How Do Local Governments Decide on Public Policy in Fiscal Federalism? Tax vs. Expenditure Optimization

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June 19, 2008

Abstract

Previous literature widely assumes that taxes are optimized in local public finance and expenditures adjust residually. This paper endogenizes the choice of optimization variable. Concretely, it analyzes how federal policy towards local governments influences the equilibrium choice. Unlike the presumption in the literature, the paper shows that local governments may choose to optimize over expenditures, in particular when federal policy subsidizes local fiscal effort. Efficiency of local policy is sensitive to the equilibrium choice. Thereby, the results enable a more precise characterization of local government behavior and offer a broader perspective of the efficiency implications of federal policy towards local governments.

JEL Classification: H7; H3; H1

Keywords: Tax vs. Expenditure Optimization, Federalism, Endogenous Commitment, Fiscal Incentives, Policy Interaction.

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1 Introduction

Models of local public finance predominantly take taxes as being optimized while expenditures are residually determined via the budget constraint. The prescription of government behavior is one way of how governments behave. In making budgetary decisions, governments may equally optimize over expenditures and let taxes adjust residually.[1] One strategic motive for selecting one or the other budgetary item as a policy variable is that they differently influences the amount of federal resources which flow to the local jurisdiction. Such strategic motives in local policy choice are well documented in the literature. For instance, local taxes are adjusted in order to receive more formulaic transfer payments (e.g. Smart, 1998, and Egger et al., 2007). Equally, anticipating a federal bailout local governments may well lure more discretionary federal transfers to the local budget by inefficient local policy choices (e.g. Qian and Roland, 1998, and Wildasin, 1997). Building on these insights, the goal of this paper is to analyze local policy-making, where the choice of policy variable is not imposed, but endogenously arises from the fundamentals of the fiscal architecture of the federation. In particular, we contrast incentives to provide public goods when local governments either optimize over taxes or expenditures and, more importantly, we analyze how these incentives determine the choice of optimization variable by local governments. In so doing, we consider two models of fiscal federalism: a model of formula-based equalization and a model of ex-post federal policy. In either model local governments levy a tax on local residents and use the proceeds along with federal transfers to provide a public good. A presumption might be that expenditure and tax optimization yield identical policy outcomes since taxes and expenditures are inherently related via the budget constraint. The presumption holds true when local economies are fiscally independent, i.e. there exist no fiscal interaction between policy choices by different local governments. The bias in the existing literature towards tax optimization is innocuous in such a fiscal environment. We show that the equivalence between tax and expenditure policy becomes invalid if local policies are linked via transfer programmes. Tax and expenditure policy have different effects on their transfer payments and local governments strategically choose their policy variable in order to gain in transfers. To illustrate the incentives involved in the equilibrium choice of policy variables, consider a two state federation in which interstate transfers exert a negative incentive effect on state policy, i.e. higher taxes lower transfer income in the tax-raising state and lure more transfers to the other state. Assume that both states initially optimize over taxes and that one state (let's say state 1) considers deviating to expenditure optimization. Such a deviation increases the cost of public good provision in state 2. The rationale is that a higher tax in state 2 reallocates transfers from state 2 to state 1. Were taxes optimized by state 1, public expenditures would

[1] Throughout the paper we interchangeably refer to tax (expenditure) optimization as tax (expenditure) policy and to the optimization variable as policy variable.

adjust residually to the rise in transfer income in state 1 with no consequences for interstate transfers. However, with expenditure optimization state 1's taxes decrease residually and this response lures more transfers to state 1, financed by a cut-back of transfers in state 2. The fiscal retrenchment incentivizes state 2 to choose a lower tax in response to the deviation by state 1. Whether state 1 benefits from the deviation to expenditure policy depends on how its utility is affected by the response of state 2. Since transfers are inversely related to own state taxes, the lower tax rate in state 2 lures more transfers to state 2, financed by a cut-back in transfers to state 1. Thus, the deviation lowers state 1's utility. The delineated policy incentives apply to both states and in equilibrium states set taxes optimally and let expenditures adjust residually. A reversed type of reasoning applies when transfer exert a positive incentive effect on state policy.[2] A deviation to expenditure setting lures more transfers to the deviant state's budget and in equilibrium states choose to optimize over expenditures.

A straightforward question relates to the sensitivity of the results to the type of federal policy which links states. To infer into it, we consider a second model of fiscal federalism frequently invoked in the literature. In particular, we allow states to "see through" the federal tax policy decision.[3] State policy affects not only transfers, but also how state residents are treated under the federal income tax. In this setting the divergent interaction of tax and expenditure policy implies that both states may not optimize over taxes even though transfers discourage state fiscal effort. In particular, provided the disincentive effect of transfers policy is sufficiently pronounced, the equilibrium choices turn out to be asymmetric in the sense that one state chooses to optimize over taxes, whilst the other state optimizes over expenditures.

In sum, the paper shows that the federal tax-transfer system influences the equilibrium choice of local policy variables. Thereby, the analysis allows to make more informed predictions as to the efficiency of pubic good provision in fiscal federalism. For instance, when transfers encourage local taxation, the prediction of both models considered in the paper is that state governments optimize over expenditures. Public good are more severely downward distorted than when taxes are optimized (as widely assumed in the literature). Differently, when transfers undermine taxing incentives, the efficiency prediction as perceived in the literature turns out to be consistent with the equilibrium choice in the first model considered in the paper, whilst with ex-post federal tax policy the equilibrium only entails tax policy setting if the disincentive effect of transfer policy is not too pronounced. Otherwise, expenditures are set by one state and public good provision is higher (either less underprovision or more severe overprovision) relative to the widely held conjecture in the literature.

