variable is the consolidated cantonal plus municipal tax rate $T_{ic,t}$, instead of the municipal tax rate t_{ic}, and that vertical strategic interactions are not modeled directly ($t_{c,t}$ is absent from the right-hand side of the equation). This is due to the inclusion of state-year fixed effects that effectively control for the state tax policy.[5] As it will become clear later, state-year fixed effects are key for the identification strategy of horizontal strategic interactions by capturing all events at the state level that affect municipality tax policy.

The main issue in the estimation of equation (4) arises because the tax rate of a neighboring municipality itself depends on the tax rate of municipality i.

[4] This is what Agrawal (2016) calls a "diagonal externality" between different levels of governments that do not share the same tax base. Following his work, one should also include in equation (1) the distance to the state border and an interaction term between vertical and horizontal externalities. As I concentrate in this paper on horizontal strategic interactions among municipalities sufficiently close to a state border, I abstract here from these last two terms.

[5] With state-year fixed effects, using $T_{ic,t}$ as a dependent variable is equivalent to using t_{ic}. I follow here the spatial regression literature by using the same variable ($T_{ic,t}$) on the left- and right-hand sides of the equation.

Moreover, many time-varying determinants of one jurisdiction's tax rate, such as local economic conditions, are likely to be unobservable and spatially correlated, such that $\overline{T}_{-i,t}$ will inevitably be correlated with $\varepsilon_{ic,t}$ and the estimation of α will be biased. Following the discussion above, $t_{-c,t}$ can be used as an instrument for $\overline{T}_{-i,t}$ provided it satisfies two conditions. First, it is exogenous, i.e., $\text{cov}(t_{-c,t}, \varepsilon_{ic,t}) = 0$ in equation (4). Second, it should be relevant, i.e., it should imply sufficient variation in $\overline{T}_{-i,t}$.

A. *The Instrument*

Figure 1 illustrates the approach through a map. It shows a municipality i and its four main neighbors across a state border between two states, A and B.[6] Consider that for reasons unrelated to municipalities 1 to 4, state A raises t_A. Under some assumptions on vertical strategic interactions (discussed below), this raises the consolidated state plus municipal tax rate in municipalities 1 and 2 but does not directly change the tax bill a taxpayer has to pay by living in state B. Municipalities located in state B have no incentive to change their tax rate, unless tax bases are mobile and municipalities interact strategically in their tax setting.[7] I propose instrumenting $\overline{T}_{\{1,2,3,4\}}$ with the state tax rate of state A, t_A.

Regarding the exogeneity condition, a first requirement is that t_A has an effect on T_i only through a change in $\overline{T}_{\{1,2,3,4\}}$. A concern arises if the mobile tax base would react systematically differently to a change in the state-level compared to the municipality-level tax rate. I assume here that taxpayers care only about their total tax bill regardless of its composition.[8] Second, individual municipalities should not systematically affect state-level tax policies (no reverse causality). This is likely to be fulfilled in states with a sufficiently high number of municipalities and a population not too concentrated in municipalities close to one particular state border. To see this, assume that state A is composed by M municipalities of sizes n_j such that the state population $N = \sum_{j=1}^{M} n_j$. The tax base elasticity of municipality 1 to the tax rate of municipality i is $\varepsilon_{n_1,t_i} = \frac{\partial n_1}{\partial t_i}\frac{t_i}{n_1}$, whereas the state-level tax base elasticity of state A to the tax rate of municipality i is $\varepsilon_{N,t_i} = \varepsilon_{n,t_i}\frac{n_1+n_2}{N}$ (assuming $\varepsilon_{n_1,t_i} = \varepsilon_{n_2,t_i} = \varepsilon_{n,t_i}$). Hence, state A is unlikely to react to t_i provided $\frac{n_1+n_2}{N}$ is small enough. Following the empirical literature on vertical strategic interactions, one may also assume that states act as first movers with municipalities reacting

[6] The set of strategically relevant municipalities is not known and should be defined according to some prior. In this illustrative example, a maximum road distance of 5 kilometers (km) between municipalities' main towns selects municipalities 1 to 4. The empirical part shows results for different distance bandwidths, with a baseline cutoff of 10 km.

[7] I abstract here from political-economy mechanisms (such as "yardstick competition") that predict a positive spatial correlation in tax rates among neighboring municipalities, an outcome not supported by the empirical evidence provided by this paper.

[8] Taxpayers may, however, be more aware of changes in tax rates at the local (state) level than at the state (local) level. I assume here that salience-induced behaviors are absent. Another issue arises if tier-specific tax rates are used to finance different public goods that are valued differently by taxpayers. In this case, the expenditure (tax rate) composition would matter as in Keen and Marchand (1997). This issue exemplifies the limit to the generalization of the method, a point discussed in Section IB.

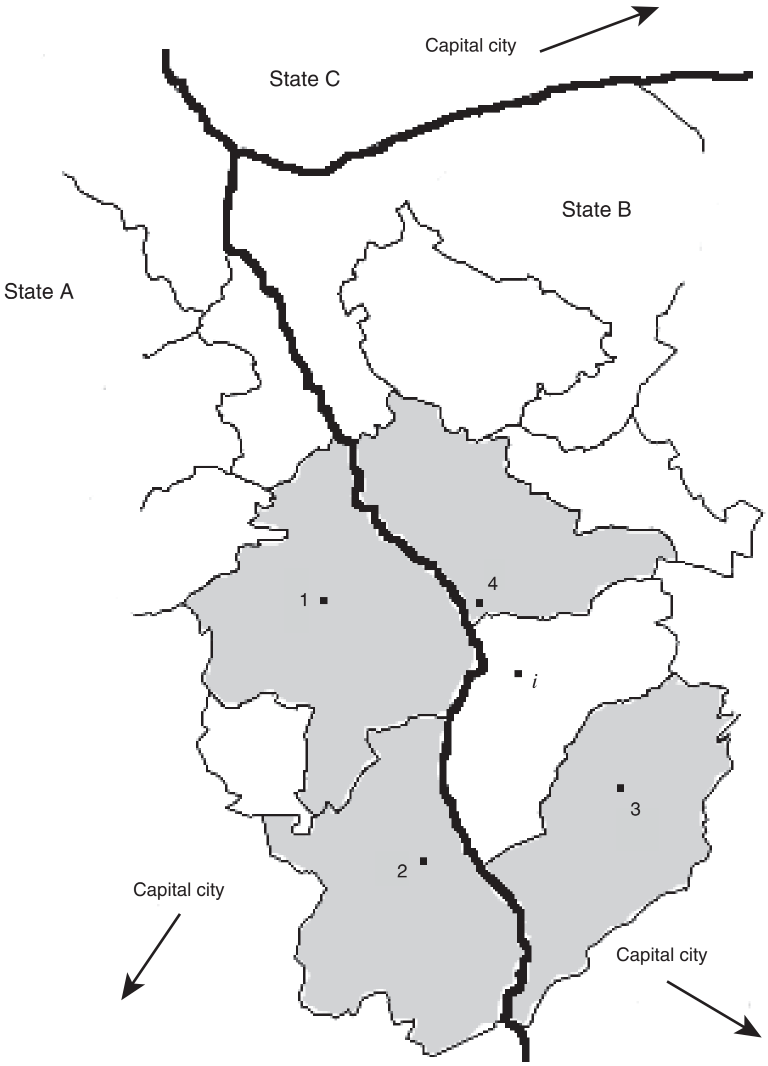

Figure 1. Neighboring Municipalities across a State Border

Notes: This illustrative map represents municipalities in Switzerland at the state (cantonal) border between Bern, Aargau, and Luzern. State borders are in bold. Points represent municipalities' population-weighted centroids. The main neighboring municipalities of municipality *i* are in gray. They are selected according to a maximum road distance to *i*'s centroid of 5 km.

subsequently (see, e.g., Hayashi and Boadway 2001). To further minimize the potential for reverse causality, I shall use $t_{-c,t-1}$ as an instrument.

Third, state-level tax reforms in *A* should not be driven by some unobserved factors that also affect the taxation decision of municipality *i* and its neighbors. The key concern here is the existence of (horizontal) strategic interactions among states themselves. These strategic interactions are controlled for in equation (4) by the state-year fixed effects $\delta_{c,t}$. These fixed effects capture all state-wide policies in one state as well as all confounding shocks that simultaneously affect all municipalities in one or several states. State-year fixed effects imply that the identification of strategic interactions among neighboring municipalities stems from the within-state differential response of municipality i to changes in t_A, compared to other municipalities in the same state (state B) not affected by t_A, i.e., municipalities located at another border than the border with state A.[9]

Thus far, the instrument and the inclusion of state-year fixed effects capture confounding factors that occur at a small spatial scale (only border municipalities) or at a large spatial scale (state-wide shocks). Another concern for the instrument's validity is the existence of shocks that may affect the fiscal decision of state A and (only) border municipalities in state B. This arises if border municipalities share, for example, the same labor market. Such local confounding factors will not be captured by state-year fixed effects. However, they are arguably a concern only if state A is a small state. In terms of Figure 1, the exogeneity assumption requires that state A is a large state with a capital city located "far away" from municipality i, such that their fiscal decisions are independent. In Section IIIC, I show that my results are robust to the exclusion of small states (cantons) and of states in which the capital city is located close to the state border. Note, also, that fiscal decisions driven by confounding factors are likely to be positively correlated, thus biasing the estimate of strategic interactions toward zero if tax rates are strategic substitutes.

