Does Tax Competition Tame the Leviathan?*

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Abstract

We study the impact of tax competition on equilibrium taxes and welfare, focusing on the jurisdictional fragmentation of federations. In a representative-agent model of fiscal federalism, fragmentation among jurisdictions with benevolent tax-setting authorities unambiguously reduces welfare. If, however, tax-setting authorities pursue revenue maximization, fragmentation, by pushing down equilibrium tax rates, may under certain conditions increase citizen welfare. We exploit the highly decentralized and heterogeneous Swiss fiscal system as a laboratory for the estimation of these effects. While for purely direct-democratic jurisdictions (which we associate with relatively benevolent tax setting) we find that tax rates increase in fragmentation, fragmentation has a moderating effect on the tax rates of jurisdictions with some degree of delegated government. Our results thereby support the view that tax competition can be second-best welfare enhancing by constraining the scope for public-sector revenue maximization.

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1 Introduction

Is tax competition good or bad for the wellbeing of society? This has been a question of concern to federal states for as long as taxpayers have been free to settle in whatever part of their country they pleased. And as lucrative tax bases are becoming ever more mobile across national borders too, this issue is fast rising towards the top of the international policy agenda. The main opposing arguments are straightforward. Advocates of tax harmonization think of governments as essentially benevolent maximizers of social welfare, whose ability to offer the optimum level of public goods is undermined by the erosion of their tax base. Conversely, those who view tax competition as a force for good consider governments as self-interested revenue maximizers, whose voracity may be constrained by tax competition. These are stock arguments in debates concerning tax coordination, such as on the taxation of e-commerce across US states, on harmonization of value added taxes and corporate taxes in the European Union, or on the definition of "harmful tax competition" by the OECD.

Research in this area abounds.[1] Economic theory provides elegant statements of the conditions under which tax competition may be a force for good or a force for bad. Edwards and Keen (1996), for example, show that the net welfare effect of tax competition hinges on the relative magnitude of two parameters: the marginal excess burden of taxation and the government's marginal ability to divert tax revenue for its own uses. Such parameters, however, elude precise measurement. Empirical work has therefore focused on indirect approaches, based on observable variables. The most prominent strategy, initiated by Oates (1972, 1985), is to study the relationship between government size and "decentralization", where decentralization is understood alternatively as the share of sub-federal government in consolidated revenues or expenditure (centralism), or as the number of sub-federal governments (fragmentation).[2] This approach draws its working hypothesis from Brennan and Buchanan's (1980) description of governments as revenue-maximizing Leviathans, whose tax raising powers could be held in check by decentralization. Negative partial correlations between government size and decentralization were therefore interpreted as evidence in support of the Leviathan view, and, implicitly at least, of the conjecture that tax competition is a force for good. It has come

[1] See Wilson and Wildasin (2004) for a comprehensive survey.

[2] Important later contributions to this literature include Nelson (1987), Wallis and Oates (1988), Zax (1989) and Forbes and Zampelli (1989). For a survey, see Feld, Kirchgässner and Schaltegger (2003).

to be recognized, however, that this approach faces a major identification problem, because negative partial correlations between government size and decentralization are also predicted by a model of horizontal tax competition among fully benevolent governments - in which case tax competition is welfare reducing.[3] Hence, regressing government size on decentralization does not allow conjectures on underlying government objectives or on the welfare consequences of tax competition. Recognizing the interpretational ambiguity besetting much of the existing empirical literature, Epple and Nechyba (2004, p. 2463) note that "the work stimulated by Oates addresses the issue of whether spending falls with increased competition, but does not address the issue of whether resources are used more efficiently as competition increases". Similarly, Wilson and Wildasin (2004) conclude their survey with the observation that "more work is needed to incorporate reasonable political processes into tax competition models, leading to sharper empirical distinctions between good and bad tax competition".

In this paper we seek to advance towards that aim through two main contributions. First, we address the difficulty of distinguishing good from bad tax competition in a way that is tied rigorously to the theory. We derive a reduced-form relationship which involves only observable variables and maps monotonically into welfare effects, drawing on a model of fiscal federalism in the vein of Keen and Kotsogiannis (2002). In this model too, the difference between welfare-improving and welfare-reducing tax competition hinges on largely unobservable structural parameters. However, we can establish the following simple prediction: if the relationship between states' "smallness" and the equilibrium state tax rate is positive for states that have relatively benevolent governments, and if, other things equal, this same relationship turns negative for states that have less benevolent governments, then the latter effect can be interpreted as evidence of welfare-increasing "Leviathan taming" in these states. The intuition is straightforward. The smaller a state j, the less it internalizes the externalities created by its choice of tax rate on the tax base of other jurisdictions, both horizontally (i.e. for the other states in the federation, whose tax base shrinks if state j lowers its tax rate) and vertically (i.e. for the federal government, whose tax base increases if state j lowers its tax rate). Smallness therefore exacerbates distortions created by externalities. Dominant horizontal externalities lead to state taxes that are too low, while vertical externalities push towards state taxes that

[3] This has in fact first been pointed out by Oates (1985, footnote 2) himself, as he stated that "other sorts of models besides Leviathan could produce such an outcome".

are too high. If smallness is *positively* correlated with state tax rates set by relatively *benevolent* governments, this implies that the dominating externality pushes towards equilibrium state taxes that are too high. If smallness is at the same time *negatively* correlated with tax rates among *Leviathan* states, all else equal, this implies that smallness (i.e. tax competition) must be a good thing for the citizens of those states, as it countervails both their governments' intrinsic desire to overtax and the externalities pushing towards excessively high taxes.

An empirical evaluation of this prediction requires extraneous information on the benevolence of government. Our second main contribution is to exploit an empirical setting that allows us to distinguish *a priori* between government objectives across jurisdictions. We compile a detailed new data set of local taxation in Switzerland, which offers a propitious laboratory for research on tax competition thanks to the exceptional institutional diversity and fiscal autonomy of Swiss sub-federal jurisdictions. With its three hierarchically nested layers of government (central, cantonal and municipal), Switzerland can be considered a federation of federations, thus allowing identification from variation between as well as within federations (cantons). Another feature of the Swiss data is that they allow us to classify jurisdictions by the benevolence of their governments, where we associate benevolence with the intensity of direct-democratic control in matters of local taxation. We thereby have empirical measures for all the variables that appear in the theoretical prediction we wish to test.

We estimate the impact of government benevolence on the relationship between local tax rates and the relative smallness of jurisdictions, controlling for differences in revenue needs, locational attractiveness and systemic idiosyncrasies. A GMM estimator is employed to allow for unobserved spatial dependence. We find that, if they have benevolent governments, relatively smaller jurisdictions set higher equilibrium tax rates, but that this relationship is reversed in jurisdictions with greater scope for governmental revenue maximization. Hence, our estimation results coincide with the theoretical prediction. Our empirical specification allows us to interpret this finding as evidence that tax competition lowers equilibrium taxes *because* governments are Leviathans, and the underlying theory identifies this as evidence of beneficial tax competition. We thereby overcome the interpretational ambiguity of prior empirical work.

Our paper contributes to some additional issues raised in the literature. One recurrent theme in empirical research following Oates (1985) concerns the appropriate definition of "decentralization", the metric for the intensity of tax competition. We plead in favor of the fragmentation version: while, to the extent that governments are benevolent, relative sizes of federal and subfederal government budgets are endogenous, the number of jurisdictions, and thus the relative size of a representative jurisdiction, can more plausibly be treated as exogenous with respect to citizens' *fiscal* preferences.[4] We therefore model the intensity of tax competition via differences in states' smallness, in terms of their population shares, and we treat the fiscal share of the subfederal government level as an endogenous variable.

By allowing for fiscal interdependencies not only among same-level governments but also among different hierarchically nested government layers, our analysis furthermore takes account of the fact that the standard model of purely horizontal tax competition is increasingly inappropriate as a framework for analyzing non-coordinated tax setting in many real-world contexts. Both fiscal decentralization from national to sub-national governments and (to an as yet lesser extent) delegation of fiscal competencies from national governments to supranational institutions are evident global trends.[5]

The configuration studied in this paper is therefore not specific to the Swiss case. In general, vertical externalities are more likely to dominate the smaller is the sub-federal fiscal share. Average revenues of our subfederal jurisdictions (municipalities) amount to some 70% of corresponding federal (canton) revenues, which is a relatively high sub-federal fiscal share in international comparison.[6] The scope for vertical externalities should therefore be rather greater in many other federations. In addition, even the "Leviathan" governments in our Swiss data are subject to direct-democratic controls via voluntary referendums, which means that elected officials still enjoy comparatively little leeway to pursue their self-serving aims. Other nations' sub-federal jurisdictions likely exhibit greater scope both for both vertical externalities and revenue maximization than Swiss municipalities, and hence our results imply that there is even greater scope for Leviathan-taming tax competition in many other federations.

[4] Fragmentation represents the standard approach for modelling the intensity of tax competition in theories of fiscal federalism and Leviathan governments (see, e.g., Epple and Zelenitz, 1981; Keen and Kotsogiannis, 2003; Eggert and Sørensen, 2008). We consider the possibility of endogenous jurisdictional smallness in our estimations. Note that our definition of *jurisdictional* fragmentation differs from the fragmentation of the budgetary process in a single jurisdiction, studied e.g. by Perotti and Kontopoulos (2002).

[5] See Epple and Nechyba (2004) for a survey of the theoretical and empirical literature on fiscal decentralization.

[6] According to taxpolicycenter.org, 2006 US state own-source tax revenue corresponded to some 40% of federal tax revenue, while the relative size of of local tax revenue to state tax revenue ranged from 18% (Vermont) to 115% (Florida).

Finally, our study is related to a growing literature that seeks to establish how different democratic institutions shape policy outcomes. The impact of direct democracy represents one of the key themes in this research area. In a comprehensive survey of this literature, Besley and Case (2003, p. 45) put the central insight as follows: "the possibility of initiatives forces greater agreement between voter preferences and policy outcomes, assuming that representatives elected to the legislature have views that are out of step with the citizens at large". In the same vein, Matsusaka (2005) concludes that "direct democracy works", precisely because it mitigates agency problems between voters and potentially Leviathan governments. Gerber (1996) and Besley and Coate (2000) model how the availability of direct-democratic instruments will push policy outcomes towards the preferences of the median voter. This proposition is supported empirically by Gerber (1999) and Matsusaka (2004, 2007), based on extensive analyses of US data.[7] Our contribution is to explore the effect of direct democracy on local taxation via its interaction with fiscal externalities. This causal link has not, to our knowledge, been studied before.

The paper is organized as follows. Section 2 sketches the theoretical model underlying our analysis and presents the estimable predictions. In Section 3, we discuss our estimation strategy and describe the empirical setting. Regression results are reported in Section 4, and Section 5 offers a concluding summary and discussion.

2 Theory

2.1 Leviathan taming in a fiscal federation

The theoretical framework informing our estimation strategy is a "small open federation" variant of the model developed by Keen and Kotsogiannis (2002). We allow for heterogeneous government objectives and state sizes while retaining the assumptions that private agents hold identical preferences and that there is a single mobile tax base. The details of the model are presented in Appendix A. Here, we offer a verbal summary of its main features and of the testable prediction used to identify welfare-improving Leviathan-taming tax competition

[7] Based on data for the Swiss cantons, Feld and Matsusaka (2003) and Funk and Gathmann (2005) find that direct democracy acts as a brake on public expenditure. Frey and Stutzer (2000) even report that, *ceteris paribus*, residents of more direct democratic cantons are happier than those of cantons with more strongly delegated government.

empirically.