[2]For instance transfer schemes which equalize fiscal capacities are one type of transfers which exert a positive incentive effect - e.g. Smart (1998). Transfer schemes which build on the notion of fiscal capacity equalization are implemented in e.g. Australia, Canada, Germany and Switzerland.

[3]The type of "seeing through" delineates a game of decentralized leadership - see e.g. Wildasin (1997), Qian and Roland (1998), Caplan et al. (2000), Akai and Sato (2005) and Koethenbuerger (2007).

The results are of relevance for instance for the design of corrective policy. The prediction as to the magnitude and even as to the sign of the inefficiency generically differs in models with (exogenous) tax optimization and with an endogenous selection of policy variables, and so does the appropriate matching component of the Pigouvian grant. Also, the analysis offers a more nuanced perspective of the effects of federal transfer policy on local public finance. For instance, a reform of the federal transfer formula, which leaves more own-source tax revenues to local governments, may not necessarily promote local spending incentives. Conditioned on the initial choice of policy variables, public expenditures will indeed rise following the reform. However, phasing in the endogeneity of the policy variables, the unconditional fiscal response may entail a reduction in local public spending.

While the notion that expenditure and tax policy have different implications for local public finance is well established in the literature, it lacks (to the best of our knowledge) an analysis of when local governments opt for one or the other type of policy setting. In particular, Wildasin (1988) and Bayindir-Upmann (1998) contrast expenditure and tax policy in the presence of capital mobility among jurisdictions. Hindriks (1999) compares transfer and tax competition when households are mobile. The papers do not endogenize the choice of policy instruments over which local governments compete in fiscal competition. More related to the present paper, Akai and Sato (2005) contrast expenditure and tax policy setting in a two-tier federal system in which the federal government provides transfers ex-post. Equally, the choice of the optimization variable is exogenous to the analysis.

Although this paper formally abstracts from tax base mobility, it is helpful in predicting which policy scenario considered e.g. in Wildasin (1988) can be sustained as an equilibrium choice. Applying the methodology of the paper to the setting in Wildasin (1988), in which capital mobility is the only fiscal linkage between states, reveals that competition over taxes is the equilibrium choice. The result is supportive for almost all papers on capital tax competition to date which assume that states compete over taxes and expenditures adjust residually.

Finally, the choice of optimization variable determines with which policy variable state governments commit towards other states' fiscal policy.[4] The endogenous choice of commitment relates the paper to the Industrial Organization literature on endogenous timing of moves, and hence commitment, in models of firm competition (e.g. Van Damme and Hurkens, 1999, and Caruana and Einav, 2008). Therein, the sequencing of decision is determined endogenously, while the choice of optimization variable is exogenous. In this paper it is reversed: the sequence of moves is exogenous while the choice of optimization variable (for

[4]Optimizing over, for instance, the tax rate implies that other states perceive the tax rate to be held fixed, and thus to be pre-committed, when they choose their policy.

state governments) is endogenous.[5]

The outline of the paper is as follows. Section 2 introduces a model of formula-based equalization and Section 3 characterizes the choice of the optimization variable. Section 4 extends the basic model by allowing for ex-post federal tax policy, i.e. local governments have the capacity to "see through" the federal choice of taxes, and characterizes the selection of policy variables. Section 5 summarizes and concludes.

2 Model

Consider two states which may differ with respect to preferences and endowments. The representative household in state i ($i = 1, 2$) derives utility from private and public consumption, c^i and g^i, according to the utility function $U^i(c, g) = u^i(c) + u^i(g)$ where $u^i_k > 0$ and $u^i_{kk} < 0$, $k = c, g$.[6,7] Households have an endowment I^i which is subject to taxation. The private budget constraint is

$$c^i = I^i - T^i, \tag{1}$$

where T^i are taxes levied by state government i. State governments finance public expenditures $\{g^i\}_{i=1,2}$ by locally collected taxes $\{T^i\}_{i=1,2}$ and interstate transfers $\{z^i\}_{i=1,2}$

$$g^i = T^i + z^i. \tag{2}$$

The transfer to state i, z^i, is conditioned on the level of locally collected tax revenues T^i and tax revenues of the neighbor jurisdiction T^j,

$$z^i = \gamma(T^i, T^j), \tag{3}$$

where $z^i + z^j = 0$. Given the generality of the transfer formula, we impose three reasonable assumptions: First, $\left|z^i_{T^i}\right| < 1$ such that changes in taxes do not imply an over-proportional change in transfers.[8] Second, states are symmetrically treated by transfer policy in the sense that $\text{sign}\{z^1_{T^1}\} = \text{sign}\{z^2_{T^2}\}$. The transfer formula may still be non-linear in taxes and thereby the slopes $\{z^i_{T^i}\}_{i=1,2}$ may differ in magnitude over the range of feasible taxes. Third, $\text{sign}\{z^i_{T^i}\}$ is non-reversal, i.e. it is the same for all feasible levels of taxes.