Regarding the (first-stage) relevance of the instrument, state-level tax policies should imply economically and statistically significant variations of $\overline{T}_{\{1,2,3,4\}}$. If this condition were not satisfied, the instrument would be "weak" and the estimate of strategic interactions would be imprecisely measured and too high (in absolute value).[10] The effect of t_A on $\overline{T}_{\{1,2,3,4\}}$ depends, first, on the reaction of municipalities 1 and 2, that is, on within-state A vertical interactions. Vertical interactions are even more likely to arise at state borders, where the common tax base may presumably easily relocate to and from another state.[11] The net effect of state-level tax policies on the consolidated tax rate of municipalities in the same state cannot be predicted, since the sign of vertical interactions is ambiguous (see, e.g., Keen and Kotsogiannis 2002). However, the identification strategy of this paper requires no prior on this sign. All that is required is that municipalities 1 and 2 do not exactly offset changes in the state-level tax rate t_A. This can be tested by a first-stage F-test on the instrument.

The quality of the first-stage estimation depends also on the reaction of i's neighbor municipalities located on the same side of the state border (municipalities 3 and 4) to a change in T_{1A} and T_{2A}. This reaction is likely to vary with the distance to the state border. Municipalities located further away from the border than i may react less. The sign of the tax reaction function also matters. If tax rates are strategic substitutes, municipalities 3 and 4 will decrease their tax rates to any increase in T_{1A} and T_{2A}. Thus, the *average* tax rate of municipalities 1 to 4 may not change, even if T_{1A} and T_{2A} change and strategic interactions are strong. Overall, the total effect of

[9] This strategy comes at the price of discarding from the identifying set all states that share a border with only one other state.

[10] In the empirical section, I analyze 30 years of cantonal and municipal personal income taxation in Switzerland, showing important variations of the cantonal tax rate, both between cantons and over time (see Section IIA).

[11] Brülhart and Jametti (2006) shows that vertical interactions between municipalities and cantons play a significant role in the determination of local tax rates in Switzerland.

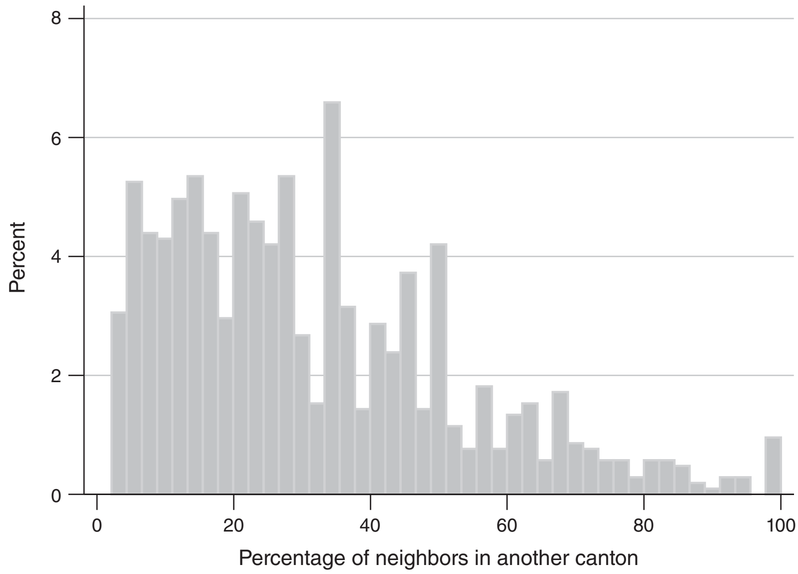

FIGURE 2. DISTRIBUTION OF THE PERCENTAGE OF NEIGHBORING MUNICIPALITIES IN SWITZERLAND LOCATED IN ANOTHER CANTON

Note: Municipalities have at least one neighboring municipality within a road distance of 10 km that is located in another canton.

state-level tax policies on $\overline{T}_{\{1,2,3,4\}}$ depends crucially on the share of neighboring municipalities directly affected by these reforms. I propose following the strategy used in the peer effects literature and multiply the instrument by the share of neighboring municipalities located in a state other than the state of municipality i (see, e.g., Moffitt 2001 and Lalive and Cattaneo 2009). This strategy recognizes the fact that tax reforms in neighboring states will affect municipalities on the other side of the state border only if they affect the tax rates of a sufficient number of competing municipalities. In my illustrative example, $\overline{T}_{\{1,2,3,4\}}$ is thus instrumented by $t_A \times 0.5$.

Figure 2 plots the distribution of the shares of neighbor municipalities in Switzerland that are located in a canton other than that of the reference municipality (using a 10 kilometers-distance cutoff). As expected, for most municipalities the majority of their neighbors belongs to the same canton. Nevertheless, the share of municipalities with a high number of neighbors in another canton is far from negligible.

B. *Generalization of the Instrument to Other Settings*

The instrument makes use of multi-tier decision making where the policy enacted at one (upper) level is spatially delimited. Fiscal policies in federal systems represent an exemplary case, but the instrument might potentially be applied to other systems or policies. I provide an application in Section IVC in which I estimate the elasticity of the tax base with respect to local income tax rates, instrumenting local tax rates with neighbor-canton tax rates.

My approach is not limited to jurisdictions at state borders but could be used to study, e.g., competition among potentially distant jurisdictions (cities) located in different states over a globally mobile tax base (high-skilled workers as in Moretti and Wilson 2017). The state policy, however, is more likely to depend on policies and economic conditions in its major cities compared to peripheral (border) jurisdictions. State-level reforms should then be carefully documented as exogenous.

Second, I address endogeneity issues that are not limited to fiscal policies but common to all studies featuring interaction between agents over space (see, e.g., Gibbons, Overman, and Patacchini 2015). Decisions taken at an upper level of decision making might therefore be used as an exogenous source of variation for local policies and potentially address identification issues caused by reverse causality, omitted variables, or sorting that bias causal effects, even in border discontinuity designs.[12] School quality, for example, depends on policies that are taken at various levels from the school itself to the school districts or the state. Land use regulations, while mostly undertaken at the local level, might also depend on state-wide policies or rulings. However, these policies typically involve various dimensions (teacher quality and class sizes, environmental regulations and building permit approval time, etc...). If economic agents react differently to these various components, the exclusion restriction will be violated, and upper-level policies cannot be used as an instrument for local policies.

I now proceed to estimate strategic personal income tax interaction among Swiss municipalities.

II. Empirical Analysis

A. *Setting*

Switzerland is a highly decentralized country where the main political units are the 26 cantons and the 2,485 municipalities (in 2012). The number of municipalities per canton ranges from 3 to a maximum of 382, with an average of 96. In 2012, the average population per municipality was 3,235 with a maximum of 381,000.

Cantons and municipalities enjoy large fiscal autonomy. About 50 percent of cantonal and municipal revenue are raised through their own taxes. At both levels, the personal income tax is the main fiscal instrument, accounting for 61 percent of tax revenue at the cantonal level and 68 percent at the municipal level.[13] Personal income taxes are residence-based, whereas corporate taxes are source-based (with formula apportionment).

Cantons choose multiple aspects of their tax systems. First, they set deductions and exemptions for the definition of the taxable income as well as a complete statutory tax schedule. Then, they fix annually a multiplier applied to the basic statutory

[12] See Duranton, Gobillon, and Overman (2011) for a combination of spatial differencing and instrumental variable strategy. My proposed instrument has the advantage of not requiring spatial differencing for its validity.

[13] Corporate taxes account for 18 percent (16 percent for municipalities) and wealth taxes for 8 percent (9 percent) of revenues.

tax schedule, thus determining applied tax rates in any given year. Any change in the tax base or schedule implies a revision of the fiscal law and is ultimately submitted to a referendum. In contrast, cantonal multipliers are adapted each year by cantonal parliaments to the canton's fiscal objectives.

Municipalities have to apply the cantonal definition of the tax base and schedule but can decide on a municipal tax multiplier that applies to the basic statutory tax rate. Municipal multipliers are fixed annually by municipal parliaments or citizen assemblies.[14] A central feature of this system is that municipalities are restricted to a single instrument—their tax multiplier—such that intra-cantonal variation in the consolidated personal income tax rate is perfectly captured by a single variable, municipal tax multipliers.[15]

On average, cantonal and municipal taxes account for similar shares of the consolidated tax liability.[16] The average consolidated cantonal plus municipal tax rate for an unmarried taxpayer with a gross annual income of CHF 1,000,000 (the highest income listed in official statistics) is 23 percent in 2012, ranging from 6 percent to a maximum of 30 percent.[17] The average tax rate at the cantonal level is 11 percent, ranging from 3 percent to 20 percent. Key to this paper, cantonal tax rates also exhibit important variation over time (see Figure A.1 of the Appendix).[18]

B. *Cantonal Borders*

I concentrate on the consolidated municipal and cantonal tax rate for the personal income tax in municipalities close to a cantonal border. Figure 3 shows the 1,047 border municipalities in Switzerland, defined as having at least 1 neighbor within a road distance of 10 km that is located in another canton. All border municipalities for which cantonal borders correspond to topographical particularities like the Alps in the South/Southeast are thus not considered as road distances exceed the cutoff. Cantonal borders mostly do not coincide with language borders nor do they divide functional labor markets or other economic institutions. They do not deter mobility either. According to data from the Population Census of 2000, 30 percent of people arriving in or moving out of border municipalities in my sample change their canton of residence (roughly 2 percent of the corresponding municipal population). Moreover, 15 percent of all employed individuals residing in these border municipalities commute daily to another canton (33 percent of all commuters), with an average commuting distance of 17 km.

[14] In most cantons, multipliers are required to be the same for personal income, wealth, and corporate taxes. In the few cantons where they could differ, cantonal and municipal multipliers remain highly correlated in practice. Finally, in a majority of cantons, other entities such as parishes are allowed to set their own tax multiplier. These multipliers are very low in general.

[15] Some exceptions exist. In the canton of Neuchâtel (before 2001) and in the canton of Solothurn (before 1986), municipalities were allowed to set their own tax schedule. In the canton of Basel-Stadt (three municipalities), the municipal tax rate of the municipality of Basel is included into the cantonal tax rate. As this plausibly violates the exogeneity assumption of the instrument, I drop the canton of Basel-Stadt from the empirical analysis.

[16] Important variations across cantons exist. The cantonal share of the consolidated tax liability ranges from 25 percent in the canton of Schwyz to 95 percent in the canton of Glarus.