We consider a federation with a central government and N fiscally autonomous sub-federal states j. These states are alike in all respects bar their size and their governments' preferences. The single taxable production factor is perfectly mobile among states as well as between the federation and the outside world. States share an identical production technology featuring decreasing returns. Owners of the production factor consider returns on their factor from within and from outside the federation as imperfect substitutes, which implies that equilibrium rates of return will be equalized among states but might differ between the federation and the rest of the world.

The federal and state governments tax the production factor at rates T and t_j respectively. Tax receipts are transformed into publicly provided goods, from which residents derive positive utility.[8] State governments can be (a) purely benevolent, in which case their objective function coincides with citizens' utility function, (b) pure Leviathans, in which case their only objective is to maximize tax receipts, or (c) they can hold intermediate preferences, where the Leviathan parameter $\mu_j \in [0, 1]$ represents the weight they attribute to revenue maximization.[9]

Equilibrium state tax rates t_j^* are suboptimal from the point of view of citizens except for knife-edge configurations. Since all fiscal externalities intensify as states get smaller, we take the relative "smallness" of states (defined as one minus their population share in the federation) as a metric for the intensity of tax competition. We can identify four effects that determine the equilibrium level of state tax rates relative to the social optimum t_j^{opt}:

- a *Leviathan effect*, which pushes up t_j for all state sizes (as higher μ_j implies greater government appetite for tax revenues),
- a *horizontal tax externality*, which pushes down t_j as states get smaller (the standard "race to the bottom" effect),

[8] This model abstracts from vertical transfers. Below we show that transfers are essentially negligible in our empirical application.

[9] Keen and Kotsogiannis (2003) model the Leviathan by assuming that some exogenously given fraction of tax revenues are used for expenditure that benefits only the government itself. Adopting this modeling approach would not change our main results. Eggert and Sørensen (2008) represent Leviathans as pursuing vote maximization through rents offered to public-sector employees, who have a positive weight in the social welfare function. It turns out that this leads to qualitatively equivalent conclusions regarding the desirability of horizontal tax competition to those identified by Edwards and Keen (1996) and therefore to those implied in our model as well.

- a *vertical tax externality*, which pushes up t_j as states get smaller (as smaller states internalize to a lesser extent the positive externality they bestow upon the federal government via low t_j), and

- a *tax exporting effect*, which pushes t_j up or down depending on whether a particular state is an importer or an exporter of the mobile factor (as the tax burden may or may not be imposed on out-of-state residents).

It can be shown that, with purely benevolent governments, intensified tax competition via smaller state size will reduce welfare, irrespective of the dominant tax externality.[10] However, even the parsimonious model studied here does not allow for analytical results on the welfare implications of state size for positive values of the Leviathan parameter.[11] This reflects the difficulty of linking (observable) tax effects of changing state size to (unobservable) welfare effects, which in turn represents the central intellectual challenge this paper seeks to address.

We can, however, identify a mapping from tax effects of state sizes to welfare in one particular configuration. This mapping is established through two propositions and a conjecture.[12]

Proposition 1 *Suppose that, for a given level of Leviathan government preferences ($\mu_j = \overline{\mu}$), intensified tax competition implied by smaller state size leads to higher equilibrium tax rates. In that case tax competition is unambiguously welfare reducing.*

The logic of this result is as follows. If equilibrium tax rates rise as states get smaller, this must mean that vertical tax externalities dominate the horizontal tax externalities, as they are the only force pushing towards higher taxes as states get smaller. Combined with the tendency of Leviathans to overtax irrespective of state size, this implies suboptimally high state tax rates.

Proposition 2 *Suppose Proposition 1 holds for an interior value $\overline{\mu} < 1$. Then there exists a pivotal level $\mu_j^* > \overline{\mu}$, above which intensified tax competition implied by smaller state size leads to lower equilibrium tax rates.*

[10] This mirrors the result of Keen and Kotsogiannis (2004). The formal proof of this result in our specific setting can be provided on request.

[11] One exception should be noted. Keen and Kotsogiannis (2003) show that tax competition between *purely Leviathan* governments is unambiguously welfare improving in the special case where federal and state-level public goods are perfect substitutes.

[12] Formal statements and proofs are provided in Appendix A.

How is it possible that the relationship between state size and the tax rate switches sign as μ_j increases? The intuition is as follows. The more Leviathan a state government, the less it cares about federally financed public goods, since federal funds are assumed to be distributed equally to all citizens without transiting through state budgets. As a result, the vertical externality loses force as μ_j increases. In the limit, for a pure Leviathan state, the existence of the upper-level government is irrelevant to the relationship between smallness and chosen state tax rates. Hence, if the vertical externality is strong for a relatively benevolent state government, leading taxes to rise in state smallness, the relative force of this externality will be reduced if that state government becomes more Leviathan, leading equilibrium state taxes to fall in smallness.

Finally, we can formulate the following conjecture, which maps Proposition 2 into welfare.

Conjecture 1 *Suppose Proposition 1 holds for one set of states. Suppose that, for an otherwise identical set of states with more strongly Leviathan governments ($\mu_j = \overline{\overline{\mu}} > \mu_j^*$), smaller state size is associated with lower equilibrium tax rates. In this case, intensified tax competition implied by smaller state size is unambiguously welfare improving for all the states with high μ_j.*

This conjecture is based on extensive simulations reported in Appendix B. It is the main result informing our empirics, as it allows us to make welfare statements based on observed relationships between tax rates, state sizes and government types.

Conjecture 1 states that the fall in equilibrium tax rates beyond the pivotal level of Leviathanism, μ_j^*, will be welfare enhancing for all state sizes. This is illustrated in Figure 1, which plots the deviation of equilibrium state tax rates from their optimum ($t_j - t_j^{opt}$) against different levels of smallness.[13] When governments are purely benevolent ($\mu_j = 0$) and there is only one sub-federal state, the state tax rate is optimal ($t_j = t_j^{opt}$). Negative correlations between tax rates and smallness have sometimes collectively been interpreted as evidence of Leviathan taming. It turns out that taxes fall in smallness irrespective of government preferences in all cases where horizontal externalities dominate. In those configurations, increasing

[13] Simulations suggest that the relationships depicted in Figure 1 are mostly convex with respect to smallness. In addition, the crossing points of the t_j functions for different levels of μ_j under dominant vertical externalities may occur at different levels of smallness. We abstract from such details of functional form, the graph serving a purely expositional purpose.

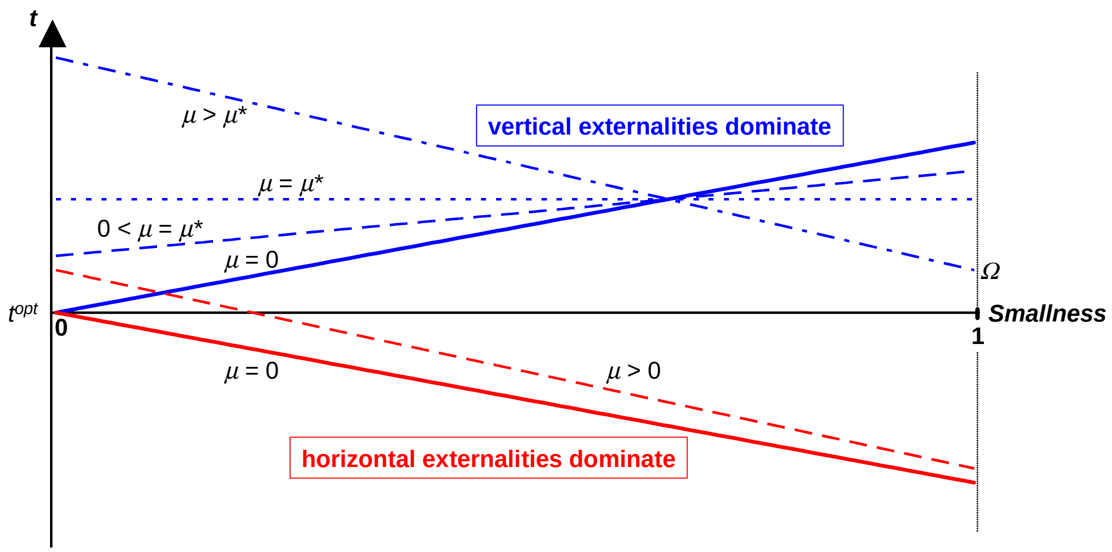

Figure 1: Smallness, Leviathan and equilibrium tax rates

smallness (i.e. tax competition) can be a good or a bad thing, depending on whether t_j is above or below t_j^{opt}. Traditionally, regressions of government size on decentralization were (at least implicitly) predicated on the assumption that t_j is above t_j^{opt}, but this is not something that can be ascertained empirically. Hence the usefulness of the case where equilibrium tax rates rise in smallness for μ_j up to a pivotal level μ_j^*, but fall in smallness for μ_j above μ_j^*. In that case, Conjecture 1 states that smallness (i.e. tax competition) is an unambiguous force for good for all $\mu_j > \mu_j^*$, as t_j is monotonically lowered by increasing smallness towards t_j^{opt}, but t_j never falls below t_j^{opt}, i.e. the equilibrium tax rate under dominant vertical externalities is never lower than the first-best tax rate t_j. In terms of Figure 1, Conjecture 1 is equivalent to stating that Φ will not lie below the horizontal axis.

2.2 Fragmentation

The key variable driving the intensity of tax externalities in our model is the relative smallness of states, whereas the related empirical literature uses two different exogenous variables, fragmentation and centralism.

Our definition of smallness can be taken as a measure of *fragmentation*, because, from the point of view of a representative state, a fragmented federation implies relatively small states. The model clearly shows that observed inverse relationships between tax rates and fragmentation are not sufficient to infer Leviathan governments. However, it also offers an analytically rigorous version of the popular view that intensified competition from increased fragmentation can "tame the Leviathan" (without constraining it excessively), provided that vertical externalities dominate when state governments are relatively benevolent.

The empirical Leviathan literature has paid considerable attention to *centralism*, i.e. the allocation of fiscal powers between the federal and state government levels. This is represented by the ratio of federal and state-level expenditures, which, with balanced budgets, is related (albeit not necessarily equal) to the ratio of average tax rates t/T. The parameters that determine the equilibrium state tax rate and the equilibrium federal tax rate will also determine the ratio t/T. This means that equilibrium level of centralism depends in part on citizens' fiscal preferences. Unlike fragmentation, the degree of centralism should not therefore be considered as an exogenous determinant of the intensity of tax competition.[14]

What about the exogeneity of smallness? Jurisdictional definitions may be endogenous with respect to taxation in certain settings (Perroni and Scharf, 2001), especially in the context of single-purpose districts (Hoxby, 2000). Our analysis is based on general-purpose jurisdictions with historically predetermined boundaries, such that jurisdictions' size in geographic terms can reasonably be taken as exogenous. Smallness in population terms, however, may in reality be to some extent influenced by tax rates. We return to this issue in the empirical part.

3 Empirical setting

3.1 The regression model

The model of fiscal federalism described above implies:[15]

$$t_{jk} = f\left(n_{jk}, \mu_{jk}, T_k, \mathbf{t}_{-j,k}\right) | \mathbf{x}_{jk}, \tag{1}$$

where j again indexes states, k denotes different federations, n_{jk} represents smallness, and

[14] See also Wilson and Janeba (2005), who study how the choice of t/T may be used strategically by the central government to minimize the distortions arising from the interplay of horizontal and vertical tax externalities. Note that, notwithstanding our assumption (spelt out in Appendix A) that T is independent of the distribution of investor-firms across states, T is likely to be influenced by t.

[15] Specifically, see equations (7) and (11) in Appendix A.

$\mathbf{X}_{jk}$ represents state-level and federation-level idiosyncrasies in revenue needs and tax-base elasticities.