[5] Note, the two types of commitment, i.e. sequencing of moves and choice of optimization variable, are not equivalent. The former relates to sequential games while the latter already exists in simultaneous move games. Also, with the former type it is the best-response of players which determines the value of commitment. With the latter it is only the residual variation of policy variables (determined by the budget constraint rather than first-order conditions) which is decisive for the choice of the commitment strategy.

[6] Additive preferences are without loss of generality in section 4. In section 5 the identified equilibria extend to non-additive preferences when private and public consumption are complements ($U^i_{cg} < 0$) or weak substitutes, i.e. U^i_{cg} is not too positive.

[7] As long as confusion cannot arise we omit the state-specific superscript for consumption levels.

[8] Subscripts denote partial derivatives throughout.

The transfer scheme (3) embeds different types of formulaic transfers which most notably differ w.r.t. the sign of the transfer response $z^i_{T^i}$. As an example, transfers which share locally collected tax revenues across states typically respond negatively to a rise in own-source tax revenues (e.g. Baretti et al., 2002), whilst fiscal capacity equalization transfers rise in response to a hike in own-state tax rates (Smart, 1998).[9]

State governments are benevolent and maximize utility of the representative household, while the federal government maximizes the sum of utilities.

Straightforwardly, the (first-best) efficient public expenditure level in state i satisfies

$$\frac{u^i_g}{u^i_c} = 1. \tag{4}$$

The marginal rate of substitution between public and private consumption has to equal the social marginal rate of transformation (normalized at unity).

Unless otherwise stated, the sequence of fiscal decisions is:[10]

Stage 1: States simultaneously choose whether to optimize over taxes or expenditures.

Stage 2: States simultaneously optimize over the policy variable chosen at the first stage.

Stage 3: Transfers $\{z^i\}_{i=1,2}$ are paid, taxes $\{T^i\}_{i=1,2}$ are collected, and households consume $\{c^i, g^i\}_{i=1,2}$.

We solve for the subgame-perfect equilibrium (in pure strategies) by applying backward induction.

3 Equilibrium Analysis

To isolate the incentive effects inherent to federal policy, it is instructive to first characterize local decision-making in the absence of transfers, i.e. $z^i \equiv 0$. In this case changes in taxes yield a one-to-one change in expenditure levels. The tax price of marginal public spending is unity irrespectively of whether the change in taxes is fixed and expenditures adjust residually or vice versa. Thus, solving

$$\max \qquad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (1) \text{ and } (2) \tag{5}$$

[9] To firmly model fiscal capacity equalization transfers we would have to introduce a tax-sensitive tax base. One possibility is to allow for endogenous labor supply which negatively responds to higher state taxes on labor - e.g. Smart (1998). The extension would complicate the exposition of the paper, without affecting the main results of the analysis.

[10] An alternative sequence of events is considered in Section 5.

either by differentiating w.r.t. T^i (with g^i being residually determined) or w.r.t. g^i (with T^i being residually determined) yields the first-order condition

$$\frac{u_g^i}{u_c^i} = 1. \tag{6}$$

Public goods are efficiently provided. Note, in the absence of federal transfers optimal state policy is independent of the neighbor state's policy and so is utility in each state. Given the absence of fiscal interaction between states and the equivalence between tax and expenditure optimization within a state, we conclude that any choice of policy variable by both states is an equilibrium of the policy selection game.

We now re-introduce federal transfer policy and analyze the extent to which the equivalence result is preserved. Consider first that state government j optimizes over taxes T^j. Optimal state policy follows from

$$\max \qquad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (1), (2) \text{ and } (3), \tag{7}$$

taking T^j as given. Differentiating w.r.t. T^i or g^i gives

$$\frac{u_g^i}{u_c^i} = \frac{1}{1 + z_{T^i}^i}. \tag{8}$$

The equivalence between tax and expenditure optimization is formally shown in the appendix. When $z_{T^i}^i < 0$ (> 0) state i anticipates a loss (gain) in transfers in response to a rise in taxes with the consequence that public goods become underprovided (overprovided) relative to the first-best rule (4).

Instead, when state government j optimizes over expenditures, state i realizes that taxes in the neighboring state adjust residually. It will adjust whenever changes in state i's taxes imply a change in state j's transfer income. Transfer income as perceived by state i is implicitly determined by

$$z^{i*} = \gamma(T^i, g^j + z^{i*}), \tag{9}$$

which follows from inserting (2) and $z^{i*} + z^{j*} = 0$ into (3). State i solves

$$\max \qquad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (1), (2) \text{ and } (9), \tag{10}$$

taking g^j as given. Differentiating w.r.t. T^i or g^i, the optimal policy satisfies (see the Appendix):

$$\frac{u_g^i}{u_c^i} = \frac{1}{1 + z_{T^i}^{i*}}. \tag{11}$$

State government i equates the marginal rate of substitution between private and public consumption to the tax price of marginal public expenditures. Public consumption is underprovided (overprovided) relative to the first-best rule when $z^{i*}_{T^i} < 0$ (> 0).