[17] In 2012, the average exchange rate was 0.9 Swiss franc (CHF) to the US dollar.

[18] For example, between 1983 and 2012, there have been 27 episodes of cantonal tax changes greater than 10 percent, occurring in 19 cantons.

Figure 3. Municipalities within 10 km of a Cantonal Border

Notes: Municipalities in gray have at least one municipality within a road distance of 10 km that is located in another canton. Cantonal borders are in bold. The canton of Basel-Stadt (three municipalities) is not used in the sample (see Section IID). Road distances are taken from the online route planner search.ch.

To gauge the representativeness of the retained sample of municipalities, Table 1 compares population characteristics (nationality, age, income, and education), political orientation (support in favor of left-of-center parties), economic activity (employment shares by sector, unemployment, and tourist destination), amenities (number of movie theaters in the neighborhood), and geographic features (urban area, area, altitude, and lake shore) of border and non-border municipalities. From column 3, it appears that differences between the two samples are statistically significant for a majority of background variables. However, these differences are economically small. Column 4 reports these differences in percentage deviation from their mean. The most important difference is found for the variable "Tourist destination" and reflects the location of most tourist resorts in the Alps. This also explains the difference in altitude. Other differences are small, and I do not expect my conclusions to be driven by special features of border municipalities selected in my sample.[19]

C. *The Estimating Equation*

My starting point is equation (4),

$$T_{ic,t} = \alpha \overline{T}_{-i,t} + \beta' \mathbf{X}_{ic,t} + \gamma_i + \delta_{c,t} + \varepsilon_{ic,t},$$

where

$$\overline{T}_{-i,t} = \sum_{j \neq i}^{N} w_{ij} T_{j,t}.$$

[19] As I shall show in Table 2, coefficients measuring the spatial correlation of tax rates for all municipalities and for border municipalities are not statistically significantly different from each other.

Table 1—Background Characteristics of Border and Non-border Municipalities

	Border municipalities	Non-border municipalities	Difference	In mean deviation (percent)
	(1)	(2)	(3)	(4)
Panel A. Background characteristics				
Population (in 1,000)	2.58	2.99	−0.41	−14.59
Percent foreign nationals	9.83	10.76	−0.93	−8.98
Percent young (≤ 20)	20.42	19.65	0.77	3.86
Percent old (≥ 80)	3.08	3.47	−0.39	−11.82
Percent primary sector	13.07	12.16	0.90	7.17
Percent secondary sector	33.08	29.94	3.14	10.04
Percent tertiary sector	53.85	57.90	−4.05	−7.21
Unemployment rate	1.96	2.29	−0.33	−15.35
Total employment (per capita)	0.24	0.27	−0.03	−11.54
Percent votes for left-of-center parties	18.23	18.50	−0.27	−1.47
Urban area	0.36	0.36	−0.00	0.00
Center of urban area	0.03	0.03	−0.00	0.00
Tourist destination	0.01	0.10	−0.09	−150.00
Number of movie theaters within 10 km	3.08	3.28	−0.20	−6.25
Lake shore	0.13	0.18	−0.04	−25.00
Altitude (m.a.s.l.)	535.98	685.98	−150.00	−24.10
Productive area (km^2)	553.11	494.59	58.52	11.27
Panel B. Migration-related characteristics				
Percent top 10% income	8.43	7.97	0.46	5.63
Percent bottom 50% income	52.85	56.22	−3.37	−6.15
Gini index	0.32	0.34	−0.02	−6.06
Percent high education (tertiary)	15.93	15.16	0.77	4.97
Percent intermediate education	79.68	80.82	−1.14	−1.42
Percent no education	4.40	4.02	0.37	8.85
Number of municipalities	1,047	1,423		

Notes: Border municipalities have at least one neighboring municipality within a road distance of maximum 10 km that is located in another canton. Urban area, center of urban area, tourist destination, and lake shore are binary variables. Employment is the total full-time equivalent employment in the secondary and tertiary sectors. Productive area is the total area minus forest, water, and alpine areas. Top 10 percent income includes taxpayers with a taxable income in the highest decile. Bottom 50 percent income includes taxpayers with a taxable income below the median. In 2010, the top decile includes all taxpayers with a taxable income over CHF 105,000 (56,000 in 1983), and the median income is CHF 44,000 (24,000 in 1983). Income shares and the Gini index are computed using the federal income tax statistics from 1983 to 2010. Standard errors are clustered two ways—by municipality and by year.

Source: Swiss Federal Tax Administration, Bern. Other data from the Population Census of 1980, 1990, and 2000.

Note that $\overline{T}_{-i,t}$ is not restricted to municipalities within the same canton and may include municipalities across the canton border.[20] Here, w_{ij} are ex ante chosen weights. As a baseline specification, I use uniform weights defined as

$$w_{ij}^{U} = \begin{cases} \frac{1}{N} & \text{if } d_{ij} \leq D \text{ km} \\ 0 & \text{otherwise} \end{cases}, \tag{5}$$

[20] For this reason, the variable of interest is the consolidated cantonal and municipal tax rate at the municipality level and not municipal tax multipliers that are not comparable across cantons.

where d_{ij} is the shortest road distance between municipalities i and j, $N = \sum \mathbf{1}_{d_{ij} \leq D\,\text{km}}$ and $D = 10$ km.[21]

Following the discussion in Section IA, $\overline{T}_{-i,t}$ is instrumented by $t_{-c,t-1} \times S_{ic}$, where $S_{ic} = N_{-c}/N$ is the share of neighboring municipalities located in the neighboring canton ($N_{-c} = \sum \mathbf{1}_{d_{ij} \leq D \text{ and } j \notin c}$). If municipalities have neighbors in more than one canton, the instrument becomes $\overline{t}_{-c,t-1} \times S_{ic}$, where $\overline{t}_{-c,t-1}$ is constructed with the same weights as in (5). To account for any remaining correlations in the error term not captured by fixed effects, standard errors in all estimations are clustered two ways—by municipality and by year.

D. *Data*

My main variable is the consolidated cantonal and municipal personal income tax rate by municipality between 1983 and 2012.[22] These tax rates are published by the Swiss Federal Tax Administration for a sample of the largest municipalities and are defined as shares of the consolidated cantonal, municipal, and church tax liability in gross annual income for different categories of taxpayers (unmarried, married without children, and married with two children) and income classes (from CHF 10,000 to CHF 1,000,000). I expand these data to all municipalities and compute cantonal tax rates for all cantons with a methodology detailed in online Appendix A.[23]

The control vector **X** in equation (4) contains municipality characteristics including population, the percentage of foreign nationals, the percentage of young aged less than 20 and old aged more than 80, the percentage of employees in the secondary and tertiary sectors respectively, total full-time equivalent employment, the unemployment rate, the share of votes in favor of left-of-center parties in national elections, and the number of movie theaters within 10 km. Migration-related characteristics, listed in Table 1, are likely to be endogeneous and are therefore not included in **X**. Other background characteristics show no or very little variation over time. They are captured by municipality fixed effects and are thus not included in the regressions. Note also that state- (canton-)year fixed effects in equation (4) restrict the set of identifying observations to cantons that have more than one neighbor. This

[21] Appendix B presents results with alternative specifications of spatial weights.

[22] There were 2,485 municipalities in Switzerland in 2012. The canton of Basel-Stadt (three municipalities) is dropped because its tax system plausibly violates the exogeneity assumption of the instrument required by the identification strategy of this paper (see footnote 15). The district of Laufen (13 municipalities) and one municipality in the canton of Jura are dropped because they changed canton during the sample period. If municipalities merge, the average value of previous jurisdictions is reported for the new jurisdiction according to the list of municipalities as of December 31, 2012. If municipalities split, the average value of the new jurisdictions is reported for the previous jurisdictions. This is the case for six existing municipalities that are not included in the dataset. The merger of the 25 municipalities of the canton of Glarus into 3 municipalities in 2011 was not taken into account. Instead, I report missing values for that canton after 2011.

[23] Some special features of the tax system or missing information prevent the computation of cantonal tax rates in the cantons of Neuchatel (before 2001), Solothurn (before 1986), and Appenzell Innerrhoden (before 2001). To avoid spurious variation in $\overline{T}_{-i,t}$ when these cantons appear in the sample, values of neighboring municipalities are also set to missing.

implies the exclusion from the set of identifying observations of 30 municipalities for a distance to a cantonal border of 10 km.

III. Results

A. *Baseline Results*

In the subsequent analysis, the dependent variable is the consolidated tax rate for an unmarried taxpayer with a gross annual income of CHF 1,000,000. This is the top income listed in official statistics and refers presumably to the most mobile tax base.[24] The results for other categories of taxpayers are presented in Appendix B, Section B.

Table 2 presents results based on equation (4) using the standard approach in the literature. In column 1, the explanatory variable of interest is the average tax rate of all neighboring municipalities within a road distance up to 10 km, irrespective of the canton they belong to. In column 2, I consider only municipalities that have at least one neighbor located in another canton.[25] These two columns are estimated with OLS, knowing that they are unlikely to be consistent as the tax rate of neighboring municipalities is endogenous, thus biasing the estimates upward (Brueckner 2003). Column 3 follows the conventional approach in spatial econometrics and instruments the tax rate of neighboring municipalities with the average background characteristics of these jurisdictions. It thus assumes—improbably—that background characteristics of neighboring jurisdictions are orthogonal to unobserved determinants of taxation of municipality *i*.