A negative relationship between state tax rates and smallness could reflect (a) the dominance of horizontal externalities and relatively benevolent governments, or (b) the presence of Leviathan state governments. According to the theory, a positive relationship would in turn point unambiguously to dominant vertical externalities.

If underlying state government objectives (μ_{jk}) are measurable, the natural empirical specification becomes:

$$t_{jk} = \beta_0 + \beta_1 n_{jk} + \beta_2 \mu_{jk} + \beta_3 \left(n_{jk} * \mu_{jk}\right) + \beta_4 T_k + \gamma \bar{t}_{-j,k} + \mathbf{X}_{jk} \boldsymbol{\delta} + u_{jk}, \quad (2)$$

where $\bar{t}_{-j,k}$ is a weighted average of neighboring state tax rates, and u_{jk} is a stochastic disturbance.

The estimated coefficient $\widehat{\beta}_1$ represents the (inverse of the) tax effect of size for relatively benevolent governments ($\mu_j = \overline{\mu} = 0$).[16] If $\widehat{\beta}_1 > 0$, vertical externalities dominate at $\overline{\mu}$, and Proposition 1 applies. The coefficient $\widehat{\beta}_3$ then quantifies the differential effect of smallness on state tax rates for "relatively Leviathan" governments ($\mu_j = \overline{\overline{\mu}} > 0$). This will be our main coefficient of interest.

According to Conjecture 1, if $\widehat{\beta}_1 > 0$, $\widehat{\beta}_3 < 0$, and $\widehat{\beta}_1 + \widehat{\beta}_3 < 0$, we can infer that tax competition tames the Leviathan and increases social welfare. We call this "*strong Leviathan taming*": stiffer tax competition from increased smallness improves welfare in Leviathan states. Another possible parameter configuration is $\widehat{\beta}_1 > 0$, $\widehat{\beta}_3 < 0$, but $\widehat{\beta}_1 + \widehat{\beta}_3 \geq 0$. We refer to this as "*weak Leviathan taming*". In this case, stiffer tax competition from increased smallness is less harmful in Leviathan states than in relatively benevolent states.

Some additional issues:

- Governments are unlikely to admit that they do not pursue citizens' welfare, hence μ_{jk} is not directly observed. Our basic assumption is that decisions in municipalities with greater scope for direct democratic participation in the tax setting process are more likely to correspond to the benevolent policy, whereas more indirect democratic control

[16] For our empirical purposes, we treat μ as a dummy variable, setting the lower-bound value $\overline{\mu}$ equal to zero.

offers greater leeway to Leviathan governments.[17]

- Estimation of (2) requires variation in μ_{jk} and in n_{jk} (N). This is most likely to be found in a comparison of multiple federations, which ideally should be similar to each other in all other relevant respects. Note that for the identification of the effect illustrated in Figure 1, we do not need to observe the full spectrum of μ_{jk}, but only some instances of $\mu_{jk} > \mu^*_{jk}$ and some instances of $\mu_{jk} < \mu^*_{jk}$.

- The theoretical model assumes states to be identical except for their size. Empirical estimation needs to control for relevant asymmetries across states, such as revenue needs, preferences for public goods, tax base elasticities and locational advantages. Hence, state-level control variables $\mathbf{X}_{jk}$ are included in (2).

- The reduced-form configuration we seek to take to the data is independent of the way the federal tax rate is set.[18] However, the federal tax rate T_k is unlikely to be independent from state tax rates - be it via strategic interactions between the two governments levels, or through state- and federation-specific exogenous features that drive both t and T. Likewise, t_j and t_{-j} will be interdependent. Such interdependence could for instance be the result of yardstick competition, whereby citizens of a jurisdiction inform their choices by observing tax decision in surrounding jurisdictions. We will address this issue by instrumenting T_k and $\bar{t}_{-j,k}$.

- t_{jk} could be spatially correlated in a way that is not explained by the model, i.e. via spatial dependence among u_{jk}. We therefore use the spatial GMM estimator proposed by Conley (1999), which applies a distance weighting up to some bound to the off-diagonal elements of the covariance matrix while allowing us to keep instrumenting the endogenous regressors.[19]

- We consider the inclusion of federations' *centralization ratios* as an additional control variable, by way of a robustness check and for comparability with the relevant empirical

[17] This assumption finds strong theoretical and empirical support - see the references to the relevant literature in the Introduction.

[18] Note that the vertical externalities considered in our model are of the "bottom-up" type: fiscal choices of sub-federal states are affected *by the existence* of a federal layer, irrespective of the strategic interaction between governements at different hierarchical levels.

[19] We choose a distance bound of 15 km. Sensitivity tests show the value of this bound to be unimportant for our qualitative results.

literature (but without being warranted by the theory). Centralization is measured as the ratio of state revenues to consolidated (state + federal) revenues. In view of the evident endogeneity issue, we instrument this variable.

- We express all non-dichotomous variables in natural logs, so that the estimated coefficients can be interpreted as elasticities.

3.2 Switzerland: a laboratory for research on tax competition

Although the reduced-form predictions we seek to put to the test could conceivably also be estimated on data for other federal systems, Switzerland presents a particularly propitious empirical setting. The Swiss fiscal constitution distinguishes three largely autonomous jurisdictional layers (national, cantonal and municipal). Each jurisdictional layer collects a roughly equal share of total tax revenues.[20] We will concentrate on the cantonal and municipal levels. Direct taxation at both these levels of government encompasses four conventional tax bases: personal income and wealth, and corporate income and capital.[21] Personal income is by far the most important tax base, accounting for over 70% of municipal and over 60% of cantonal tax revenues. Summary statistics are given in Tables 1 and 2.

Several institutional features make Switzerland particularly well suited to our study:

- *Multiple federations*: The three-tier fiscal constitution implies that Switzerland can be considered as a federation of federations. We will take cantons to represent the federations (k) of our empirical model, while municipalities represent the states (i, j). Switzerland is divided into 26 cantons, which in turn contain between 3 (Basel Stadt) and 404 (Berne) municipalities.[22]

- *Different degrees of direct democracy*: There is substantial variation across municipalities and cantons in the intensity of direct democratic involvement in the tax setting process. Measures of this intensity serve as our proxy for μ_j. We distinguish three categories: "*assembly*" municipalities that set taxes via show of hands at town hall meetings of

[20] Over our sample period 1985-2001, revenue shares have remained fairly constant at some 30, 40 and 30 percent for the national, cantonal and municipal government levels, respectively (Feld *et al.*, 2003).

[21] In contrast to many other countries, property taxation is small even at the local level.

[22] These numbers refer to 1995. The total number of municipalities is in slow decline, as micro-municipalities (some with populations below 100) are encouraged to merge. Since our sample includes 131 relatively large municipalities, such changes do not affect our data.

the entire citizenry and are thus associated with the lowest values of μ_j; "*referendum*" municipalities, whose constitutions feature compulsory referenda on fiscal decisions above certain thresholds and are associated with intermediate values of μ_j; and a residual "*Leviathan*" category of municipalities where fiscal matters are largely under the control of elected executives.

- *Overlapping tax bases*: Tax bases are identical within each canton, since they are determined by the cantonal tax law. Moreover, even across cantons, tax bases are very similar, as the information to determine the national tax base is drawn from tax forms used to report to the cantonal authorities.

- *Fiscal autonomy*: In spite of considerable harmonization of tax *bases* across cantons, cantonal authorities enjoy full autonomy in choosing tax *rates*. Most cantons use the following procedure to set taxes. The cantonal tax law determines a tax schedule on the four tax bases. This schedule determines the level and progressivity of each tax instrument. The cantonal authorities annually decide on a multiplier that shifts the base tax schedule, determining the effectively applied cantonal tax. Most cantons fix a single multiplier across all tax bases. Similarly, most municipalities annually set a single multiplier, which, applied to the cantonal tax schedule, determines the effectively applied municipal tax. This particular procedure implies that cantonal and municipal authorities concentrate their decisions on tax bases with the highest impact on tax revenue (i.e. personal income taxes). Reflecting the high degree of cantonal and municipal tax setting autonomy, tax rates and schedules vary substantially across cantons and municipalities. For example, the highest municipal income tax rate recorded in our database exceeds the lowest one by a factor of five, for a given level of income (see also the standard deviations reported in Table 2).

- *Small transfers*: Although vertical and horizontal fiscal transfers do exist in Switzerland, they are small. According to national statistics, net average vertical transfers represent less than 2 percent, and net horizontal transfers less than 4 percent, of total municipal revenue.

3.3 Data

We have collected a panel data set of municipal and cantonal tax rates and control variables for the years 1985, 1991, 1995, 1998 and 2001. The dataset covers up to 130 municipalities.

The information underlying our categorization of municipalities by degree of direct democracy in fiscal matters is taken from a survey conducted in the mid-1990s.[23] Among our sample municipalities, 38 are identified as assembly municipalities, 36 as referendum municipalities and 56 Leviathan municipalities. We construct two alternative dummy variables, denoted by $\widetilde{\mu}$, and their associated data samples. In the "referendum sample", the dummy variable is set to 0 for all assembly or referendum municipalities, and to 1 for the remaining (Leviathan) municipalities. In the "assembly sample", the dummy variable is set to 0 only for the assembly municipalities, while the referendum municipalities are dropped. Hence, the assembly sample has a smaller number of observations but a larger implied distance between $\widetilde{\mu} = 0$ and $\widetilde{\mu} = 1$. $\widetilde{\mu}$ exhibits useful variance, as it differs among many same-canton municipalities as well as between cantons: while the total sample standard deviation of $\widetilde{\mu}$ is 0.49 (referendum sample, see Table 1), the within-canton standard deviation still amounts to 0.30.

Since $\widetilde{\mu}$ features as a regressor in our empirical model, it is implicitly assumed to be an exogenous feature. As pointed out e.g. by Besley and Case (2003), institutions are ultimately endogenous too. $\widetilde{\mu}$ could depend on, or be simultaneously determined with, t in two evident ways. On the one hand, local communities might push for more direct democracy if delegated governments chronically overspend, in which case high (lagged) t is associated with low $\widetilde{\mu}$. On the other hand, the predominantly conservative mentality of certain local electorates could simultaneously induce lower t and a lower $\widetilde{\mu}$. One way to address this issue would be to draw on intertemporal changes in decision-making institutions, and to control for lagged and time-invariant location specific effects. Democratic institutions, however, have a habit of being highly persistent. No changes in the decision-making systems of our sample municipalities had occurred at least up to 2000 (Micotti and Bützer, 2003). Additional evidence on the stability over time of direct democratic institutions in Swiss cantons is provided by Feld and Matsusaka (2003). The durability of the institutional structure to some extent mitigates concerns about

[23] These data were collected for the study by Feld and Kirchgässner (2001). We are very grateful to Lars Feld for sharing them with us.

endogeneity. Moreover, the controls in our regression models capture the main fault lines in Swiss political culture (different language groups, young versus old voters, rural versus urban regions, and low-lying versus mountain regions).[24]

Since most municipalities set a single multiplier on the cantonal tax schedule, our main focus is on a revenue-weighted average of standardized versions of a representative set of effective tax rates. We call this aggregate the "*tax index*". Both municipal and cantonal tax indices have mean zero by construction. Specifically, the tax index is constructed as the revenue weighted mean of effective average tax rates for nine representative tax payers, covering both personal income and wealth and corporate income and capital.[25]

The *smallness* of a municipality is defined relative to its canton as $n_{jk} = 1 - \frac{P_{jk}}{P_k}$, where P_{jk} is the population of municipality j in canton k, and P_k is the respective cantonal population. For the population measures, we consider only residents with Swiss citizenship, since what we seek to represent is municipalities' political weight in the canton.