Comparing (8) and (11) reveals that state i's policy is inefficient for any choice of optimization variable in the neighboring state, but the scope of inefficiency depends on which variable the neighboring state optimizes. Implicit differentiation of (9) and using $z^i_{T^j} = -z^j_{T^j}$ yields

$$z^{i*}_{T^i} = \frac{z^i_{T^i}}{1 + z^j_{T^j}} \quad \Rightarrow \quad z^{i*}_{T^i} < z^i_{T^i}. \tag{12}$$

The change in transfers is higher when state j optimizes over taxes.[11] The rationale is that tax and expenditure policy interact differently through the transfer scheme. More concretely, assume higher taxes reduce entitlement payments, $z^i_{T^i} < 0$. A rise in state i's taxes reduces transfers to state i and, in order to balance the budget, transfers to state j increase. When state j optimizes over taxes, the additional transfer income increase public expenditures in state j. Transfer payments are unaffected by the residual adjustment. Differently, when state j optimizes over expenditures, the rise in transfer income reduces state i taxes. In response, more transfers go to state j, financed by a cut-back of transfers to state i. The negative repercussion on state i's budget renders public good provision more costly. An analogues line of reasoning holds when $z^i_{T^i} > 0$. In this case a higher tax in state i decreases state j's transfer income. When state j optimizes over expenditures, state j's taxes rise residually which yields a budget-balancing retrenchment of state i's transfer income. The retrenchment dilutes state i's incentives to spend on public consumption. We can thus summarize:

Lemma 1: *State i's incentives to provide public goods are less pronounced when state j optimizes over expenditures rather than taxes. In particular, provided $z^i_{T^i} < 0$ (> 0) public goods are more severely underprovided (less severely overprovided) in state i when public expenditures rather taxes are subject to optimization in state j.*

In any stage-2 game, the states' best-responses are implicitly defined by the respective first-order conditions. Equilibrium existence follows from standard fixed point theorems. We assume uniqueness and global stability of equilibrium throughout.[12]

We will now turn to the subgame perfect choice of the optimization variable at stage 1 of the game. This involves a comparison of the stage 2 utility for any possible combination of optimization variable by both states. We will first analyze the case when $z^i_{T^i} < 0$ and,

[11] Thus, in case $z^i_{T^i} < 0$ the first-order condition (11) only holds provided $z^i_{T^i}$ is not too negative. Otherwise, state i will select a zero tax rate. To save on notation we abstract from corner solution in what follows.

[12] Taking the absolute value of the slope of the states' best-responses, global stability prevails when the product of the slopes is smaller than unity.

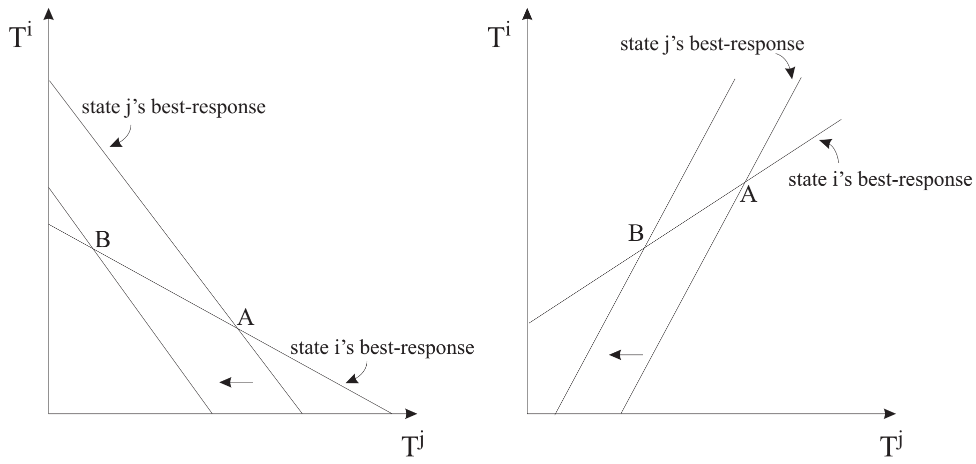

Figure 1: Best-Responses for $z^i_{T^i} < 0$ (left panel) and $z^i_{T^i} > 0$ (right panel).

following (12), $z^{i*}_{T^i} < 0$. Consider both states initially optimize over taxes. When state i deviates from tax to expenditure optimization, state i's public good level and thus taxes stay the same unless state j faces an incentive to change its policy.[13] In fact, state j faces a distinct interaction of policy variables via the transfer scheme when state i optimizes over g^i rather than T^i. Implied by Lemma 1, the tax price of marginal public expenditures rises and for any tax choice by state i state j's chooses a lower tax. Given that best-responses have a slope smaller one is absolute value, the tax T^j will be at a lower level in the new equilibrium. To infer the induced change in state i's well-being, we compute state i's utility when it optimally sets state policy for given state j's policy. To this end, let's define $v^i(T^j)$ as the utility evaluated at taxes T^i satisfying the optimality condition (8) for given T^j.[14] Invoking the envelope theorem and rearranging (all these steps are relegated to the Appendix), the change in utility $v^i(T^j)$ in response to a hike in state j's taxes is

$$\frac{dv^i(T^j)}{dT^j} = u^i_g z^i_{T^j}. \tag{13}$$

Since $z^i_{T^j} = -z^j_{T^j} > 0$ and T^j drops, state i experiences a loss in transfers and thus utility following the deviation. By symmetry of policy incentives, neither state has an incentive to switch to expenditure optimization given that the neighbor state optimizes over taxes. A reversed type of argument applies when $z^i_{T^i} > 0$ with the consequence that state i's utility increases when setting expenditures rather than taxes.

To graphically illustrate state i's best-response, consider $z^i_{T^iT^j} = 0$. In this case, states' taxes are unambiguously strategic substitutes (complements) if $z^i_{T^i} < 0$ (> 0). The left panel

[13]Recall, for a given level of taxes in state j, state i's utility is independent of whether taxes or expenditures are optimized by state i - see (8).