All three estimates suggest positive and statistically significant spatial correlations in tax rates. The first two columns show no difference between border and non-border municipalities, and the coefficients are comparable to those found in previous studies. The instrumental variable strategy presented in column 3 does not qualitatively affect our findings. The coefficient is even larger.[26]

These results are typical for the empirical tax competition literature (see, for example, the overview in Allers and Elhorst 2005, Table 1). The positive and statistically significant coefficient is interpreted as evidence for the existence of tax competition over mobile tax bases. However, even if the over-identification test does not reject the null hypothesis of the absence of correlation between the instruments and the error term, it is difficult to be convinced that these standard instruments are truly exogenous, due to endogenous population sorting and the existence of spatially correlated shocks.[27]

Table 3 presents the results of my instrumental variable strategy. Cantonal tax rates of neighboring cantons ($t_{-c,t-1}$), multiplied by the share of municipalities located in these cantons (S_{ic}), are used to instrument the average tax rate of neighboring

[24] This corresponds to the top 0.1 percent income in 2010. Between 1983 and 2012, cumulative inflation was 60 percent. Cantons adjust their tax schedule for inflation on a regular basis. These adjustments are not a cause for concern as long as they are exogenous to municipal tax decisions. Only in the canton of Valais do municipalities fix their own adjustment level.

[25] Note that the spatial lag includes non-border municipalities.

[26] This is probably due to a weak instrument problem, as suggested by a first-stage *F*-test (reported below coefficient estimates), lying below the critical value of Stock and Yogo (2002).

[27] Note that the over-identification test is based on the assumption that at least one instrument is valid.

Table 2—Spatial Correlations in Tax Rates

	All municipalities	Border municipalities	
	OLS	OLS	IV
	(1)	(2)	(3)
Tax rate of neighboring municipalities	0.444	0.425	0.662
	(0.031)	(0.045)	(0.166)
First-stage F-test on instruments			6.197
Over-identification test (p-value)			0.695
Observations	70,127	28,362	28,362
Number of municipalities	2,428	1,047	1,047
Number of years	28.90	27.10	27.10

Notes: The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq 10$ km). Border municipalities have at least one neighboring municipality located in another canton. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. The instruments in column 3 are the average value of controls in neighboring municipalities. The over-identification test reports the p-value of the Hansen J-statistic. Standard errors in parentheses are clustered two ways—by municipality and by year.

Table 3—Strategic Interactions in Tax Rates: IV Strategy

	IV	Reduced form	First stage
	(T_{ic})	(T_{ic})	($\overline{T}_{-i}$)
	(1)	(2)	(3)
Tax rate of neighboring municipalities	−0.497		
	(0.223)		
Cantonal tax rate of neighboring cantons × share of municipalities		−0.140	0.282
		(0.053)	(0.052)
First-stage F-test on instrument			29.80
Observations	28,362	28,362	28,362
Number of municipalities	1,047	1,047	1,047
Number of years	27.10	27.10	27.10

Notes: The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq 10$ km). Municipalities have at least one neighboring municipality located in another canton. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Average values of neighboring municipalities are also included as controls. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

municipalities of municipalities located within a road distance of 10 km from a cantonal border. Average values of control variables for neighboring municipalities are also included in $\mathbf{X}$ with identical spatial weights to those applied to tax rates. The first column of Table 3 reports the IV estimate, while the second and third columns decompose the IV estimates into the effect of the respective instrument on the tax rate of municipality *i* ("reduced form") and its effect on the endogenous average tax rate of neighboring municipalities ("first stage"), respectively.

My central result is shown in the first column of Table 3.[28] The IV estimate implies that a 10 percentage point increase in the average tax rate of neighboring municipalities leads a municipality to *decrease* its tax rate by 5 percentage points.[29] The results do not change if no control variables or if only background characteristics of own municipalities are included in the regressions, alleviating concern over potential endogeneity of controls (see Appendix Table A1). The reduced-form estimate presented in Table 3, column 2, already identifies the existence and the nature of strategic interactions among municipalities. It is negative and quite precisely estimated. The first-stage coefficient is also statistically significant, and the F-test is well above the critical value. Note that the multiplication of the cantonal tax rate of neighboring cantons by the share of municipalities located in these cantons is crucial for the relevance of the first-stage estimation. Without this multiplication, the first-stage coefficient is null, and the F-test is far below the critical value.

The properly identified results presented in Table 3 contrast with those presented in Table 2 and lead to the opposite conclusion on the nature of the strategic tax setting among neighboring municipalities. Tax reaction functions are found to have a negative slope, and tax rates are thus strategic substitutes rather than strategic complements. Hence, positive spatial correlations found in Table 2 seem to reflect simultaneous changes in tax rates due to common shocks or correlated changes in local conditions rather than strategic decisions. My result also suggests that instrumenting the average tax rate of neighboring municipalities by the characteristics of these municipalities does not provide the exogenous source of variation required for identification.

B. *A Pairwise Approach*

In a spatial regression model, the first-stage quality of my proposed instrument depends on the share of municipalities located in neighboring cantons. It also depends on whether tax rates are strategic complements or strategic substitutes (see the discussion in Section IA). An alternative strategy is to estimate a pairwise model. Under this approach, equation (4) is estimated for all pairs of border municipalities that are located in different cantons. It is thus redefined as

$$T_{ic,t} = \alpha T_{-ic,t} + \beta' \mathbf{X}_{ic,t} + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t}, \tag{6}$$

where $T_{-ic,t}$ is the tax rate of a neighboring municipality located in another canton and γ_p is a pair fixed effect. Municipalities are paired with every canton-neighbor municipality located within a road distance of 10 km. Each pair appears twice, with

[28] The full set of estimated parameters is reported in Table A1, column 3, of the Appendix.

[29] The average value of the dependent variable, the consolidated cantonal and municipal tax rate for an unmarried taxpayer with a gross annual income of CHF 1,000,000 is 26 percent, with a minimum of 6 percent and a maximum of 35 percent.

a given municipality being once on the left-hand side and once on the right-hand side of the equation. The tax rate of the municipality on the right-hand side of the equation is instrumented by the cantonal tax rate of the canton the municipality belongs to. Identification relies specifically on cross-border strategic interactions. However, it discards from the analysis the reaction of municipality i to the tax rates of municipalities located in the same canton and sharing the same cantonal border. If tax rates are strategic substitutes, municipality i decreases its tax rate for any increase in the tax rate of a competing municipality on the other side of the cantonal border. But it decreases less if other municipalities in the same canton also decrease their tax rates. The pairwise approach does not control for these "feedback" effects. The estimate of strategic interactions should then be higher (closer to zero if taxes are strategic substitutes), provided these effects have the same sign as cross-border interactions.

Table 4 presents the results for the 5,324 municipality pairs based on a maximum road distance of 10 km. These estimates confirm the existence and the nature of strategic interactions among municipalities where taxes are strategic substitutes. Column 3 shows that the first-stage coefficient is statistically significant and almost identical to the coefficient presented in Table 3. Reduced-form and IV estimates, however, are lower (in absolute value) than the corresponding estimates in Table 3.

These two approaches can be seen as two bounds for the estimation of the magnitude of strategic interactions: a 10 percentage points increase in the tax rate of the reference group leads to a decrease in tax rate between 3 and 5 percentage points.

C. *Robustness*

The validity of the identification strategy depends crucially on the exogeneity of the instrument. Canton-level fiscal reforms have to be orthogonal to unobserved determinants of taxation of municipalities located on the other side of the cantonal border. Concerns arise mainly if cantons substitute for fiscal decisions of border municipalities or if cantons and border municipalities react to a common shock. This could be an issue especially in small cantons where a high share of the cantonal population live in border municipalities or if the capital city is located close to a cantonal border.

Table 5 presents results of the IV strategy for a subset of "large" cantons. The share of the cantonal population living in border municipalities is computed for each canton pair. In column 1, cantons in which 70 percent or more of the cantonal population reside in municipalities located at one particular cantonal border are dropped. In columns 2, 3, and 4, the maximum population share is lowered to 50 percent, 40 percent, and 30 percent, respectively. In column 5, all cantons in which the capital city is located within 10 km from the cantonal border are dropped. This excludes from the analysis four cantons in column 1, six cantons in column 2, nine cantons in column 3, 11 cantons in column 4, and 11 (different) cantons in column 5.[30] All municipalities sharing a border with these cantons are discarded.

[30] These cantons are Appenzell Innerrhoden, Appenzell Ausserrhoden, Basel-Landschaft, and Schaffhausen in column 1. In column 2, the list of excluded cantons also includes Zug and Solothurn. Column 3 further discards Nidwalden, St. Gallen, and Thurgau, while column 4 further excludes Fribourg and Neuchâtel. In column 5, Appenzell Innerrhoden, Appenzell Ausserrhoden, Basel-Landschaft, Schaffhausen, Zug, Solothurn, St. Gallen, Thurgau, Aargau, Ticino, and Luzern are discarded.

Table 4—Cross-Border Interactions: A Pairwise Approach

	IV (T_{ic}) (1)	Reduced form (T_{ic}) (2)	First stage (T_{-ic}) (3)
Tax rate of paired municipality	−0.332		
	(0.093)		
Cantonal tax rate of paired canton		−0.091	0.274
		(0.016)	(0.052)
First-stage F-test on instrument			28.18
Observations	146,236	146,236	146,236
Number of pairs	5,324	5,324	5,324
Number of years	27.50	27.50	27.50

Notes: The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. The sample contains all pairs of municipalities located in two different cantons and within a maximum road distance of 10 km. Each pair appears (at least) twice. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Values of the paired municipality are also included as controls. All estimations include pair and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by (unique) pair and by year.