A range of control variables are included in all estimated equations (see Table 1 for summary statistics).

- Theory suggests that we should control for the respective *cantonal tax rates*, the equivalent of T. In addition, we control for the spatially weighted *tax rates of other municipalities*, $\bar{t}_{-j}$, so as to capture direct strategic interactions among municipalities. $\bar{t}_{-j}$ is constructed as the average tax index of all municipalities excluding j, weighted by the inverse of the square of their euclidean distance from j.[26] Both these variables are instrumented via two-stage least squares with three identifying canton-level variables, the canton population living in urban areas, cantonal area and the canton's number of municipalities. The instrument sets furthermore include spatially weighted averages of all exogenous municipality-level variables.

[24] Feld and Matsusaka (2003), in regressions at canton level, furthermore control for the parliamentary strength of left-wing parties, to control for "ideology"; and they instrument $\widetilde{\mu}$. Neither of these extensions affects their results in any substantial way.

[25] We used ANOVA to characterize the levels and shapes of tax schedules with a parsimonious set of representative tax payers. Three representative cases were identified to describe tax schedules on personal income, two cases were identified for wealth taxes, three cases were identified for corporate income taxes, and one case was identified for capital taxes. See Brülhart and Jametti (2006) for further details.

[26] Application of linear spatial weights changes none of our qualitative findings. We prefer square weights given previous findings on spatial decay functions based on intra-national migration (e.g. Schwartz, 1973) and commuting (e.g. Harsman and Quigley, 1998). Note that these control variables may also capture horizontal tax-competition effects that transgress canton borders.

- Further controls are warranted to allow for differences in municipalities' public revenue needs. We include regressors measuring municipal *population*, the share of *population under 20*, the *share of population over 65*, municipal *area*, and a dummy for municipalities that represent *urban centers*. Municipal area captures two effects: it implies revenue needs for transport and communication services, and it is strongly positively correlated with the mountainousness of municipalities.

- Variables are added to control for differences in municipalities' locational attractiveness, and thus their inherent appeal to potential tax payers: *distance to the nearest freeway*, *distance to the nearest international airport*, and *length of lake shore within the municipality.*

- A dummy for the *Latin* (i.e. French and Italian speaking) cantons controls attitudinal differences between those cantons and the German speaking majority.

- Although most municipalities enjoy complete autonomy in setting their tax rates, there are some exceptions. Five of the 26 cantons have *harmonized municipal tax rates* on corporate income and capital, whilst leaving municipalities' freedom to set personal taxes unconstrained. We therefore include a dummy that equals one for the relevant cantons and taxes.[27]

4 Results

4.1 Baseline regressions

Our baseline spatial GMM estimation results of the empirical model (2) are shown in Table 3, separately for the referendum definition and for the assembly definition of $\widetilde{\mu}$. In order to facilitate the comparison of effect sizes, we also report standardized (beta) coefficients. The diagnostic tests for overidentifying restrictions and weak instruments, reported in the last three rows of Table 3, are satisfactory.

[27] We deliberately do not include canton fixed effects, since such fixed effects would pick up most of the variability in T_k and thus introduce endogeneity bias. However, some institutional idiosyncracies require additional controls. We include a dummy for the canton of Geneva, which features joint taxation and a special revenue sharing arrangement between cantonal and municipal authorities; and for the canton of Basel-Land, which places restrictions on municipal tax autonomy.

We first concentrate on the results based on the referendum definition (first results column of Table 3), which encompasses our full data set. The model performs well. All statistically significant coefficients on the control variables conform with expectations: urban centers and remote municipalities (measured by distance to the nearest airport) have relatively high taxes; while municipalities with long lake shores and those located in the Latin regions have relatively low taxes.[28] The positive coefficient on spatially weighted tax rates of surrounding municipalities suggests that tax rates are strategic complements, consistent with our theoretical assumption.

Our main parameters of interest are those represented in the first three rows of the table. We find the main effect of smallness to be positive (although not statistically significant). This is consistent with the scenario underlying Propositions 1 and 2: for relatively benevolent municipalities ($\widetilde{\mu} = 0$), vertical externalities dominate ($\frac{\partial t_j}{\partial p_j} < 0$).[29]

Our estimation also confirms that direct-democratic fiscal powers represent a valid proxy variable for revenue maximization: the coefficient on the Leviathan dummy ($\widetilde{\mu}$) is statistically significantly positive. This means that at the point where smallness is zero, i.e. where intra-cantonal tax competition cannot exist, less direct-democratic municipalities have significantly higher average tax rates than more direct-democratic ones. The size of this effect is considerable, as it implies that, without intra-cantonal tax competition, Leviathan municipalities' average tax rate is 45 percent ($= e^{0.37} - 1$) higher than that of otherwise identical benevolent municipalities.[30]

Our third and most important empirical result is that we find a negative coefficient on the interaction variable between $\widetilde{\mu}$ and smallness. Hence, greater scope for Leviathan government reduces the tax-raising effect of smallness. Stated in reverse: fragmentation, while yielding inefficiently high equilibrium tax rates for benevolent municipalities, acts as a counterweight to the desire for high taxes on the part of Leviathan municipalities. The coefficient on the

[28] While consolidated (municipal plus cantonal) tax rates are generally higher in the Latin cantons, municipal taxes tend to be lower, reflecting a higher degree of centralism in those cantons.

[29] The negative coefficient on the harmonized-tax dummy provides additional evidence for the existence of vertical externalities: canton-wide tax harmonization drives municipal tax rates down rather than up.

[30] Looking at raw means in the full data set (Table 1), we observe that Leviathan municipalities, have slightly *lower* average tax rates than benevolent municipalities. This may seem paradoxical, but it is of course entirely consistent with a model where differences in tax levels are determined also by different exogenous revenue needs and interdependencies among jurisdictions. Inference should therefore be based on an empirical model that controls for relevant covariates.

interaction between $\widetilde{\mu}$ and smallness being larger in absolute value than the coefficient on smallness suggests the presence of what we have termed “strong Leviathan taming”, which in turn implies that fragmentation is (second-best) welfare improving in so far as the Leviathan municipalities are concerned. In a statistical sense based on a Wald test of $\widehat{\beta}_1 + \widehat{\beta}_3 = 0$, however, we cannot reject the null that Leviathan taming is merely of the “weak” form: stiffer tax competition induced by increased smallness is at least less harmful for Leviathan municipalities than for benevolent municipalities.

The second data column of Table 3 displays results for regressions with the narrower definition of “benevolence”, where $\widetilde{\mu}$ is set to zero only for municipalities that make fiscal decision via a vote by an assembly of the entire citizenry, and municipalities with intermediate (i.e. referendum based) systems are left out. We observe that this changes our main results in the expected way. The coefficient on smallness increases by a factor of more than three and becomes statistically significant. The main effect of the Leviathan dummy is again statistically significantly positive, and its magnitude is considerably larger, which is in line with the starker difference between $\widetilde{\mu} = 0$ and $\widetilde{\mu} = 1$ under the assembly definition. The estimated coefficient implies that a municipality which faces no intra-cantonal tax competition will raise its tax rate by fully 148 percent ($= e^{0.91} - 1$) if it switches from a system based on compulsory fiscal referenda to a system with delegated fiscal authority. Our main interest again concerns the slope-shifting effect of $\widetilde{\mu}$. This coefficient increases by a factor of 2.4 (from -2.95 to -7.19), and it remains statistically significantly negative. The interaction effect also remains larger in absolute terms than the main effect of smallness, which is consistent with strong Leviathan taming, although this difference again is not statistically significant. The results obtained for the assembly definition confirm those found in the larger data set underlying the referendum definition, and they are somewhat crisper still. This is in line both with our mapping of decision-making systems to μ and with the predictions of the theory, as the institutional distance between $\widetilde{\mu} = 0$ and $\widetilde{\mu} = 1$ is larger with the assembly definition than with the referendum definition.

4.2 Extensions

We consider a number of extension to the benchmark estimations of Table 3, concentrating on the full data sample based on the referendum definition.

First, we consider a number of alternative specifications using spatial GMM. One might reasonably suspect reverse causality to affect smallness, if population flows were sufficiently sensitive to tax differentials that in practice smallness were to a significant extent determined by tax burdens. We address this issue alternatively by replacing the population-based measure of smallness by its area-based equivalent (Table 4, first data column), and by instrumenting smallness and its interaction term (second data column). Our qualitative results turn out not to be affected. Point estimates on smallness and on the interaction terms of smallness with $\widetilde{\mu}$ retain their signs but are larger in absolute value. The net effect of smallness for Leviathan municipalities remains negative, which is consistent with strong Leviathan taming. This effect is statistically significant when we instrument for smallness.[31]

A second extension is to augment our baseline specification with instrumented centralization ratios (Table 4, third and fourth data columns). Inclusion of this variable is not warranted by the theory, but we consider it by way of a robustness test and for comparability of our results to those of related empirical studies. While the coefficients on centralization themselves are not statistically significant, the main effect and the interaction effect of smallness again retain their signs. Strong Leviathan taming continues to be supported. We therefore conclude that the centralism variable is not itself significant and does not qualitatively change our results.

As a further robustness check, we estimate the baseline model using two-stage least squares, which remains unbiased in the presence of spatial autocorrelation in u_{jk} but is less efficient than spatial GMM. The results are shown in Table 5. Moran's I, computed on the residuals and reported in the bottom row of Table 5, strongly supports the presence of spatial error dependence, validating our choice of spatial GMM as the principal estimator. As expected, most coefficients are less precisely estimated with two-stage least squares than with spatial GMM. None of our qualitative results, however, depends on the choice of estimator: point estimates and standard errors are similar to those of our baseline regressions in Table 3 and

[31] When we instrument smallness with its area-based equivalent (second data column of Table 4), the first-stage F statistics for the interaction term are small, suggesting weak instruments. Results for this specification therefore ought to be interpreted with some caution.

to the additional specification reported in Table 4. We again find evidence that is consistent with strong Leviathan taming, which in two cases is statistically significant.

Finally, we estimate the baseline model separately for the nine representative tax bases that underlie the construction of our tax indices. Although most municipalities decide on a single multiplier that shifts tax schedules symmetrically for all tax bases, it might be interesting to specify the regressions as if the municipal choices were independent across tax bases. Table 6 reports the main and interaction effects of smallness and $\widetilde{\mu}$ for the assembly and referendum definitions of $\widetilde{\mu}$ respectively. We continue to find satisfactory statistics on overidentifying restrictions, but first-stage F tests suggest weak instrument problems for a majority of regression runs. The estimated coefficients for the three representative personal income taxes (which, we recall, account for about 70% of municipal tax revenues) are qualitatively similar. They all suggest that vertical externalities dominate the tax choices of municipalities governed by citizens' assemblies, implying inefficiently high tax rates of relatively small municipalities, while the remaining (Leviathan) municipalities see their tax rates reduced by smallness, suggesting a salutary effect of tax competition in their case. In five out of the six regression runs concerning tax rates on personal income, we find statistically significant evidence of strong Leviathan taming, the sum of the coefficients on smallness and $\widetilde{\mu}$*smallness being statistically significantly negative. Interestingly, the most important of all the representative tax bases (married household with median income) provides the strongest evidence of strong Leviathan taming, with all three relevant coefficients having the appropriate signs as well as being statistically significant (t statistics on main and interaction effects of Smallness, and Wald statistic on the sum of the main + interaction effects of smallness).[32]

5 Conclusions

In "Oates regressions", jurisdictional fragmentation is often found to be associated with lower tax rates. Traditionally, it has been difficult to read a clear interpretation into such results, because a negative partial correlation between fragmentation and tax rates could represent

[32] As a further robustness test, we re-estimated the model using only "interior" municipalities, which do not border another canton. This is to explore whether interactions across canton borders, which would be more relevant to border municipalities than to interior municipalities, confound our results. Our substantive findings turn out to be robust to this manipulation. Detailed results can be obtained from the authors.

either (second-best efficient) Leviathan taming via horizontal tax competition, or a race to the bottom away from the socially optimal tax rates. This paper offers a theory-driven empirical reassessment of Oates's approach.