[14]Given the equivalence between tax and expenditure optimization by state i, $v^i(T^j)$ applies prior and after state i's deviation.

in figure 1 depicts the best-responses by both states when $z^i_{T^i} < 0$ where point A is the initially prevailing equilibrium of the stage-2 game.[15] The switch to expenditure policy by state i shifts state j's best-response inwards. The locus of state i's best response function stays the same (implicitly defined by (8)) and the new equilibrium tax choices are illustrated by point B in Figure 1. From (13), the change in state i's utility when moving along state i's best-response function from A to B is negative. Hence, state i becomes worse off due to the deviation. The right panel in Figure 1 depicts the states' best-responses for $z^i_{T^i} > 0$. The initial equilibrium of the stage-2 subgame is point A. Following state i's deviation to expenditure policy state j's tax price rises and state j's best-response function shifts inwards. Taxes T^j decrease (see point B in Figure 1). Following (13) and $z^i_{T^j} = -z^i_{T^i} < 0$, state i's utility rises when moving along state i's best-response from A to B. Thus,

Lemma 2: *Assume that state j optimizes over taxes. State i's best-response is to optimize over taxes (expenditures) iff $z^i_{T^i} < 0$ (> 0).*

Now consider that state j initially optimizes over g^j and state i over T^i. A deviation by state i to expenditure optimization increases the tax price in state j - see Lemma 1. By the virtue of equilibrium stability, the deviation yields a lower expenditure level and thus taxes in state j. Defining $v^i(g^j)$ as state i's utility evaluated at public policy which satisfies the optimality condition (11), the envelope theorem implies (see the Appendix)

$$\frac{dv^i(g^j)}{dg^j} = u^i_g \frac{z^i_{T^j}}{1 + z^j_{T^j}}. \tag{14}$$

Since changes in transfers must be budget-balancing, i.e. $z^i_{T^j} = -z^j_{T^j}$, transfers to state i drop (rise) in response to a lower expenditure level in state j and so does utility when $z^i_{T^i}$ < 0 (> 0).[16]

Lemma 3: *Assume that state j optimize over expenditures. State i's best-response is to optimize over taxes (expenditures) iff $z^i_{T^i} < 0$ (> 0).*

Combining Lemma 2 and 3, we can conclude that when $z^i_{T^i} < 0$ state i loses in transfers and, thereby, utility when optimizing over expenditures rather than taxes, irrespective of whether state j optimizes over taxes or expenditures. Hence, the only subgame perfect equilibrium of the policy selection game is that both states optimize over taxes. When $z^j_{T^j} > 0$ state i gains in transfers and, thereby, utility when optimizing over expenditures rather than taxes. Again, this holds irrespective of whether state j optimizes over taxes or expenditures.

[15]For simplicity, best-responses are drawn as linear functions.

[16]The diagrammatic exposition of the choice of policy variables is analogous to Figure 1. Contrary to the figure, state j's best-response is now defined over expenditures rather than taxes.

Consequently, the only subgame perfect equilibrium of the policy selection game entails states to optimize over expenditures. In sum,

Proposition 1: *The subgame perfect equilibrium of the policy selection game entails tax (expenditure) optimization when transfers undermine (strengthen) state fiscal incentives, i.e* $z^i_{T^i} < 0$ (> 0).

States compete for transfers and strategically chooses the optimization variable so as to lure more funds to the public budget. The incentives equally apply when states do not compete for transfers, but for mobile resources. In this case the interstate flow of resources is in capital rather than in transfers. Concretely, consider a model of symmetric capital tax competition when governments spend tax revenues on a public consumption good (Zodrow and Mieszkowski, 1986, and Wildasin, 1988). Therein, the formal analog to $z^i_{T^i}$ is how the capital tax base responds to own-state tax hikes. The response is negative and the conclusion is that states choose to compete for mobile capital by optimizing over taxes.[17]

4 Ex-Post Federal Tax Policy and Formula-Based Transfers

In the sequel we analyze the robustness of the sign and the magnitude of the incentive effects involved in tax and expenditure optimization and the influence the incentive effects exert on the choice of the optimization variable. In so doing, we resort to an alternative, frequently invoked model in which the federal government has taxing authority, but cannot commit to tax policy, i.e. it sets federal policy after states have determined their policy. This type of vertical interaction is referred to as decentralized leadership and lies at the root of the soft budget constraint syndrome in fiscal federalism - see e.g. Wildasin (1997), Qian and Roland (1998), Caplan et al. (2000), Akai and Sato (2005) and Koethenbuerger (2007).

In particular, consider the federal government has access to taxes $\{t^i\}_{i=1,2}$. The budget constraint of the household in state i becomes

$$c^i = I^i - T^i - t^i. \tag{15}$$

For simplicity, we retain the assumption that transfers are budget-balancing, $z^i + z^j = 0$. The federal budget constraints thus are

$$t^1 + t^2 = 0 \quad \text{and} \quad z^1 + z^2 = 0. \tag{16}$$

[17] In particular, as shown by Wildasin (1988) competition over expenditures yields a more downward distorted level of public consumption expenditure and of taxes. Thus, a deviation to expenditure optimization by one state leads to lower capital taxes in the neighboring state and, thereby, to an outflow of capital in the deviant state. Anticipating the negative effect on own-state revenues, states choose to compete over taxes. A formal proof of this result is relegated to Appendix C.