Table 5—Strategic Interactions in Large Cantons

	Maximum population share at one cantonal border				
	70% (1)	50% (2)	40% (3)	30% (4)	No capital city at border (5)
Tax rate of neighboring municipalities	−0.322	−0.458	−0.753	−0.225	−0.993
	(0.179)	(0.245)	(0.385)	(0.298)	(0.397)
Reduced form					
Instrument	−0.125	−0.156	−0.179	−0.073	−0.260
	(0.064)	(0.078)	(0.078)	(0.094)	(0.090)
First-stage F-test on instrument	53.53	63.20	28.15	36.01	29.99
Observations	23,730	17,509	13,740	7,453	9,071
Number of municipalities	864	629	498	257	337
Number of years	27.50	27.80	27.60	29	26.90

Notes: In column 1, cantons in which 70 percent of the cantonal population lives in municipalities located at one particular cantonal border are dropped. In columns 2, 3 and 4, this threshold is lowered to 50 percent, 40 percent, and 30 percent, respectively. In column 4, cantons in which the capital city is located within 10 km from a cantonal border are dropped. The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. The instrument is the cantonal tax rate of neighboring cantons multiplied by the share of neighboring municipalities located in these cantons. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq$ 10 km). Municipalities have at least one neighboring municipality located in another canton. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Average values of neighboring municipalities are also included as controls. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

The first line of Table 5 reports IV estimates while the second reports reduced-form estimates. All coefficients are negative and precisely estimated, with the exception of the most restrictive specification in column 4 where the effect is identified using only 258 municipalities.[31] The baseline results are therefore robust to the exclusion of small cantons in which the exogeneity assumption is less likely to hold. Strikingly enough, the coefficient is higher (in absolute value) as one "zooms in" the larger cantons (with the exception of column 4). As expected, potential violations of the exogeneity assumption bias the estimate of strategic interactions toward zero if tax rates are strategic substitutes.

Further robustness checks are presented in Appendix B. In Appendix B, Section A, I explore alternative spatial weights and show that strategic interactions are stronger among proximate jurisdictions (see also Section IIID below). The results presented in Appendix B, Section B, indicate that municipalities react to changes in tax rates targeting high-income taxpayers but not to changes for other categories of taxpayers.

D. *The Spatial Reach of Strategic Interactions*

Table 6 explores the spatial reach of strategic interactions, that is, the distance up to which municipalities interact strategically in their tax setting. Columns 1 to 4 show how municipalities located at different distances from a cantonal border react to changes in the cantonal tax rate of neighboring cantons. For this analysis, the cantonal tax rate of neighboring cantons is not multiplied by the share of municipalities located in these cantons. Panels A to D present the associated maximum road distance D used to select neighboring cantons in the four distance bandwidths.

The results suggest that municipal tax decisions interact more the closer the municipalities are located to the cantonal border. The effect is the strongest (in absolute value) between 0 and 5 km from the border, decreases rapidly between 5 and 10 km, and increases again between 10 and 15 km. This pattern is consistent with tax rates being strategic substitutes. Municipalities between 15 and 20 km do not react to fiscal reforms of neighboring cantons, suggesting that strategic interactions are bound spatially. The spatial reach of strategic interactions can thus be estimated to be of some 15 km.[32]

E. *Heterogeneity of Strategic Interactions*

Table 7 explores whether municipalities react differently to a positive and a negative change in the tax rate of neighboring cantons. With mobile tax bases, any increase (decrease) in the cantonal tax rate of neighboring cantons and thus in the average tax rate of municipalities located in these cantons implies a positive (negative) revenue shock for municipalities located on the other side of the cantonal border. Columns 2 and 3 present the results for negative and positive changes, respectively, while columns 1 and 4 concentrate on the 50 percent most negative and positive changes.

I find that municipalities react differently to positive and negative tax rate changes by neighbors. As shown in columns 3 and 4, municipalities decrease their tax rates

[31] This is not surprising given that—with canton-year fixed effects—the identifying set of observations are restricted to cantons that share a border with at least two other cantons.

[32] This result is in line with the findings of Eugster and Parchet (2019).

Table 6—Strategic Interactions in Tax Rates for Different Distance Bandwidths

	Distance to cantonal border			
	0–5 km	5–10 km	10–15 km	15–20 km
	(1)	(2)	(3)	(4)
Panel A. D = 5 km				
Cantonal tax rate of neighboring cantons	−0.157			
	(0.047)			
Observations	13,041			
Panel B. D = 10 km				
Cantonal tax rate of neighboring cantons	−0.158	−0.066		
	(0.045)	(0.032)		
Observations	12,949	15,297		
Panel C. D = 15 km				
Cantonal tax rate of neighboring cantons	−0.162	−0.081	−0.134	
	(0.043)	(0.035)	(0.051)	
Observations	12,690	14,968	9,575	
Panel D. D = 20 km				
Cantonal tax rate of neighboring cantons	−0.169	−0.076	−0.137	0.006
	(0.041)	(0.037)	(0.052)	(0.029)
Observations	12,375	14,773	9,379	6,970
Number of municipalities	476	567	349	264

Notes: The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. In panels A to D, neighboring municipalities are municipalities within a maximum road distance of 5, 10, 15, and 20 km, respectively. Neighboring cantons are selected such that at least one neighboring municipality is located in these cantons. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Average values of neighboring municipalities are also included as controls. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

if competing municipalities increase their tax rates.[33] Interestingly, results in column 1 show that municipalities react positively to large negative shocks by reducing their tax rate (results are borderline not statistically significant with a *p*-value of 0.11). In this case, tax rates are not strategic substitutes but strategic complements. This indicates that strategic interactions among municipalities are to some extent asymmetric. The theoretical model developed in the next section helps developing intuition for this result.

IV. A Model of Residence-Based Income Tax Competition

This section theoretically investigates the strategic interaction of neighboring local jurisdictions in their setting of a residence-based income tax. I show that tax rates are strategic substitutes if the elasticity of the marginal utility of the public

[33] Small and statistically insignificant coefficients in Table 7, column 4, may be due to the small sample size.

Table 7—Heterogeneity of Strategic Interactions

	Tax change in neighboring canton			
	50% Most negative	Negative	Positive	50% Most positive
	(1)	(2)	(3)	(4)
Tax rate of neighboring municipalities	0.194	−0.392	−0.716	−0.315
	(0.121)	(0.253)	(0.314)	(0.293)
Reduced form				
Instrument	0.102	−0.159	−0.195	−0.113
	(0.062)	(0.097)	(0.084)	(0.105)
First-stage F-test on instrument	25.93	25.24	13.11	8.99
Observations	9,577	20,419	7,101	1,859
Number of municipalities	360	766	279	94
Number of years	26.60	26.70	25.50	19.80

Notes: Tax change in neighboring cantons is the average yearly growth rate of cantonal tax rates over the sample period. The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. The instrument is the cantonal tax rate of neighboring cantons multiplied by the share of neighboring municipalities located in these cantons. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq$ 10 km). Municipalities have at least one neighboring municipality located in another canton. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Average values of neighboring municipalities are also included as controls. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

good with respect to the tax rate is above one. This is notably the case in the presence of economies of scale in the provision of the local public good.

The economy is populated by a unit mass of identical individuals with exogenous income w and preference $U(c,g)$ over a private consumption good c and a locally provided public good g.[34] Individuals choose where to reside among J identical jurisdictions. In each jurisdiction j, the locally provided public good g_j is financed by a residence-based linear income tax t_j levied on the N_j jurisdiction's residents.

Local governments use total tax revenue $R_j = t_j N_j w$ to produce a local public good. The costs of providing the local public good (in units of the private consumption good) is given by a cost function $C(g_j, N_j)$ that depends on the level of the public good and the number of residents in jurisdiction j. The government budget constraint is

$$C(g_j, N_j) \leq t_j N_j w. \tag{7}$$

There are economies of scale with respect to the level of public good whenever $C(g_j,N_j)/g_j > C_g$ and economies of population scale whenever $C(g_j,N_j)/N_j > C_N$, where $C_g \equiv \partial C(g_j,N_j)/\partial g_j$ and $C_N \equiv \partial C(g_j,N_j)/\partial N_j$ are the marginal costs with respect to the level of public good and the number of residents, respectively.

[34] The utility function $U(c,g)$ is continuous, twice continuously differentiable in c and g, and strictly quasi-concave, and the marginal rate of substitution between c and g is decreasing in g.

Marginal costs are assumed to be constant such that the economies of scale (if present) are never exhausted and that there is a one-to-one mapping between a given level of public good, the number of residents, and the costs of providing the public good. The local government chooses the tax policy t_j that satisfies the budget constraint with equality and that is supported by a majority of the residents, anticipating the location decisions of the individuals and taking the tax rate of the other jurisdictions as given.[35]

A. *Location Choices*

Individuals have idiosyncratic preferences over locations. An individual i, if she decides to live in jurisdiction j, has indirect utility given by

$$V_{ij} = U\big(c_j(t_j), g_j(t_j)\big) + x_{ij},$$

where $U\big(c_j(t_j), g_j(t_j)\big)$ is the valuation of living in jurisdiction j common to all individuals and x_{ij} is the idiosyncratic valuation of location j. Note that according to individual's budget constraint, $c_j(t_j) = (1 - t_j)w$ and tax rates are chosen such that equation (7) is satisfied with equality in every jurisdiction. In what follows, the utility function is assumed to be such that $\partial V_{ij}/\partial t_j < 0$.[36]

Individual i locates in the location j that gives her higher utility than any other location j'. Assuming that x_{ij} is distributed extreme value with variance $\pi^2/6$, the fraction N_j of individuals living in jurisdiction j is given by

$$N_j(t_j, t_{-j}) = \frac{\exp V_j}{\sum_i \exp V_i}.$$

It follows that a change in the tax rate t_j of jurisdiction j has an effect on the number of residents in jurisdiction j given by[37]

$$\frac{\partial N_j}{\partial t_j} = N_j(1 - N_j)\left[\frac{\partial V_j}{\partial t_j} - \frac{\partial V_{-j}}{\partial t_j}\right] < 0,$$

and that a change in another jurisdiction's tax rate t_{-j} has an effect on the number of residents in jurisdiction j given by

$$\frac{\partial N_j}{\partial t_{-j}} = N_j N_{-j}\left[\frac{\partial V_j}{\partial t_{-j}} - \frac{\partial V_{-j}}{\partial t_{-j}}\right] > 0.$$

[35] With identical individuals, the problem of local governments amounts to maximizing the utility of the representative individual. See Eugster and Parchet (2019) for a tax competition model with heterogeneous individuals in which local governments anticipate the effects of sorting on both the provision of a public good and on the political equilibrium.