We show that the interpretational ambiguity can be overcome when one considers a model of fiscal federalism featuring vertical as well as horizontal tax externalities, and when one can draw on extraneous information on the democratic constraints on tax-setting authorities at the sub-federal level. According to the theory, tax-rate reducing competition among jurisdictions with some degree of Leviathan government behavior is welfare improving if, all else equal, competition among more benevolent jurisdictions would have raised equilibrium tax rates.

We employ data on tax setting in Swiss municipalities and cantons for an assessment of this prediction. A sizeable subsample of Swiss municipalities set tax rates by direct democratic participation of the citizenry, which constrains local executives to behave "benevolently". We find that, for these direct-democratic municipalities, the basic relationship between relative "smallness" and average tax rates is positive: the smaller they are, the higher their tax rates. This is consistent with dominant vertical externalities in a model of tax competition among benevolent jurisdictions in federal systems.

Our central finding is that, other things equal, the relationship between fragmentation and tax rates turns negative (or at least not significantly different from zero) for the municipalities with less direct democracy and more delegated fiscal authority. Hence, we infer in this case that tax rates fall (or at least do not rise) in fragmentation *because* these municipalities offer some scope for Leviathan government behavior. Set against the theory, we can interpret this finding not only as evidence of Leviathan taming via jurisdictional fragmentation but also as a manifestation of welfare-enhancing tax competition.

The flip side of our central finding, of course, is that the significant impact of fragmentation on the taxes of direct-democratic municipalities implies welfare-reducing distortions from (vertical) tax externalities. Coordinated tax setting by benevolent governments remains the first-best policy. However, to the extent that there are constitutional or other limits on the feasibility of direct-democratic participation in sub-federal fiscal policy making, our analysis suggests that the competitive pressures arising from sub-federal jurisdictional fragmentation are likely to be welfare enhancing.

How general is this result? As discussed above, the conditions for beneficial tax competition seem if anything more likely to hold in many other contexts than our Swiss data set. First, many real-world federations (e.g. US states or EU member countries) have considerably smaller sub-federal fiscal shares than Swiss cantons, and thus even greater scope for dominant vertical tax externalities.[33] Second, given the pervasiveness of direct-democratic institutions in Switzerland, most sub-federal governments enjoy considerably greater leeway for revenue maximization than Swiss municipal authorities. Hence, there is reason to expect even greater scope for Leviathan-taming tax competition in many other federations.

Could this extrapolation from our data set be tested empirically? The critical component are observable differences in institutional constraints at the sub-federal level. Although the extent of sub-national institutional diversity observed in Switzerland may well be unique in the world, empirically exploitable variation exists in other federations as well. Romer and Rosenthal (1982), and Farnham (1990), for example, have exploited differences in the availability of citizens' initiatives at the level of US communities in a study of local expenditure levels. As an alternative, one might use the closeness of local election results as an inverse proxy for the latitude local politicians enjoy to make decisions that diverge from the median voter's preferences. Such an approach finds support in the results found by Besley and Case (2003), whereby stronger party competition in US state legislatures yield lower tax burdens; and in those obtained by List and Sturm (2006), according to which more narrowly elected state governors try harder to satisfy the preferences (in terms of environmental spending) of their electorate.

There are some evident limits to the generality of our study. By adopting a representative-agent framework with a single tax base, our analysis has abstracted from welfare effects arising through Tiebout sorting, through policy interactions concerning multiple tax bases, through expenditure-side inefficiencies such as waste induced by red tape in large centralized bureaucracies, through differential policy responses among jurisdictions of unequal intrinsic attractiveness to the mobile tax base, or through different forms of indirect democracy.[34] Moreover, explicit consideration of horizontal and vertical fiscal transfers might be warranted in alterna-

[33] See also the calculations based on parameters for the US economy by Keen and Kotsogiannis (2002, 367f.), indicating that dominance of vertical externalities among US states is a real possibility.

[34] On the last three effects, see, respectively, Bandiera, Prat and Valletti (2008), Cai and Treisman (2005) and Janeba and Schjelderup (2008).

tive empirical settings.

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A Appendix: A model of taxation in a fiscal federation

A.1 Basic structure

Consider a federation with $N \geq 1$ states. Each state j is populated by M_j investor-firms.[35] Hence, the federation's total population is given by $\sum_{j=1}^{N} M_j = M$. Investor-firms determine the within-federation, per-firm supply (S) and demand (K) of a perfectly mobile production factor.[36] Firms use an identical concave production technology $F(K_j)$, with $F' > 0$ and $F'' = c < 0$, implying that the slope of the demand for capital does not depend on the tax rate. The net-of-tax rate of return ρ of the factor is determined in a federation-wide capital market. The factor is taxed by federal and state governments at rates T and t_j respectively, with $\tau_j = T + t_j$. We denote the vector of state tax rates by $\mathfrak{t}$, with elements t_j. The vector of equilibrium state tax rates is denoted by $\mathfrak{t}^*$.

Profit maximization determines per-firm capital demand $K_j = K(\rho + \tau_j)$, with $K_j' = 1/c$. State j's aggregate capital demand is simply $M_j K_j$. Rent, defined as the difference between the value of production and the rental cost of capital, $\pi_j = \pi(K_j)$, is distributed to the resident investors.

Each investor is endowed with e units of K, of which S_j is invested within the federation and the remainder is invested in the rest of the world (ROW).[37] Without loss of generality, returns in the ROW are normalized to zero. This implies that ρ can take negative values if the rate of return is lower in the federation than in the ROW.

Preferences over private goods are given by

$$W_j^{private} = (e - S_j) + \pi_j + u((1+\rho) S_j), \tag{3}$$

where $u(\cdot)$ is an increasing and concave function, implying a "home bias" in investment. Domestic and foreign incomes being considered as imperfect substitutes, differences in the rate of return between the federation and the ROW can exist even with perfect capital mobility.

The investment decision implies per-investor capital supply $S_j = S(\rho)$, which turns out to be identical across states. Capital supply from state j is thus given by $M_j S$. For analytical convenience, we assume that inward investment from outside the federation is zero.[38] Market clearing implies that $\sum_j M_j S(\rho) = \sum_j M_j K(\rho + \tau_j)$ and determines the equilibrium rate of return in the federation. The effect on the rate of return of a change in state j's tax rate is (using $K_j' = 1/c$)

$$\frac{\partial \rho}{\partial t_j} = \frac{M_j K'}{\sum_j M_j (S' - K')} = p_j \frac{K'}{(S' - K')} < 0, \tag{4}$$

where $p_j = \frac{M_j}{M}$ is the population share of state j. Similarly, the effect on ρ of a change in the tax rates of *all* states is

$$\rho' \equiv \frac{\partial \rho}{\partial \mathfrak{t}} = \frac{\sum_j M_j K'}{\sum_j M_j (S' - K')} = \frac{K'}{(S' - K')} \in [-1, 0).$$

Hence, $\frac{\partial \rho}{\partial t_j} = p_j \rho'$. This implies that the change in the net-of-tax rate of return with respect

[35] We will use the terms "investor" and "firm" interchangeably.

[36] K can represent any mobile production factor that might be taxed by governments, e.g. labor. For simplicity we denote it as "capital".

[37] In the interpretation of K as labor, e represents endowments of time which can be "invested" in the labor market. Note that one might equivalently interpret the model in terms of an intertemporal savings decision as in Keen and Kotsogiannis (2002), by relabeling "investment in ROW" as first-period consumption and "domestic investment" as investment for second-period consumption.

[38] Allowing for two-way investment flows would complicate the model without changing any of our qualitative results.

to a change in one state's tax rate is independent of the distribution of the federal population among the other states (as the distribution of $p_{i\neq j}$, does not feature in $\frac{\partial \rho}{\partial t_j}$).

Publicly provided goods are produced with constant returns and distributed equally to all investor-firms. No tax revenue is wasted. This implies per-capita budget constraints $g_j = t_j K(\rho + \tau_j)$ for the state governments, and $G = \frac{1}{M}\sum_j TM_j K(\rho + \tau_j)$ for the federal government.

Publicly provided goods enter agents' utility function. Total indirect utility for an investor in state j can be written as

$$W_j = (e - S) + \pi(\rho + \tau_j) + u((1+\rho)S) + \Gamma(g_j; G), \tag{5}$$

where $\Gamma(g_j; G)$ is increasing and concave in both arguments.[39]

A.2 Government preferences and citizen welfare

The existing literature identifies two polar cases: benevolent governments and purely revenue-maximizing (Leviathan) governments. We assume that intermediate cases are also possible, and that state governments, to the extent that they are benevolent, only consider the utility of their own subjects. This is captured by the following per-capita objective function of state governments:

$$\Omega_j = \left(1 - \mu_j\right) W_j + \mu_j t_j K(\rho + \tau_j), \tag{6}$$

which nests the two polar scenarios as well as intermediate cases.[40] We allow the intensity of Leviathan preferences μ_j to vary among states. For $\mu_j = 0$, the government's objective function coincides with the individual utility function of the state's residents, whereas $\mu_j = 1$ represents a pure Leviathan.[41]

State governments maximize Ω_j taking into account agents' choices, factor-market clearing and the budget constraints. Using (4), and the fact that $\pi' = -K$, we can write the first-order condition, evaluated at equilibrium and implicitly determining state tax rates as

$$\begin{array}{l} H_j \equiv \left.\frac{\partial \Omega_j}{\partial t_j}\right|_{\mathsf{t}=\mathsf{t}^*} = \left(1-\mu_j\right)\left\{\frac{1}{(1+\rho)}Sp_j\rho' - K_j\left(p_j\rho'+1\right) + \Gamma_g\left[K_j + t_j K'\left(p_j\rho'+1\right)\right]\right. \\ \left. +\Gamma_G\left[TK'p_j\left(\rho'+1\right)\right]\right\} + \mu_j\left[K_j + t_j K'\left(p_j\rho'+1\right)\right] = 0. \end{array}, \tag{7}$$

where $\frac{1}{1+\rho} = u'$ (see (5)).

This first-order condition implies

$$\left.\frac{\partial(t_j K_j)}{\partial \mathsf{t}}\right|_{\mathsf{t}=\mathsf{t}^*} = \left.\frac{\partial(g_j)}{\partial \mathsf{t}}\right|_{\mathsf{t}=\mathsf{t}^*} = K_j + t_j K'\left(\rho'+1\right) \geq 0. \tag{8}$$

Hence, at equilibrium, tax revenues increase with a symmetric rise in states' tax rates.[42] Changes in equilibrium state tax rates are therefore monotonically related to changes in tax revenues and public spending. This implies that our empirical approach based on tax rates is consistent with Oates-type specifications, which use tax revenues or public spending as the endogenous variable.

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[39] A possible functional form is $W_j = (e - S_j) + B\left[(1+\rho)S_j\right]^{\beta} + \pi_j + g_j^{\delta} G^{\gamma}$, which we use for our simulations (see Appendix). We shall furthermore impose that $\rho + \tau_j > 0$, allowing us to use conventional functional forms without further transformations.

[40] Note that the solution to the maximization problem of Ω_j is identical to that of the aggregate objective $M_j\Omega_j$, given that M_j is exogenous.