Federal taxes redistribute private income across states, while transfers redistribute public funds across states.[18] The budgetary dichotomy simplifies the analysis without affecting the qualitative results.[19]

The sequence of decisions becomes:

Stage 1: States simultaneously choose whether to optimize over taxes or expenditures.

Stage 2: States simultaneously optimize over the policy variable chosen at the first stage.

Stage 3: The federal government selects $\{t^i\}_{i=1,2}$ for given state policy.

Stage 4: Transfers $\{z^i\}_{i=1,2}$ are paid, taxes $\{t^i, T^i\}_{i=1,2}$ are collected, and households consume $\{c^i, g^i\}_{i=1,2}$.

Solving backwards, the federal government solves

$$\max_{\{t^i\}_{i=1,2}} \sum_{i=1,2} u^i(c,g) \quad \text{s.t.} \quad \text{Eqs. } (2),(3),(15) \text{ and } (16), \tag{17}$$

taking states' policy choices as given. In so doing, the federal government sets taxes so as to equalize the marginal utility of private consumption, i.e.

$$u_c^i = u_c^j, \quad i \neq j. \tag{18}$$

At stage 2 state government i anticipates the effect its policy has on the federal government's choice of tax rates. Assume first that state j optimizes over taxes. Differentiating the federal first-order condition (18) and the federal budget constraint w.r.t. t^i, t^j, and T^i and inserting $-T^i_{t^i} = T^i_{t^j}$ in the differentiated first-order condition, to eliminate the t^j derivative, gives

$$t^i_{T^i} = -\frac{u^i_{cc}}{u^i_{cc} + u^j_{cc}} \in (-1, 0). \tag{19}$$

More locally collected tax revenues T^i reduce private consumption in state i. To equalize the marginal utility of consumption across states (see (18)), the federal government reduces the federal tax rate t^i.

Replacing (1) by (15) in state i's optimization problem (7) and additionally taking (16) and (19) into account, public good provision satisfies

$$\frac{u_g^i}{u_c^i} = \left(1 - \frac{u^i_{cc}}{u^i_{cc} + u^j_{cc}}\right) \frac{1}{1 + z^i_{T^i}} \tag{20}$$

[18] A non-uniform tax scheme can be implemented by a uniform federal tax scheme and state-specific subsidies to address disparities in private consumption. Thus, the net tax revenue the federal government collects in each state differs (as allowed for here).

[19] The identified equilibria of the policy selection game equally exist in the absence of the assumption. Details of the calculations are available upon request.

independently of whether state i optimizes w.r.t. T^i or g^i (see the Appendix). The federal tax-transfer policy influences the perceived tax price of marginal public expenditures. Ex-post federal tax policy provides a subsidy on state i's taxing effort, while the transfer scheme may impose a tax on state i's taxing effort (when $z^i_{T^i} < 0$). The possibly counteracting effects of federal tax-transfer policy render public good provision inefficiently high or low.

Differently, consider state i conjectures that state j sets expenditure levels and determines taxes residually. Starting at (18), analogously iterating the steps involved in deriving (19) and noting (9), the marginal adjustment in t^i following a rise in T^i is

$$t^i_{T^i} = -\frac{u^i_{cc}}{u^i_{cc} + u^j_{cc}} - \frac{u^j_{cc} z^{j*}_{T^i}}{u^i_{cc} + u^j_{cc}}. \tag{21}$$

The first term coincides with (19); representing a subsidy on state i's marginal tax revenues. As to the second term, the change in state i's taxes translates into a change in entitlement payments z^{j*}.[20] As state j's taxes adjust residually, private consumption in state i rises (drops) when $z^{j*}_{T^i} > 0$ (< 0). To restore (18), the federal government offsets the imbalance in private consumption by reducing (increasing) t^i.

Substituting (1) by (15) in the state i's optimization problem (10) and additionally taking (16) and (21) into account, state i chooses a level of public goods which satisfies

$$\frac{u^i_g}{u^i_c} = 1 - \frac{u^i_{cc}}{u^i_{cc} + u^j_{cc}}. \tag{22}$$

The first-order condition holds irrespectively of whether state i optimizes over taxes or expenditures - see the Appendix. Possibly surprisingly, the tax price of marginal tax price of public expenditures is independent of how federal transfers respond to state fiscal policy. The rationale is that the adjustment in federal taxes insulates state governments from the incentive effects of transfers; albeit the federal government aligns the marginal utility of private consumption which is not directly affected by transfer payments. However, when $z^i_{T^i} < 0$ a rise in state i's tax lowers state i's entitlement payments. Given that state j is conjectured to optimize over expenditures, the inflow of transfers in state j reduces state j's taxes. Private consumption in state j rises and the federal government offsets the imbalance in private consumption across states by lowering state i's tax. The positive effect on state i's consumption is proportional to the negative effect of transfers on state i's expenditures, thereby neutralizing the effect of transfers on the tax price of marginal public expenditures. In sum, ex-post federal tax policy neutralizes the incentive effect of transfer policy and subsidizes state-financed spending. Consequently, the state i's tax price is unambiguously below

[20] z^{j*} denotes transfer payments for state j when state i conjectures state j to optimize over expenditures. It formally follows from inserting (2) into (3), to substitute T^j by the policy variable g^j, and using the budget constraint (16).