[36] In other words, the valuation of the public good is not strong enough for individuals to prefer higher tax rates.

[37] See online Appendix B for a detailed derivation of the model and more intuitions.

An increase in one jurisdiction's tax rate leads to the out-migration of the inframarginal residents with the lowest idiosyncratic preference for location j. As a consequence, the tax policy of one jurisdiction has a positive externality on other jurisdictions' tax revenue through a higher number of taxpayers. Before turning to the strategic tax setting of local governments, it is useful to derive the cross-effects in the equilibrium number of residents:

$$\frac{\partial^2 N_j}{\partial t_j \partial t_{-j}} = -\left[\frac{\partial V_j}{\partial t_j} - \frac{\partial V_{-j}}{\partial t_j}\right]^2 N_j N_{-j}(1 - 2N_j) \leq 0. \tag{8}$$

That is, the elasticity of one jurisdiction's tax base with respect to its own tax rate is non-increasing in the tax rate of another jurisdiction.

B. *Tax Rates as Strategic Substitutes*

In each jurisdiction j, the local government anticipates the effect of its tax policy on its own tax base and maximizes the utility of the representative resident, taking the tax policy in the other jurisdictions as fixed. Because the payoff function of each local government is non-decreasing in the tax policy of the other jurisdictions (through the positive tax base externality), the resulting tax competition game is a game of plain complements with the familiar result of equilibrium strategies being too low with respect to strategies that Pareto-dominate it (Eaton 2004).

Tax rates are then strategic substitutes (complements) if the *marginal* payoff function in jurisdiction j decreases (increases) in the tax rate of another jurisdiction (Bulow, Geanakoplos, and Klemperer 1985).

The marginal payoff function (MPF) of jurisdiction j is

$$MPF = w\left[-U_c + \frac{U_g}{C_g} N_j\big(1 - \varepsilon_j(1 - \sigma_j)\big)\right],$$

where U_c and U_g are marginal utilities; $\varepsilon_j \equiv -\frac{\partial N_j}{\partial t_j}\frac{t_j}{N_j} > 0$ is the elasticity of jurisdiction j's tax base with respect to its own tax rate; and $\sigma_j \equiv \frac{C_N N_j}{C(N_j, g_j)}$ is the inverse of economies of population scale.

Optimal tax rates satisfy the first-order condition $MPF = 0$ and therefore

$$N_j \frac{U_g}{U_c} = C_g\left(\frac{1}{1 - \varepsilon_j(1 - \sigma_j)}\right), \tag{9}$$

where $\frac{1}{1 - \varepsilon_j(1 - \sigma_j)}$ defines a markup over the marginal cost in the production of the local public good.

I focus on the standard case of the under-provision of the local public good with respect to the social optimum. I therefore assume that $\varepsilon_j < 1$ (i.e., I rule out revenue-increasing tax cuts), and I assume that either there is no congestion ($C_N = 0$) or, in the presence of positive congestion, there exists economies of population scale such that $0 \leq \sigma_j < 1$.

Tax rates are strategic substitutes if $\partial MPF/\partial t_{-j} < 0$. We have

$$\frac{\partial MPF}{\partial t_{-j}} = w\frac{U_g}{C_g}\left[\frac{\partial^2 N_j}{\partial t_j \partial t_{-j}} t_j(1-\sigma_j) + \frac{\partial N_j}{\partial t_{-j}}\left(1+\frac{U_{gg}}{U_g}\frac{C(g,N)}{C_g}(1-\sigma_j)\big(1-\varepsilon_j(1-\sigma_j)\big)\right)\right]. \tag{10}$$

By equation (8), $\frac{\partial^2 N_j}{\partial t_j \partial t_{-j}} \leq 0$ and by quasi-concavity of the utility function $U_{gg} < 0$. Therefore, a sufficient condition for tax rates to be strategic substitutes is

$$\left|\big(1-\varepsilon_j(1-\sigma_j)\big)\frac{C(g,N)}{C_g g_j}(1-\sigma_j)\frac{U_{gg}}{U_g}g_j\right| > 1, \tag{11}$$

where $\big(1-\varepsilon_j(1-\sigma_j)\big)$ is the elasticity of the tax revenue with respect to t_j, $\frac{C(g,N)}{C_g g_j}(1-\sigma_j)$ is the elasticity of the public good provision with respect to the tax revenue, and $\frac{U_{gg}}{U_g}g$ is the elasticity of the marginal utility of the public good with respect to the level of public good. Therefore, tax rates are strategic substitutes if the decrease in the marginal utility of the public good due to a higher tax rate is more than proportional to the change in the tax rate, that is, if

$$\varepsilon_{U_g,t_j} > 1 \tag{12}$$

where $\varepsilon_{U_g,t_j} \equiv -\big(1-\varepsilon_j(1-\sigma_j)\big)\frac{C(g,N)}{C_g g_j}(1-\sigma_j)\frac{U_{gg}}{U_g}g_j \geq 0$ is the elasticity of the marginal utility of the public good with respect to t_j.

The intuition is as follows. The marginal payoff function of jurisdiction j depends on t_{-j} through how the latter affects jurisdiction j's number of residents. This has two opposite effects. First, an increase in t_{-j} leads to an increase in N_j, which increases the marginal revenue of the tax policy in jurisdiction j: the tax policy is worth more in terms of higher marginal revenue because it is applied on a larger tax base. This is captured by the term $w\frac{\partial N_j}{\partial t_{-j}} = \frac{\partial^2 R_j}{\partial t_j \partial t_{-j}}$ in equation (10). However, the increase in t_{-j} also leads to a higher public good provision in jurisdiction j, which decreases its marginal utility. The best response of jurisdiction j to an increase in t_{-j} depends on whether by increasing its own tax rate t_j, the decrease in the marginal utility of the public good is less or more than proportional to the change in the tax rate.

C. *Discussion*

It is common in the literature to assume that the marginal utility of the public good and marginal cost of the public good are both in fixed proportion to the level of public good. In this restrictive case, $\varepsilon_{U_g, t_j} = \left(1 - \varepsilon_j(1 - \sigma_j)\right) < 1$ and tax rates are strategic complements.[38] Suppose, instead, the existence of economies of scale in the production of the public good through the existence of fixed costs (read: infrastructure). A simple cost function (with no congestion) is given by $C(N_j, g_j) = g_j + \beta_c$, where β_c is the fixed cost to provide the public good. Suppose also a Stone-Geary utility function $U(c_j, g_j) = (1-\delta)\ln(c_j) + \delta \ln(g_j - \beta_g)$, where β_g is a minimum public consumption level. Then, an increase in the tax revenue leads to a more than proportional increase in the public good, and the marginal utility of the public good decreases more than proportionally to the level of the public good.[39] The sufficient condition for tax rates to be strategic substitutes becomes simply

$$\frac{\beta_c + \beta_g}{R_j} > \varepsilon_j,$$

that is, tax rates are strategic substitutes if the share of the tax revenue devoted to the minimum public good consumption level *and/or* to the fixed costs in the production of the public good is larger than the elasticity of the tax base.

An Estimation of the Elasticity of the Tax Base.—To assess the plausibility of the above condition in the Swiss context, it is necessary to estimate the elasticity of the tax base with respect to local income tax rates. In what follows, I make use of my proposed identification strategy and instrument local income tax rates with neighbor-canton tax rates. In particular, I modify the pairwise model presented in Section IIIB to estimate a cross-canton spatial difference model of the form

$$\nabla \ln B_{ic,t} = \alpha \nabla \ln T_{ic,t} + \beta' \nabla \mathbf{X}_{ic,t} + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t}, \tag{13}$$

where ∇ denotes cross-canton spatial differences between all pairs of municipalities located in two different cantons and within a road distance of 10 km. The term $B_{ic,t}$ is the taxable income reported for the federal income tax in municipality i at year t.[40] Further, γ_p is a pair fixed effect and $\delta_{c,t}$ is a (origin) canton-year fixed

[38] The same conclusion is reached if one assumes that local governments maximize their tax revenue.

[39] Interestingly, if one assumes a CES instead of a Stone-Geary utility function, then $\left|\frac{U_{gg}}{U_g} g_j\right| = \frac{1-\varepsilon_{U,g}}{\rho}$ where $0 < \varepsilon_{U,g} \equiv \frac{\partial U}{\partial g}\frac{U}{g} < 1$ and ρ is the elasticity of substitution between the public and the private good. It follows that $\left|\frac{U_{gg}}{U_g} g_j\right| > 1$ only if the public and the private good are close complements, that is if $\rho < 1$. This is the result developed in Vrijburg and de Mooij (2016).

[40] The federal income tax statistics provide the only measure of taxable income that is perfectly comparable across municipalities as the federal code applies identically across all jurisdictions. These statistics encompass all households paying the federal income tax, thus excluding households with income below a certain threshold (approximately 20 percent of all households in 2010). Data are available on a two-year basis before 1999 (praenumerando system) and on a yearly basis afterward (postnumerando system). In the praenumerando system, the taxable income corresponds to the average income earned during the two preceding years of all households residing in a given municipality at the beginning of the fiscal period (January 1). I thus assign the taxable income of a given fiscal period to the preceding year (e.g., 1984 for the fiscal period 1985/1986, 1986 for the fiscal period 1987/1988, and so on). In the postnumerando system, the taxable income corresponds to the income earned during the same year of households residing in a given municipality at the end of the year (December 31).

effect. The cross-canton spatial difference in consolidated tax rates, $\nabla \ln T_{ic,t}$, is then instrumented with the lagged tax differential between the two neighboring cantons $\nabla \ln T_{c,t-1}$.[41]

Results are presented in Table 8. Column 1 reports the OLS estimate while columns 2 to 4 detail the results of the IV estimation strategy. I find an elasticity of the tax base with respect to local income tax rates of 0.42, a result lower than in other studies for Switzerland but higher than, e.g., for the United States.[42] Note that the OLS estimate (0.49) is close to the IV estimate, probably because the spatial differencing controls already for confounding spatially correlated local shocks.