[41] Keen (1998) combines benevolent and Leviathan motives by positing the objective function $(1-\mu)v(\rho+\tau) + \Gamma(tK, G)$, where $v()$ represents the citizens' utility from a private good and $\Gamma()$ utility from the public goods. This setup could only be applied to our analysis if federal spending G were taken as fully exogenous, which would assume away vertical externalities.

[42] Expression (8) is equivalent to expression (23) in Keen and Kotsogiannis (2003).

Given the homogeneity of agents, social welfare is characterized by W_j. Analysis of the symmetric version of this model (e.g. by Keen and Kotsogiannis, 2002, 2004) has shown that, except for knife-edge configurations, independent state-level tax setting leads to socially suboptimal equilibrium state tax rates: a symmetric change in *all* tax rates can be welfare improving. The equivalent in our setup is a marginal change in $\mathfrak{t}$. Using the fact that, for state j, the other states' tax rates enter the welfare function only indirectly via their effect on ρ, we can express the effect of such a change as

$$\frac{\partial W_j}{\partial \mathfrak{t}} = \frac{1}{(1+\rho)} S\rho' - K_j\left(\rho'+1\right) + \Gamma_g\left[K_j + t_j K'\left(\rho'+1\right)\right] + \Gamma_G T K'\left(\rho'+1\right). \tag{9}$$

For less than pure Leviathans ($\mu < 1$), subtracting (7) from (9) yields an expression that lends itself to economic interpretation:

$$\left.\frac{\partial W_j}{\partial \mathfrak{t}}\right|_{\mu_j<1} = \begin{array}{c} (1-p_j)\left[\overbrace{\left(\frac{S}{(1+\rho)} - K_j\right)\rho'}^{\lessgtr 0} + \overbrace{\Gamma_g t_j K'\rho'}^{>0} + \overbrace{\Gamma_G T K'\left(\rho'+1\right)}^{<0}\right] \\ -\frac{\mu_j}{1-\mu_j}\underbrace{\left[K_j + t_j K'\left(p_j\rho'+1\right)\right]}_{>0} \end{array} \gtrless 0.^{43} \tag{10}$$

The first set of brackets contains three terms. The first of these terms may be called a *tax exporting effect*, due to the fact that in this setting, unlike in the symmetric model, capital supply and demand in state j are not necessarily equal. This effect pushes equilibrium tax rates above or below the social optimum, depending on whether $K_j > S$ or $K_j < S$. The second term represents the *horizontal tax externality*, arising from the interaction among state governments, and driving equilibrium tax rates below the social optimum. The third term represents the *vertical tax externality*, which results from the coexistence of the federal and the state governments. This effect pushes equilibrium tax rates above the social optimum. Finally, the second brackets contain what we call the *Leviathan effect*, representing the deviation from optimal revenue collection induced by Leviathan government preferences. The Leviathan effect implies that the higher is μ_j the greater is the scope for suboptimally high state tax rates.

A.3 State size

We are now in a position to study the effect of a change in state size on the equilibrium state tax rate through a simple exercise in comparative statics. State size is our (inverse) measure of fragmentation.[44] We abstract from the impact of a small change in the size of one state dp_j on the relative size of the other states ($dp_{i\neq j} \cong 0$).

Let $\mathcal{H}$ denote the system of first-order conditions characterized by (7), $\mathcal{H}_t$ the Jacobian matrix with element i,j equal to $\frac{\partial H_i}{\partial t_j}$ and $\mathcal{H}_{p_j}$ the vector with i-th element $\frac{\partial H_i}{\partial p_j}$. The expression for the vector $\nabla \mathfrak{t}_{p_j}$ with elements $\frac{\partial t_i}{\partial p_j}$ is then given by $\nabla \mathfrak{t}_{p_j} = -\mathcal{H}_t^{-1} * \mathcal{H}_{p_j}$. Assuming that state taxes are strategic complements implies that all off-diagonal elements of the negative definite matrix $\mathcal{H}_t$ are positive. Hence all elements of its inverse are negative.[45]

[43] The corresponding expression for pure Leviathans is: $\left.\frac{\partial W_j}{\partial \mathfrak{t}}\right|_{\mu_j=1} = \underbrace{\left(\frac{S}{(1+\rho)} - K_j\right)\rho' - K_j}_{<0} + \underbrace{(1-p_j)\Gamma_g K' t_j \rho'}_{>0} + \underbrace{\Gamma_G T K'\left(\rho'+1\right)}_{<0} \gtrless 0.$

[44] The relationship between state size and fragmentation is discussed in Section 2.2.

[45] See, for example, Wansbeek and Meijer (2000, Theorem A18). The assumption of strategic complementarity is supported by a large empirical literature on tax reaction functions (see Brueckner, 2003, for a survey). Note that strategic complementarity is a sufficient, but not necessary, condition for $\mathcal{H}_t^{-1}$ to be negative.

Concerning the sign of $\frac{\partial t_j}{\partial p_j}$ (and $\frac{\partial t_i}{\partial p_j}$), we can therefore concentrate on

$$\frac{\partial H_j}{\partial p_j} = (1 - \mu_j) \left[\left(\frac{S}{(1+\rho)} - K_j \right) \rho' + \Gamma_g t_j K' \rho' + \Gamma_G T K' \left(\rho' + 1 \right) \right] + \mu_j t_j K' \rho'. \qquad (11)$$

This implies that the state tax rate may increase or decrease with state size. The net effect depends on

- the balance between horizontal and vertical tax externalities (with dominant horizontal externalities strengthening the tendency for tax rates to rise with state size, and vice-versa for dominant vertical externalities), which can be gleaned through the correspondence of bracketed terms in (10) and (11), and
- the intensity of Leviathan preferences (with stronger Leviathan preferences strengthening the relative importance of vertical externalities).

The relationship between state size and equilibrium tax rates is interesting in itself and can be measured empirically. However, we ultimately strive for statements about welfare effects of tax competition. This requires that we can establish a link between, on the one hand, the observable relationship between state size and the equilibrium tax rate (the "tax rate effect of size"), and, on the other hand, the unobservable relationship between state size, the tax rate and welfare (the "welfare effect of size"). Since relative state size serves as an inverse measure for the intensity of tax competition, the welfare effect of size can be interpreted as an inverse measure of the desirability of tax competition.[46]

The utility function (5) implies that welfare is not affected by p_j directly but indirectly via the effect of p_j on t_j. If we abstract from the determination of T by assuming that the federal tax rate is independent of the distribution of investor-firms across states, the welfare effect of a change in state j's size can then be written as

$$\frac{\partial W_j}{\partial p_j} = \frac{\partial W_j}{\partial \mathfrak{t}} \left(\sum_i \frac{\partial t_i}{\partial p_j} \right). \qquad (12)$$

Thus, the welfare effect of size is the product of (a) the derivative of state welfare relative to the vector of state tax rates and (b) the tax rate effect of size, summed across all states of the federation.

It is not possible to derive a general analytical solution for the tax rate effect of size, and hence for the welfare effect of size. As a first stepping stone towards overcoming the impossibility of a general mapping from tax to welfare effects, we can formally derive one specific but ultimately very helpful result:

Proposition A1 *Suppose* $\frac{\partial t_j}{\partial p_j} < 0$*. Then* $\frac{\partial W_j}{\partial \mathfrak{t}} < 0$ *and* $\frac{\partial W_j}{\partial p_j} > 0$*.*[47]

If $\frac{\partial t_j}{\partial p_j} < 0$, then (10) and (11) imply that $\left[\left(\frac{S}{(1+\rho)} - K_j \right) \rho' + \Gamma_g t_j K' \rho' + \Gamma_G T K' \left(\rho' + 1 \right) \right] < 0$, and the proposition follows. ■

Proposition A1 is a stepping stone towards a unique mapping from the tax rate effect of size to the welfare effect of size, for the specific case where we compare jurisdictions of which some have higher μ_j's than others, and where the tax rate effect of size for the lower-μ_j jurisdictions is negative (i.e. Proposition A1 holds for the more benevolent states).

[46] Note that our results, focusing on the change in welfare induced by a change in state size, is not inconsistent with the finding that, with horizontal tax competition and a given distribution of state sizes, smaller states obtain a higher level of welfare in equilibrium than larger states (see e.g. Bucovetsky, 1991).

[47] Propositions A1 and A2 and Conjecture A1 below are the formal equivalents to Propositions 1 and 2 and Conjecture 1 in the main text.

Proposition A2 *Suppose Proposition A1 holds for some interior value of μ_j. Then there exists a pivotal value*

$$\mu_j^* = \frac{\left(\frac{S}{(1+\rho)} - K_j\right)\rho' + \Gamma_g t_j K'\rho' + \Gamma_G T K'\left(\rho'+1\right)}{\left(\frac{S}{(1+\rho)} - K_j\right)\rho' + \Gamma_g t_j K'\rho' + \Gamma_G T K'\left(\rho'+1\right) - t_j K'\rho'}$$

above which $\frac{\partial t_j}{\partial p_j} > 0$.

Set (11) equal to 0 and the proposition follows. ■

Both the numerator and the denominator of this ratio are negative, such that $\mu_j^* \in [0,1]$. μ_j^* is low, and the scope for Leviathan-taming tax competition is large, when vertical externalities dominate horizontal externalities only relatively weakly.

As can easily be gleaned from expression (12), the relationship between the welfare effect of size and the tax rate effect of size in state j hinges on the derivative of state-j welfare with respect to the vector of state-i tax rates ($\frac{\partial W_j}{\partial \mathbf{t}}$). If the sign of this derivative can be established, the sign of the relationship between the welfare effect of size and the tax rate effect of size is also determinate. Extensive simulations show that this is indeed possible for the precise scenario sketched above.

Specifically, we track the sign of $\frac{\partial W_j}{\partial \mathbf{t}}$ as μ_j changes, for a large number of parameter combinations and with different starting values of μ_j (details are given in Appendix B). We constrain the domain of investigation by considering only cases that are compatible with Proposition A1, i.e. where $\left.\frac{\partial W_j}{\partial \mathbf{t}}\right|_{\overline{\mu}_j} < 0$, with $\overline{\mu}_j$ denoting the starting value. In other words, we explore how state governments' becoming less benevolent affects $\frac{\partial W_j}{\partial \mathbf{t}}$ if taxes are too high initially. Table A2 shows that $\left.\frac{\partial W_j}{\partial \mathbf{t}}\right|_{\mu_j > \overline{\mu}_j} < 0$ without exception for all parameter configurations that yield a solution: if the initial state tax rate is too high and the state government becomes less benevolent, the state tax rate will remain too high.[48]

If at $\overline{\mu}_j$ the tax rate effect of size is negative (i.e. $\frac{\partial t_i}{\partial p_j} < 0$) then we know from Proposition 1 that $\frac{\partial W_j}{\partial \mathbf{t}}$ must be negative too. Since, for a given p_j, higher μ_j implies upward pressure on t_j, $\frac{\partial W_j}{\partial \mathbf{t}}$ will then be also be negative for all $\mu_j > \overline{\mu}_j$, *ceteris paribus.* If we thus were to observe that, at some higher value of μ_j the tax rate effect of size turns positive, this will imply a negative welfare effect of size: tax competition will then be good for citizen welfare.

We can summarize this in the following conjecture.

Conjecture A1 *Suppose Proposition A1 holds for $\mu_j = \overline{\mu}_j$. Then $\left.\frac{\partial W_j}{\partial \mathbf{t}}\right|_{\mu_j > \overline{\mu}_j} < 0$. Thus, $\left.\frac{\partial t_j}{\partial p_j}\right|_{\mu_j = \overline{\overline{\mu}}_j > \overline{\mu}_j} > 0$ implies that $\left.\frac{\partial W_j}{\partial p_j}\right|_{\mu_j = \overline{\overline{\mu}}_j} < 0$.*

Hence, if the vertical tax externality dominates in a state under relatively benevolent government, then if a decrease in this state's size under a less benevolent government will lower equilibrium tax rates this decrease in state size increases welfare: tax competition is welfare improving.