the social cost. We can therefore summarize:

Lemma 4: *Public good provision in state i is either inefficiently high or low under tax policy setting by state j. When state j sets expenditures public good provision in state i is inefficiently high. In particular, provided $z^i_{T^i} < 0$ (> 0) state i's incentives to spend on public goods are more pronounced* (*weaker*) *when state j optimizes over expenditures instead of taxes.*

The divergence of policy incentives is due to the fact that state policy instruments interact differently through federal tax-transfer policy. For instance, consider the transfer response $z^i_{T^i}$ to be negative. Under tax policy setting by state j a higher tax rate in state i leads to fewer transfers in state i and, since $z^i + z^j = 0$, transfers in state j rise. The residual adjustment in public consumption of state j does not spill back through federal tax-transfer policy to state i. Transfers are formally conditioned only on taxes and federal tax policy seeks to align private consumption levels. Differently, when state j sets expenditures, a higher T^i reduces z^i and, since $z^i + z^j = 0$, state j enjoys higher transfers which in turn lower its tax rate T^j (residually determined). Implied by (18), the ensuing rise in c^j yields a lower federal tax rate in state i. As such, the residual adjustment in T^j positively spills back to state i; a repercussion which strengthens state i's fiscal incentives. An analogous type of reasoning leads to the conclusion that state i's policy incentives are stronger under tax policy setting by state j provided the transfer response $z^i_{T^i}$ is positive.

To infer how federal tax-transfer policy influences the choice of the optimization variable at stage 1 of the game, we characterize incentives of each state to unilaterally deviate from a given choice of policy variable. Assume first that states initially optimize over taxes. A change to expenditure policy on the part of state i leaves its public good provision rule unaffected - see (20). However, its utility changes to the extent that state j adjusts its policy in response to state i's deviation. When state j faces a neighboring state which chooses expenditures rather than taxes, the tax price decreases for $z^j_{T^j} < 0$. In this case, state j sets a higher tax rate for any choice of T^i. The ensuing equilibrium entails a higher tax T^j. The impact on state i's utility is evaluated using state i's best-response function as implied by the first-order condition (20). Define $v^i(T^j)$ as the associated utility level for a given level of T^j. Applying the envelope theorem, deriving the tax/transfer responses and rearranging (all the steps are relegated to the Appendix), we get

$$\frac{dv^i(T^j)}{dT^j} = -u^i_c \frac{1 + z^i_{T^i} + z^j_{T^j}}{1 + z^i_{T^i}} \frac{u^j_{cc}}{u^i_{cc} + u^j_{cc}}. \tag{23}$$

Provided $z^i_{T^i} + z^j_{T^j} < -1$ $(\in (-1, 0))$, utility rises (drops) following state i's change in the optimization variable.[21] The intuition is both the federal tax t^i and the transfer z^i rise in response to state j's tax hike with counteracting effects on state i's utility. The stronger the disincentive effect $z^j_{T^j}$ the larger the inflow of transfers to state i in response to a higher tax rate T^j and the more pronounced $z^i_{T^i}$ the higher the inflow of transfers to state i which results from the residual reduction in its own tax rate subsequent to the first-round inflow of transfers. If the joint effect is sufficiently strong (as measured by $z^i_{T^i} + z^j_{T^j}$) the transfer response dominates the reduction in private consumption following the rise in federal taxes $t^i_{T^j} > 0$.

Differently, consider that $z^j_{T^j} > 0$. State j decreases its tax rate in response to state i's deviation from tax to expenditure optimization and state i experiences two different effects on utility: The federal tax t^i decreases and transfers increase (as $z^j_{T^j} > 0$ implies $z^i_{T^j} < 0$). State i's utility unambiguously increases. To summarize the findings:

Lemma 5: *Consider state j optimizes over taxes. State i has an incentive to deviate from tax to expenditure policy if either $z^i_{T^i} > 0$ or $z^i_{T^i} < 0$ and $z^i_{T^i} + z^j_{T^j} < -1$.*

When state j optimizes over expenditures, a switch to expenditure optimization on the part of state i increases (decreases) expenditures and thus taxes in state j when $z^j_{T^j} < 0$ (> 0). Define $v^i(g^j)$ as state i's utility evaluated at the best-response function of state i. Invoking the envelope theorem, computing the responses in transfers and federal taxes, and rearranging yields (the derivation is dealt with in the Appendix)

$$\frac{dv^i(g^j)}{dg^j} = -u^i_c \frac{u^j_{cc}}{u^i_{cc} + u^j_{cc}} < 0. \tag{24}$$

A higher spending level and thus taxes in state j increase the federal tax levied in state i. Given that state j optimizes over expenditures, the federal tax response absorbs the incentive effects of transfer policy on state i - see Lemma 4. Thus, the rise in state j's expenditures lowers state i's private consumption. Since the deviation by state i increases (decreases) expenditures and thus taxes in state j when transfers discourage (encourage) state fiscal effort, we conclude that state i's utility decreases (increases) when transfers discourage (encourage) state fiscal effort.

Lemma 6: *Consider state j optimizes over expenditures. State i has an incentive to deviate from tax to expenditure optimization iff $z^i_{T^i} > 0$.*

What are the equilibrium implications of both Lemmata? When $z^i_{T^i} < 0$, Lemma 6 rules out expenditure optimization as an equilibrium since both states have an incentive to deviate.