This elasticity of the tax base must be compared with the share of the tax revenue devoted to minimum public good consumption and/or fixed costs. Many services provided by local governments, such as the local road network, sanitation, primary education, and fire and police protection, are arguably "necessary" for the functioning of the collectivity. They also entail nontrivial investment in infrastructure, paving the way for economies of production scale.[43] Moreover, government workers' wages can plausibly be considered as "committed" expenditures for local governments. In Switzerland, at the local level, expenditures that could reasonably be deemed as "fixed" or "committed" (at least in the short run) account for 55 percent of local fiscal and non-fiscal revenue (excluding grants from upper-level government levels).[44] This is more than the estimated elasticity of the tax base. As informed by the theoretical model, the empirical result of tax rates as strategic substitutes is therefore fully consistent with my setting.[45]

[41] This cross-canton pairwise approach combined with an instrumental variable strategy is methodologically close to, e.g., Chirinko and Wilson (2008); Rathelot and Sillard (2008); and Duranton, Gobillon, and Overman (2011) who study the effect of local taxation on business location in the United States, in France, and in the United Kingdom, respectively.

[42] For Switzerland, Brülhart and Parchet (2014) reports an elasticity of the gross income with respect to cantonal income tax rates for retired taxpayers of 0.52 (see Table 4 in their paper). Martínez (2017) reports an increase of 6.1 percent in the number of top 1 percent income taxpayers in the canton of Obwalden after a reform in 2006 increasing the net-of-tax rate for this group by 3 percent, leading to an elasticity of 2 (see Table 3, panel A, in her paper). Her results imply an elasticity of the number of top 1 percent income taxpayers with respect to the income tax rate of approximately 0.86 (for a before-reform keep rate of 70.5 percent). For the United States, Moretti and Wilson (2017) reports an elasticity of the stock of star scientists with respect to the net-of-average income tax rate of 0.4. This translates into an elasticity with respect to the income tax rate of approximately 0.19 (based on an average income tax rate for the top 1 percent income taxpayers of 32 percent).

[43] See Duncombe and Yinger (1993) for empirical evidence of economies of scale in fire protection.

[44] According to the financial statistics for municipalities for the period 1990–2014, compensation to employees represents 36 percent of fiscal and non-fiscal revenue, consumption of fixed capital 13 percent, and interest payments 5 percent. Note that social benefits (10 percent) were left aside even if they are mostly formula-based and could therefore enter the category of "committed" expenditure. Financial statistics are classified according to the Government Finance Statistics (GFS) model of the IMF.

[45] Other features of the Swiss fiscal system makes the empirical result also plausible. First, fiscal capacity equalization schemes (as opposed to revenue-sharing transfers) subsidize local taxation by increasing transfers to local governments whenever their tax base decreases. As a consequence, a jurisdiction that faces a decrease in its tax base through a more competitive environment finds it less costly to increase its tax rate, which will further reduce its tax base. Koethenbuerger (2011) analyzes the choice by local governments to optimize over expenditure levels or tax rates in the presence of different fiscal transfer schemes. He shows that under fiscal capacity equalization schemes, local governments choose to optimize over expenditure levels and to adjust their tax rates residually. Tax rates are therefore strategic substitutes following the prediction by Wildasin (1988, 1991). Interestingly, fiscal capacity equalization transfers are found not only in Switzerland but also in Canada, Sweden, Denmark, and Germany (at the municipality level). Second, balance budget requirements at the municipality level may also reinforce an expenditure-preservation strategy. In several cantons, "debt-brake" measures limit the taxation of municipalities. Under these rules, current budget deficits have to be amortized in the next budget, which must be balanced (see Casellini and Parchet 2018). Municipalities are then arguably more likely to increase their tax rate following a decrease in

TABLE 8—THE ELASTICITY OF THE TAX BASE: A PAIRWISE APPROACH

	OLS ($\nabla\ln B_{ic,t}$) (1)	IV ($\nabla\ln B_{ic,t}$) (2)	Reduced form ($\nabla\ln B_{ic,t}$) (3)	First stage ($\nabla\ln T_{ic,t}$) (4)
$\nabla\ln T_{ic,t}$	−0.495	−0.419		
$\nabla\ln T_{c,t-1}$	(0.054)	(0.108)		
			−0.122	0.292
			(0.030)	(0.026)
First-stage F-test on instrument				124.3
Observations	94,840	94,700	94,700	94,700
Number of pairs	5,324	5,324	5,324	5,324
Number of years	17.80	17.80	17.80	17.80

Notes: The dependent variable is cross-canton spatial difference of the log taxable income between paired municipalities. The sample contains all pairs of municipalities located in two different cantons and within a maximum road distance of 10 km. Each pair appears (at least) twice. The taxable income is given by the federal income tax statistics. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. All estimations include pair and (origin) canton-year fixed effects. Standard errors in parentheses are clustered two ways—by (unique) pair and by year.

Source: Federal Tax Administration, Bern

V. Conclusions

This paper proposes to make use of a multi-tier federal system to identify strategic interactions among local tax policies. Using tax reforms in the upper-level neighboring jurisdiction as an instrument, I can identify strategic interactions among lower-level jurisdictions across an upper-lever jurisdictional border. This strategy is applied to Swiss municipalities and could also be taken to other federal countries, such as the United States, where different levels of governments tax a common base. It could potentially also be extended to other settings, provided the conditions for the exclusion restriction are fulfilled.

In contrast to most existing findings, my results indicate that municipal tax reaction functions mostly have a negative slope, and that tax rates are therefore strategic substitutes. I develop a simple residence-based personal income tax competition model and show that tax rates are strategic substitutes if the elasticity of the marginal utility of the public good with respect to the tax rate is above one. Tax rates are strategic substitutes notably in the presence of economies of scale in the production of the local public good.

The result of this paper has important implications for tax coordination policies. The existence of resource-flow tax competition among local jurisdictions implies that local tax rates can be inefficiently low. Moreover, tax dispersion might result in a spatial misallocation of resources and to welfare losses that are potentially important (Fajgelbaum et al. 2019). However, tax coordination policies among independent

their tax base due to a more competitive environment, rather than to preserve their tax base by lowering their tax rate (which should be compensated by further expenditure reductions).

jurisdictions depends on whether tax rates are strategic complements or strategic substitutes. Standard results in the literature on welfare-enhancing partial tax unions (Konrad and Schjelderup 1999) and commitments in a sequential decision making with a pre-play stage (Kempf and Rota-Graziosi 2010) have been typically derived under the assumption of strategic complementarity. Simulation results by Vrijburg and de Mooij (2016) suggest that if tax rates are strategic substitutes, tax union might result in a welfare loss due to the strategic reaction of jurisdictions outside the union. Commitment in sequential decision making will also be different if tax rates are strategic substitutes, as policy games with plain complements and strategic substitutes typically feature a first-mover advantage instead of a second-mover advantage (Eaton 2004). The implications for tax coordination are left for future research.

This paper also shows that tax rates are strategic substitutes for positive and small negative tax rate changes by neighbors but strategic complements if municipalities face large tax cuts. Informed by the theoretical model, the hypothesis that emerges is that municipalities have, on average, a large share of their tax revenue devoted to "fixed" or "committed" public expenditure and increase their tax rates for small negative tax changes by neighbors, even if this negatively affects their tax base. However, municipalities lower their tax rate if their neighbors lower tax rates significantly (one might be tempted to say "aggressively"), suggesting that they might readjust their "fixed" or "committed" expenditure level and primarily target the preservation of their tax base. Future research could fruitfully investigate the implications of "expenditure commitment" for tax competition, taking insights from the literature on consumption commitment that stresses the asymmetry between small and large income shocks (see, e.g., Chetty and Szeidl 2007; Postlewaite, Samuelson, and Silverman 2008).

Appendix A. Supplementary Figures and Tables

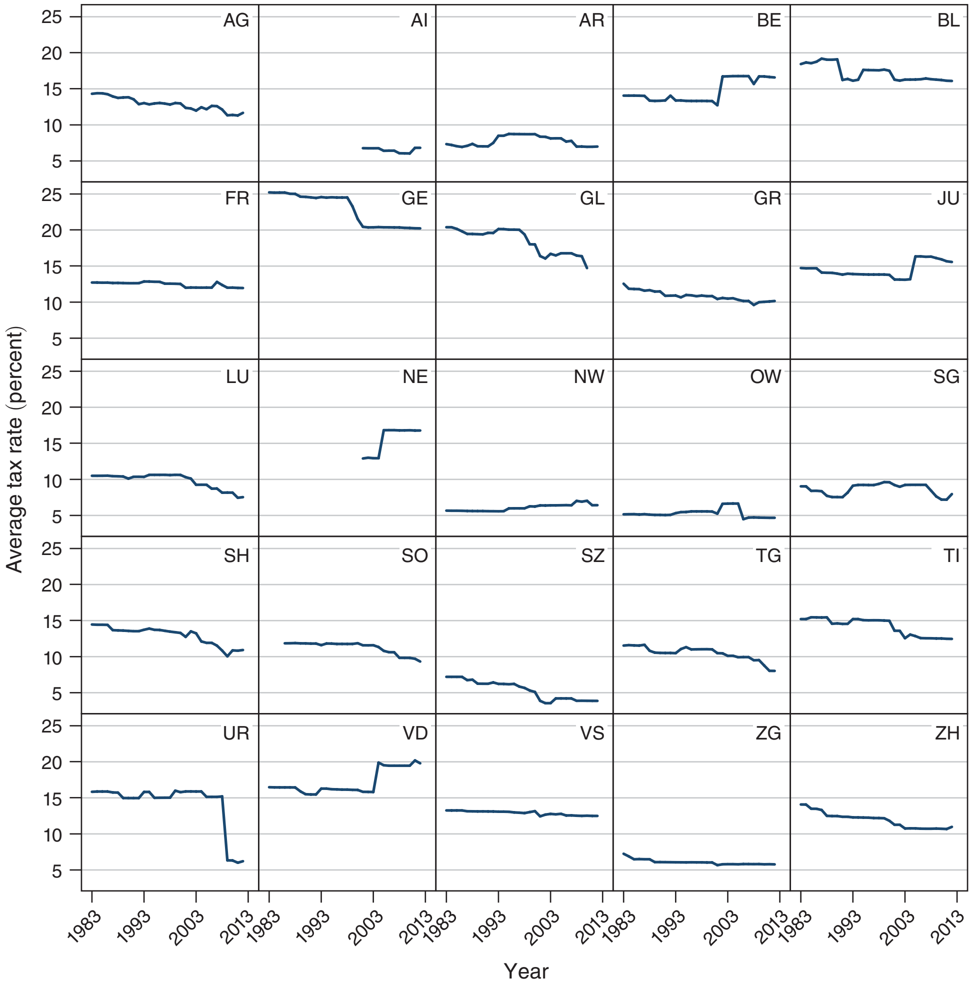

Figure A1. Evolution of the Cantonal Personal Income Tax Rate for an Unmarried Taxpayer with Gross Annual Income of CHF 1,000,000

Note: Cantonal tax rates are computed using the methodology described in online Appendix A.