In sum, if comparing two states that differ only in terms of their μs, we observe that $\left.\frac{\partial t_i}{\partial p_j}\right|_{\mu_j = \overline{\mu}_j} < 0$ and $\left.\frac{\partial t_i}{\partial p_j}\right|_{\mu_j = \overline{\overline{\mu}}_j > \overline{\mu}_j} > 0$, then this implies that $\overline{\mu}_j < \mu_j^* < \overline{\overline{\mu}}_j$, i.e. the two observed states with different levels of μ are on either side of the critical value, with the welfare consequences outlined in Conjecture A1.

[48] Table A3 shows that the reverse result holds too: if the inital state tax rate is too low, and the state government becomes more benevolent, the state tax rate will remain too low.

B Appendix: Simulations

Some aspects of our model are not analytically tractable. Therefore, we perform a series of simulations.

Functional forms must be compatible with the assumptions made in the model. The production function used is

$$F(K_j) = AK_j - \frac{\alpha}{2}K_j^2.$$

Profit maximization determines capital demand $K_j = \alpha(A - (\rho + \tau_j))$, its slope $K' = -\alpha$ and the rent function $\pi_j = \frac{1}{2\alpha}K_j^2$. We adopt

$$W_j = (e - S) + B[(1+\rho)S]^\beta + \pi_j + g_j^\delta G^\gamma$$

as the expression for aggregate indirect utility, which in turn determines the capital supply $S(\rho, \tau_j)$, and, using capital demand, ρ'.[49] Introducing the state government's objective function, using the budget constraints, we obtain

$$\Omega_j = (1 - \mu_j)\Big\{(e - S) + B[(1+\rho)S]^\beta + \pi_j + (t_jK_j)^\delta\Big(\textstyle\sum_j p_jTK_j\Big)^\gamma\Big\} + \mu_j\{t_jK_j\},$$

with the corresponding first-order condition H_j.

The simulation exercise allows us to investigate whether the equilibrium tax rate can indeed be too high or too low ($\frac{\partial W_j}{\partial t} \lesseqgtr 0$) for any value of μ_j. Furthermore, Proposition 2 is based on simulation results, which uses the expressions obtained for $\frac{\partial W_j}{\partial t}$ for different values of μ_j.

We perform a grid search across a range of parameter values (using Maple). The model parameters are p_j, A, B, α, δ, γ, T and μ_j. We work with a total of three states, $j = 1, 2, 3$, assuming that $p_2 = \frac{1}{3}$, $p_1 \in (0.05, 0.15, 0.25)$ and $p_3 = 1 - p_1 - p_2$. Additionally, we simulate all possible permutations for three different and evenly spaced values of all the parameters except μ_j. This implies a total of 6,561 runs per simulation. Then we repeat the simulation for four values of $\mu_j \in \left(0, \frac{1}{3}, \frac{2}{3}, 1\right)$.

The program solves, in each run, for the equilibrium values of the state tax rates t_j and the rate of return in the federation ρ, and it then evaluates H_{t_j} (and K_j, π_j and $\frac{\partial W}{\partial t}$) at this solution.

For the parameters A and B we take 1 as the starting value and add increments of 1; whereas T takes on the values 0.05, 0.15, 0.25. The production function parameter α is set to 0.5, 1 and 1.5. For the parameters β, δ and γ, which range between zero and one, the program starts at 0.3 with two increments of 0.3. We impose $\rho = 0$ as the starting value for the solution algorithm. This may be considered a natural starting point, as it implies that the federation rate of return equals that in the rest of the world. Some parameter combinations yield no solutions. Inspection of those cases shows that this occurs when the exogenous parameters are incompatible (high γ and low T). Furthermore, some solutions imply equilibrium state tax rate outside the plausible interval [0,1]. Since, these solutions correspond only to a small subset and (more importantly) conform with the patterns found for the plausible solutions, we do not report them separately.

Table A1 presents a basic description of the simulation results, while Tables A2 and A3 report the results leading to Proposition 2. For space reasons we present the results for state 1 only. Table A2 is key: if state tax rates are initially too high, they remain too high when μ increases, without exception.

[49] Note that in this specification $S_\tau = 0$.

Variable	Obs.	Mean	Std. dev.	Mun. or cant. with min.	Mun. or cant. with max.
Municipality-level variables					
`Tax index`	635	0.00	0.84	Freienbach (SZ)	Porrentruy (JU)
`Tax index` ($\mu = 0$)	370	0.12	0.83	Freienbach (SZ)	Porrentruy (JU)
`Tax index` ($\mu = 1$)	265	-0.18	0.82	Carouge (GE)	La Chaux-de-Fonds (NE)
μ	650	0.42	0.49	(*several*)	(*several*)
Smallness	650	0.93	0.11	Basel (BS)	Nidau (BE)
Population	650	23,570	39,180	Appenzell (AI)	Zürich (ZH)
Share of pop. under 20	650	0.16	0.04	Lugano (TI)	Einsiedeln (SZ)
Share of pop. over 65	650	0.19	0.03	Volketswil (ZH)	Riehen (BS)
Area (hectares)	650	1,945	2,608	Nidau (BE)	Davos (GR)
Urban center dummy	650	0.41	0.49	(*several*)	(*several*)
Distance to freeway (km)	650	4.04	6.68	Morges (VD)	St. Moritz (GR)
Distance to airport (km)	650	48.48	38.06	(*several*)	St. Moritz (GR)
Lake shore (meters)	650	2,173	4,490	(*several*)	Einsiedeln (SZ)
Canton-level variables					
`Tax index`	650	0.00	0.87	Schwyz	Geneva
Latin dummy	650	0.27	0.44	(*several*)	(*several*)
Harmonized-tax dummy	650	0.22	0.41	(*several*)	(*several*)
Urbanized population	650	412,345	355,027	(*several*)	Zürich
Area (hectares)	650	220,772	192,636	Basel Stadt	Graubünden
Number of municipalities	650	177.50	126.74	Basel Stadt	Berne

Table 1: Summary statistics

Tax index of log tax rates. Government objectives (μ) according to referendum definition.

Variable	Obs.	Mean	Std. dev.	Mun. or cant. with min.	Mun. or cant. with max.
`Personal income tax rate`					
single, median inc.	650	4.13	1.10	Freienbach (SZ)	Le Locle (NE)
married, median inc.	650	3.53	1.18	Freienbach (SZ)	Le Locle (NE)
married, high inc.	650	10.52	2.33	Freienbach (SZ)	Amriswil (TG)
`Personal wealth tax rate`					
wealth = CHF200,000	640	0.11	0.07	Baar, Zug (ZG)	Glarus (GL)
wealth = CHF5,000,000	640	0.31	0.06	Freienbach (SZ)	Solothurn (SO)
`Corporate income tax rate`					
2% profitability	635	3.62	1.50	Herisau (AR)	(*several*)
9% profitability	635	5.14	1.75	Freienbach (SZ)	Porrentruy (JU)
32% profitability	635	7.58	2.72	Freienbach (SZ)	Solothurn (SO)
`Corp. capital tax rate`	635	0.22	0.11	Zug (ZG)	Glarus (GL)

Table 2: Tax rates

Tax rates in percent. Municipalities in the canton of Appenzell Innerrhoden and Basel Stadt do not levy corporate taxes; municipalities in the canton of Basel do not levy personal wealth taxes.

dependent var. = log municipal tax index	Referendum definition	Assembly definition
Smallness (main effect)	1.66 (0.18) 1.08	5.50*** (0.45) 1.85
Leviathan dummy ($\widetilde{\mu}$, main effect)	0.37** (0.22) 0.18	0.91*** (0.59) 0.27
$\widetilde{\mu}$***Smallness (interaction effect)**	−2.95** (−0.21) 1.18	−7.19** (−0.42) 3.09
Cantonal tax index (T, instrumented)	0.33 (0.34) 0.20	0.37** (0.34) 0.18
Neighbors' avg. tax index ($\bar{t}_{-j}$, instrumented)	0.79* (0.25) 0.42	0.43 (0.07) 0.90
Population of municipality	−0.05 (0.04) 0.11	−0.37* (−0.28) 0.19
Share of mun. pop. under 20	0.28 (0.08) 0.26	0.23 (0.07) 0.22
Share of mun. pop. over 65	0.24 (0.05) 0.31	0.10 (0.02) 0.40
Area of municipality	0.10 (0.10) 0.07	0.30*** (0.31) 0.09
Urban center dummy	0.25** (0.15) 0.13	0.51*** (0.33) 0.19
Distance to freeway	−0.06 (−0.07) 0.05	−0.01 (−0.01) 0.08
Distance to airport	0.24*** (0.29) 0.09	0.32** (0.44) 0.13
Lake shore	−0.03*** (−0.16) 0.01	−0.03*** (−0.18) 0.01
Latin dummy	−0.53* (−0.29) 0.28	−1.43*** (−0.63) 0.33
Harmonized-tax dummy	−0.29* (−0.14) 0.16	0.18 (0.09) 0.14
Number of observations	635	310
Wald χ^2: Smallness main + interaction = 0	2.07 0.15	0.70 0.40
Wald χ^2: $\boldsymbol{\beta} = \mathbf{0}$	337.29 0.00	592.26 0.00
Hansen J statistic	5.65 0.58	7.72 0.36
1st-stage instr. F statistic, Cantonal tax	15.45	48.81
1st-stage instr. F statistic, Neighbors' tax	27.09	21.86

Table 3: Baseline tax index regressions (spatial GMM)

Beta coefficients in parentheses, standard errors below. *** significant at 1%, ** at 5% and * at 10%. Two-tail P values below χ^2 and J statistics. Regressions include intercept and dummies for Geneva and Basel-Land. All variables mean-differenced by year; non-dichotomous variables in natural logs. Cantonal tax indices and neighboring municipal tax indices instrumented using all exogenous regressors plus canton urban population, canton area, canton number of municipalities and weighted averages of municipal variables as instruments. First-stage F statistics robust to spatial autocorrelation.

dep. var. = log munic. tax index	Smallness in terms of area	Smallness instrumented	Control for centralism	Control for centralism, Smallness instrumented
Smallness (main effect)	4.74 3.87	2.12 1.35	1.44 1.56	2.92 2.25
Leviathan dummy ($\widetilde{\mu}$, main eff.)	0.44** 0.21	0.37* 0.19	0.35* 0.19	0.38** 0.18
$\widetilde{\mu}$***Smallness (interaction)**	−9.73 7.62	−4.19*** 1.52	−2.74* 1.52	−5.37** 2.20
Cantonal tax index (T, instrum.)	0.34* 0.19	0.28 0.19	0.36 0.28	0.18 0.32
Neighbors' avg. tax index ($\bar{t}_{-j}$, instrumented)	0.59 0.48	0.70* 0.42	0.76* 0.45	0.69* 0.41
Centralization ratio (instrum.)	*(n.a.)*	*(n.a.)*	−0.12 0.75	0.26 1.04
Population of municipality	−0.08 0.11	−0.09 0.10	−0.06 0.13	−0.08 0.13
Share of mun. pop. under 20	0.29 0.29	0.17 0.28	0.28 0.26	0.13 0.30
Share of mun. pop. over 65	0.25 0.33	0.23 0.31	0.23 0.33	0.25 0.31
Area of municipality	0.12 0.10	0.12 0.08	0.10 0.07	0.12 0.08
Urban center dummy	0.23* 0.12	0.24* 0.13	0.25* 0.13	0.21* 0.12
Distance to freeway	−0.06 0.05	−0.08 0.05	−0.07 0.05	−0.08* 0.05
Distance to airport	0.26*** 0.09	0.25*** 0.09	0.24*** 0.09	0.25*** 0.09
Lake shore	−0.03** 0.01	−0.04*** 0.01	−0.03** 0.01	−0.04** 0.02
Latin dummy	−0.56** 0.28	−0.48* 0.28	−0.53* 0.28	−0.46* 0.27
Harmonized-tax dummy	−0.25 0.17	−0.32** 0.16	−0.27 0.19	−0.38 0.24
Wald χ^2: Smalln. main + int'n = 0	0.50 0.48	3.00 0.08	2.09 0.15	3.93 0.05
Wald χ^2 (F): $\boldsymbol{\beta} = \mathbf{0}$	332.40 0.00	334.24 0.00	336.08 0.00	335.42 0.00
Hansen J statistic	6.70 0.46	5.32 0.62	5.43 0.61	5.87 0.56
1st-stage F stat., Cant. tax	17.22	22.49	15.45	22.49
1st-stage F stat., Mun. tax	25.70	25.48	27.09	25.48
1st-stage F stat., Centr. ratio	*(n.a.)*	*(n.a.)*	18.03	17.34
1st-stage F stat., Smalln. main eff.	*(n.a.)*	11.73	*(n.a.)*	11.73
1st-stage F stat., Smalln. int'n.	*(n.a.)*	2.21	*(n.a.)*	2.21