Table A1—Strategic Interactions in Tax Rates

	No controls (1)	**X** (2)	**X**, $\overline{\mathbf{X}}$ (3)
Tax rate of neighboring municipalities	−0.569	−0.478	−0.497
	(0.261)	(0.232)	(0.223)
Population		−0.080	−0.128
		(0.061)	(0.063)
Percent foreigners		0.031	0.025
		(0.010)	(0.009)
Percent young (≤ 20)		0.003	0.006
		(0.009)	(0.008)
Percent old (≥ 65)		−0.033	−0.023
		(0.022)	(0.021)
Percent secondary sector		−0.035	−0.029
		(0.007)	(0.006)
Percent tertiary sector		−0.026	−0.019
		(0.007)	(0.006)
Unemployment rate		0.024	0.023
		(0.020)	(0.019)
Total employment (per capita)		−0.342	−0.445
		(0.495)	(0.472)
Percent votes for left-of-center parties		−0.007	−0.005
		(0.004)	(0.004)
Number of movie theaters within 10 km		−0.001	−0.012
		(0.011)	(0.015)
Population in neighboring municipalities			0.180
			(0.144)
Percent foreigners in neighboring municipalities			0.091
			(0.045)
Percent young (≤ 20) in neighboring municipalities			0.024
			(0.038)
Percent old (≥ 65) in neighboring municipalities			−0.200
			(0.102)
Percent secondary sector in neighboring municipalities			−0.025
			(0.018)
Percent tertiary sector in neighboring municipalities			−0.072
			(0.029)
Unemployment rate in neighboring municipalities			0.039
			(0.069)
Total employment (per capita) in neighboring municipalities			2.780
			(1.672)
Percent votes for left-of-center parties in neighboring municipalities			−0.005
			(0.006)
Number of movie theaters within 10 km in neighboring municipalities			−0.017
			(0.029)
First-stage *F*-test	24.53	26.03	29.10
Observations	28,362	28,362	28,362
Number of municipalities	1,047	1,047	1,047
Number of years	27.10	27.10	27.10

Notes: The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. The instrument is the cantonal tax rate of neighboring cantons multiplied by the share of neighboring municipalities located in these cantons. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq 10$ km). Municipalities have at least one neighboring municipality located in another canton. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

Appendix B. Robustness Checks

A. *Alternative Spatial Weights*

In Table B1, I explore alternative specifications of spatial weights w_{ij}. Column 1 repeats for convenience the baseline result of Table 3. Column 2 follows the assumption that interactions are stronger the closer municipalities are in terms of road distance. Thus, inverse-distance weights are defined as

$$w_{ij}^{D} = \begin{cases} \dfrac{\frac{1}{d_{ij}}}{\sum \frac{1}{d_{ij}}} & \text{if } d_{ij} \leq D \text{ km} \\ 0 & \text{otherwise.} \end{cases}, \tag{B1}$$

Spatial weights in column 3 are defined according to relative population. If large municipalities act as "leaders," more weight should be given to neighboring municipalities that are larger in terms of population:

$$w_{ij}^{P} = \begin{cases} \dfrac{\frac{pop_j}{pop_i}}{\sum \frac{pop_j}{pop_i}} & \text{if } d_{ij} \leq D \text{ km} \\ 0 & \text{otherwise.} \end{cases}, \tag{B2}$$

A last specification assumes that jurisdictions react not to the average tax rate of neighboring municipalities but to the lowest tax rate:

$$w_{ijt}^{M} = \begin{cases} 1 & \text{if } T_{jt} = \min(T_{kt}) \,\forall k,\, d_{ik} \leq D \text{ km} \\ 0 & \text{otherwise.} \end{cases}, \tag{B3}$$

In columns 2 and 3, newly defined average tax rates of neighboring municipalities are instrumented with the cantonal tax rate of neighboring cantons, multiplied with the share of the total distance, respectively population, represented by municipalities in these cantons. In column 4, the instrument is the minimum cantonal tax rate of neighboring cantons.

The results suggest that strategic interactions are more intense among municipalities that are geographically close. Both IV and reduced-form estimates are higher (in absolute value) in column 2 than the baseline of column 1. Coefficients in column 3, where large municipalities are assumed to be dominant players, are slightly lower (in absolute value) than in the baseline. In the last column, municipalities are found to react to the lowest tax rate among their neighboring municipalities. The first-stage F-test indicates, however, that instruments are rather weak leading to an upward biased (in absolute value) and more imprecise IV estimate. The weak instrument problem in this case arises because the lowest consolidated tax rate is not necessarily found in the neighboring canton with the lowest cantonal tax rate.

Table B1—Alternative Spatial Weights

	Spatial weights			
	Uniform w^U (1)	Distance w^D (2)	Population w^P (3)	Minimum w^M (4)
Tax rate of neighboring municipalities	−0.497	−0.634	−0.358	−0.852
	(0.223)	(0.207)	(0.187)	(0.570)
First-stage F-test on instrument	29.80	47.39	34.28	5.55
Observations	28,362	28,362	28,362	27,522
Number of municipalities	1,047	1,047	1,047	1,026
Number of years	27.10	27.10	27.10	26.80

Notes: The dependent variable is the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. In column 1, the instrument is the cantonal tax rate of neighboring cantons multiplied by the share of neighboring municipalities located in these cantons. In columns 2 and 3, the cantonal tax rate is multiplied by the share of total distance, respectively population, represented by municipalities in neighboring cantons. In column 4, the instrument is the lowest cantonal tax rate among neighboring cantons. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq 10$ km). Municipalities have at least one neighboring municipality located in another canton. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Average values of neighboring municipalities are also included as controls. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

Table B2—Tax Competition for Different Categories of Taxpayers

	Consolidated cantonal and municipal tax rate							
	Unmarried taxpayer with gross annual income of CHF				Married taxpayer with 2 children with gross annual income of CHF			
	50,000 (1)	100,000 (2)	500,000 (3)	1,000,000 (4)	50,000 (5)	100,000 (6)	500,000 (7)	1,000,000 (8)
Tax rate of neighboring municipalities	−0.378	−0.185	−0.387	−0.497	0.049	−0.093	−0.277	−0.452
	(0.329)	(0.242)	(0.196)	(0.223)	(0.120)	(0.137)	(0.175)	(0.197)
Reduced form								
Instrument	−0.061	−0.040	−0.121	−0.140	0.009	−0.021	−0.077	−0.138
	(0.048)	(0.050)	(0.054)	(0.053)	(0.021)	(0.031)	(0.046)	(0.053)
First-stage F-test on instrument	11.32	15.37	33.44	29.80	14.99	20.71	39.87	34.83
Observations	28,362	28,362	28,362	28,362	28,362	28,362	28,362	28,362
Number of municipalities	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Number of years	27.10	27.10	27.10	27.10	27.10	27.10	27.10	27.10

Notes: The instrument is the cantonal tax rate of neighboring cantons multiplied by the share of neighboring municipalities located in these cantons. Neighboring municipalities are municipalities within a maximum road distance of 10 km ($D \leq 10$ km). Municipalities have at least one neighboring municipality located in another canton. All estimations include population, percent of foreigners, percent of young and old people, percent of employees in the secondary and tertiary sectors, total employment (per capita), unemployment rate, percent votes in favor of left-of-center parties, and number of movie theaters within 10 km as controls. Average values of neighboring municipalities are also included as controls. Spatial weights are uniform. All estimations include municipality and canton-year fixed effects. Standard errors in parentheses are clustered two ways—by municipality and by year.

B. *Tax Competition for Different Categories of Taxpayers*

Thus far, my dependent variable has been the consolidated cantonal and municipal tax rate on personal income for an unmarried taxpayer with a gross annual income of CHF 1,000,000. Table B2 presents the results for unmarried taxpayers and married taxpayers with two children, each with a gross annual income of CHF 50,000, 100,000, 500,000, and 1,000,000.[46]

I find that strategic interactions are indeed identified for high-income unmarried taxpayers but not for other income classes. IV estimates are negative for all categories (except one) but statistically significant only for unmarried taxpayers with a gross income of CHF 500,000 and CHF 1,000,000 and married taxpayers with two children and a gross annual income of CHF 1,000,000. This finding suggests that municipalities react only to changes in the cantonal tax schedule that affect top-income taxpayers who presumably are the most mobile.

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[46] A gross annual income of CHF 50,000 corresponds approximately to the median income over the period 1983–2010. A gross annual income of CHF 100,000 corresponds to the top 10 percent, a gross annual income of CHF 500,000 to the top 0.5 percent, and a gross annual income of CHF 1,000,000 to the top 0.1 percent.

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