Table 4: Alternative tax index regressions (spatial GMM)

All regressions based on referendum definition (635 observations). Standard errors below coefficients. *** significant at 1%, ** at 5% and * at 10%. Two-tail P values below χ^2 and J statistics. Regressions include intercept and dummies for Geneva and Basel-Land. All variables mean-differenced by year; non-dichotomous variables in natural logs. Instrument sets include variables listed in notes to Table 3, plus area-based smallness. Spatial GMM first-stage F statistics robust to spatial autocorrelation.

dep. var. = log munic. tax index	Baseline regression	Smallness instrumented	Control for centralism	Control for centralism
Smallness (main effect)	1.80* 1.00	1.85 1.29	2.25 1.54	2.28 2.96
Leviathan dummy ($\widetilde{\mu}$, main eff.)	0.16 0.16	0.23 0.17	0.17 0.16	0.22 0.17
$\widetilde{\mu}$***Smallness (interaction)**	−2.47** 1.15	−4.31** 1.67	−2.77* 1.54	−4.65 3.17
Cantonal tax index (T, instrum.)	0.17 0.18	0.20 0.19	0.09 0.27	0.13 0.39
Neighbors' avg. tax index ($\bar{t}_{-j}$, instrumented)	0.53 0.34	0.53 0.34	0.57 0.36	0.57 0.40
Centralization ratio (instrum.)	*(n.a.)*	*(n.a.)*	0.37 0.95	0.21 1.39
Population of municipality	0.01 0.11	−0.10 0.12	0.05 0.13	−0.07 0.15
Share of mun. pop. under 20	0.13 0.27	0.13 0.30	0.12 0.27	0.10 0.32
Share of mun. pop. over 65	0.23 0.33	0.17 0.33	0.29 0.36	0.23 0.40
Area of municipality	0.08 0.08	0.08 0.08	0.08 0.08	0.08 0.08
Urban center dummy	0.20 0.14	0.19 0.14	0.18 0.15	0.18 0.15
Distance to freeway	−0.07 0.05	−0.09 0.05	−0.06 0.06	−0.09 0.05
Distance to airport	0.28*** 0.09	0.28*** 0.10	0.28*** 0.09	0.28*** 0.10
Lake shore	−0.04*** 0.01	−0.04*** 0.01	−0.04*** 0.01	−0.04** 0.02
Latin dummy	−0.31 0.27	−0.38 0.28	−0.34 0.29	−0.37 0.28
Harmonized-tax dummy	−0.27* 0.15	−0.29* 0.16	−0.31* 0.17	−0.32 0.24
Wald χ^2: Smalln. main + int'n = 0	0.69 0.41	2.74 0.09	0.38 0.53	2.82 0.09
R^2	0.59	0.59	0.57	0.57
Hansen J statistic	7.85 0.35	7.04 0.43	7.46 0.28	6.48 0.37
1st-stage F stat., Cant. tax	81.30	75.98	81.30	75.98
1st-stage F stat., Mun. tax	110.87	94.55	110.87	94.55
1st-stage F stat., Centr. ratio	(n.a.)	(n.a.)	69.33	72.31
1st-stage F stat., Smalln. main eff.	(n.a.)	115.28	(n.a.)	115.28
1st-stage F stat., Smalln. int'n.	(n.a.)	43.52	(n.a.)	43.52
Moran's I (spatial autocorr.)	0.28 0.00	0.25 0.00	0.27 0.00	0.24 0.00

Table 5: Alternative tax index regressions (2-Stage Least Squares)

All regressions based on referendum definition (635 observations). Standard errors below coefficients. *** significant at 1%, ** at 5% and * at 10%. Two-tail P values below χ^2 and J statistics. Regressions include intercept and dummies for Geneva and Basel-Land. All variables mean-differenced by year; non-dichotomous variables in natural logs. Instrument sets include variables listed in notes to Table 3, plus area-based Smallness. Standard errors and first-stage F statistics based on heteroskedasticity consistent standard errors, clustered by municipality. Moran's I based on 15 km distance bands, P value below.

dep. var. = log tax rate on...	Smallness	$\widetilde{\mu}$	$\widetilde{\mu}$*Smallness	# of obs.	Wald χ^2	J stat.	F stat. T	F stat. $\bar{t}_{-j}$
Referendum definition								
Personal Income								
single median. inc.	0.36* 0.20	0.05 0.06	−0.58 0.20	650	10.36 0.00	3.93 0.79	10.11	793.53
married median inc.	0.44*** 0.17	0.07 0.06	−0.69*** 0.17	650	12.13 0.00	5.31 0.62	6.98	549.69
married high inc.	0.79 0.73	0.05 0.07	−0.87 0.72	650	2.00 0.16	6.79 0.45	8.83	2,012.95
Wealth								
200k	−1.17 0.73	0.08 0.10	−0.32 0.95	640	3.03 0.08	6.96 0.43	4.80	376.24
5m	0.38* 0.21	0.03 0.04	−0.12 0.24	640	2.19 0.14	4.92 0.67	13.54	574.55
Corporate Income								
2% profit	−0.37 0.46	−0.02 0.10	0.72 0.52	635	0.96 0.32	9.15 0.24	8.67	50.90
9% profit	−0.88* 0.50	0.12 0.09	0.94 0.58	635	0.04 0.84	9.66 0.21	9.87	52.78
32% profit	0.17 0.41	0.26*** 0.06	−0.33 0.47	635	0.28 0.60	11.39 0.12	6.62	108.72
Capital	−2.22*** 0.61	0.06 0.07	1.26* 0.72	635	4.14 0.04	11.38 0.12	13.81	110.77
Assembly definition								
Personal Income								
single median inc.	0.80** 0.33	0.18*** 0.04	−1.03*** 0.37	325	12.47 0.00	8.16 0.31	15.95	3,780.34
married median inc.	0.66* 0.36	0.15*** 0.05	−0.81** 0.38	325	3.76 0.05	5.99 0.54	13.78	1,512.34
married high inc.	2.24** 0.90	0.31*** 0.08	−2.49*** 0.95	325	11.88 0.00	8.21 0.31	20.96	9,622.86
Wealth								
200k	−0.53 1.34	0.19 0.44	0.01 5.63	315	0.01 0.92	2.95 0.89	4.96	300.03
5m	1.04*** 0.32	0.20*** 0.07	−1.58*** 0.53	315	1.26 0.26	7.09 0.42	16.95	918.97
Corporate Income								
2% profit	0.14 0.69	0.20* 0.11	−0.31 1.20	310	0.05 0.82	5.19 0.64	6.80	516.10
9% profit	0.96* 0.57	0.23*** 0.07	−0.67 0.79	310	0.47 0.50	5.60 0.59	7.50	1,044.38
32% profit	1.81*** 0.50	0.29*** 0.09	−1.49* 0.90	310	0.34 0.56	3.02 0.88	6.75	640.70
Capital	−0.95 1.86	0.17 0.20	0.50 2.25	310	0.06 0.80	2.57 0.92	8.18	417.40

Table 6: Regressions for individual tax instruments (spatial GMM)

Standard errors below coefficients. *** significant at 1%, ** at 5% and * at 10%. χ^2 statistics of Wald test of H0: Smallness main + interaction = 0; two-tail P values below. Non-reported controls are identical to Table 3; except harmonized-tax dummy, which is not included for personal taxes. Cantonal tax indices (T) and other municipal tax indices ($\widehat{t_i}$) instrumented using all exogenous regressors plus identifying instruments (see notes to Table 3). First-stage F statistics robust to spatial autocorrelation.

μ	Runs with $\sum_i \frac{\partial W_1}{\partial t_i} < 0$ (state taxes too high)	Runs with $\sum_i \frac{\partial W_1}{\partial t_i} > 0$ (state taxes too low)	no solution
0	3,111	3,370	80
$\frac{1}{3}$	5,624	922	15
$\frac{2}{3}$	6,361	200	0
1	6,445	116	0
Sum	*21,541 (82.1%)*	*4,608 (17.6%)*	*95 (0.1%)*
$\Delta\mu$	Runs with $\frac{\Delta t}{\Delta\mu} < 0$ (Leviathan has lower taxes)	Runs with $\frac{\Delta t}{\Delta\mu} > 0$ (Leviathan has higher taxes)	No solution
0-$\frac{1}{3}$	0	6,481	80
$\frac{1}{3}$-$\frac{2}{3}$	0	6,546	15
$\frac{2}{3}$-1	1,218	5,343	0
Sum	*1,218 (6.2%)*	*18,370 (93.3%)*	*95 (0.5%)*

Table A1: Basic simulation results

Simulations are described in Appendix B. Each simulation run covers 6,561 different parameter configurations. Some solutions imply equilibrium state tax rates outside [0,1].

μ	Runs with $\sum_i \frac{\partial W_1}{\partial t_i} < 0$ (state taxes too high)	Runs with $\sum_i \frac{\partial W_1}{\partial t_i} > 0$ (state taxes too low)
0	3,111	n.a.
$\frac{1}{3}$	3,111	0
$\frac{2}{3}$	3,111	0
1	3,111	0
$\frac{1}{3}$	5,624	n.a.
$\frac{2}{3}$	5,624	0
1	5,624	0
$\frac{2}{3}$	6,361	n.a.
1	6,361	0

Table A2: Simulation results: reducing government benevolence when taxes are initially too high

Simulations are described in Appendix B. Only runs where $\left.\frac{\partial W_j}{\partial t}\right|_{\overline{\mu}} < 0$ are considered. Some solutions imply equilibrium tax rates outside [0,1].

μ	Runs with $\sum_i \frac{\partial W_1}{\partial t_i} < 0$ (state taxes too high)	Runs with $\sum_i \frac{\partial W_1}{\partial t_i} > 0$ (state taxes too low)
1	n.a.	116
$\frac{2}{3}$	0	116
$\frac{1}{3}$	0	116
0	0	116
$\frac{2}{3}$	n.a.	200
$\frac{1}{3}$	0	200
0	0	200
$\frac{1}{3}$	n.a.	922
0	0	922

Table A3: Simulation results: increasing government benevolence when taxes are initially too low

Simulations are described in Appendix B. Only runs where $\left.\frac{\partial W_j}{\partial t}\right|_{\overline{\mu}} > 0$ are considered. Some solutions imply equilibrium tax rates outside [0,1].