[21] For expositional simplicity we throughout omit the generic case of $z^i_{T^i} + z^j_{T^j} = -1$ in which utility v^i stays the same.

Lemma 5 shows that tax optimization is an equilibrium if transfer responses $z^i_{T^i} + z^j_{T^j}$ are not too pronounced. Otherwise, we observe an asymmetric equilibrium, i.e. one state optimizes over taxes whilst the other state does so over expenditures. When $z^i_{T^i} > 0$ Lemma 5 rules out tax policy as an equilibrium outcome and the only policy which is immune to unilateral deviations is expenditure optimization - see Lemma 6. To summarize,

Proposition 2: (*i*) *When transfer policy undermines state fiscal incentives* ($z^i_{T^i} < 0$) *the subgame perfect equilibrium of the policy selection game entails both states to optimize over taxes if the overall disincentive effect of transfer policy, as measured by* $z^i_{T^i} + z^j_{T^j} < 0$, *is sufficiently weak, i.e.* $z^i_{T^i} + z^j_{T^j} \in (-1, 0)$. *Otherwise, states choose to optimize over different policy variables in equilibrium.* (*ii*) *When transfer policy strengthens state fiscal incentives* ($z^i_{T^i} > 0$) *the subgame perfect equilibrium involves both states to optimize over expenditures.*

As in the model of Section 3, states choose their policy variable such that the induced adjustment in fiscal policy of the neighboring state yields a favorable response in the federal policy programme. However, different to the preceding model, tax optimization is not the unique equilibrium outcome when transfers discourages states to rely on own-source public funds. In fact, states select themselves into different policy regimes if the disincentive effect is sufficiently strong.[22]

The fact that states may not optimize over the same policy variable opens up the possibility that the tax price of marginal public expenditures drops when transfer policy exerts a stronger disincentive effect on state policy. For illustrative simplicity, assume the transfer system (3) to be linear and symmetric, $z^i_{T^i} = z^j_{T^j}$. The linearity allows us to use the slope $z^i_{T^i}$ as a policy instrument. A reform of the linear transfer formula such that $z^i_{T^i} + z^j_{T^j}$ changes from a value above -1 to a value below -1, yields an equal change in the magnitude of the slope in both states. Conditional on the initial choice of policy variables (here taxes - see Lemma 6), incentives to spend on public goods are predicted to be diluted (see (20)). Taking the endogeneity of the policy variable into account, one state changes from tax to expenditure policy while the other state still engages in tax policy. As implied by Lemma 4, spending incentives are strengthened in the non-switching state and, owing to equilibrium stability, expenditures in the non-switching state will be at a higher level.

5 Conclusion

The paper explores how federal policy influences the choice of policy variable by state governments. Previous literature predominantly takes taxes to be optimized and expenditures

[22]The required strength of the disincentive effect is not implausibly large. Empirical estimates of the "marginal tax" federal transfer programmes impose on own-source tax revenues may well exceed 0.5 (e.g. Baretti et al., 2002, and Zhuravskaya, 2000).

follow residually. The paper provides an equilibrium analysis of the choice of policy variable. The equilibrium choice turns out to be sensitive to the way the federal tax-transfer policy tags state policy. Still, a common finding in both models considered in the paper is that governments choose to optimize over expenditures when federal transfers subsidize state fiscal effort. The paper's results are of relevance for the design of corrective policy and for evaluating the impact of federal tax-transfer schemes on the efficiency of state policy. Specifically, the conditional response (i.e. for a given choice of policy variable) and the unconditional response (i.e. accounting for the choice of policy variable) of local policy to changes in federal policy differ not only quantitatively, but may also differ qualitatively. A reform of the federal tax-transfer system, which discourages state spending conditional on the choice of policy variable, may in fact promote spending incentives when accounting for the endogeneity of the choice.

A natural question is whether the strategic incentives pertaining to the choice of policy variables may not be more multi-faceted than suggested in the paper. For instance, decomposing the expenditure side of the budget into consumption outlays and infrastructure investment, states are equally in a position to compete for transfers by optimizing over, for instance, consumption expenditures and taxes and letting infrastructure spending adjust residually. Which pair of policy variables constitutes an equilibrium choice and how the choice influences the efficiency of the local public sector is an interesting question which is left to future research.

A Appendix

Subsequently, we characterize the state's first-order condition by first deriving the tax price of marginal public expenditures. The optimality conditions then follows from aligning the tax price to the marginal rate of substitution between private and public consumption.

A.1 Derivation of (8)

Tax policy A rise in state i's tax rate dT^i implies a change in transfers by $z^i_{T^i} dT^i$, and public expenditures increase by $dg^i = (1+z^i_{T^i})dT^i$. The tax price of marginal public spending is $dT^i/dg^i = 1/(1+z^i_{T^i})$. Thus, the first-order condition is (8).

Expenditure policy Inserting (2) into (3), to express transfers to state i as an implicit function of policy variables in state i, g^i, and state j, T^j, we have $\bar{z}^i = \gamma(g^i - \bar{z}^i, T^j)$ with slope $\bar{z}^i_{g^i} = z^i_{T^i}/(1+z^i_{T^i})$. A rise in expenditure by dg^i now leads to a change in transfers by $\bar{z}^i_{g^i} dg^i$. In response to it, taxes have to increase by $dT^i = (1 - z^i_{g^i})dg^i$. Hence, $(1 - z^i_{g^i})$ is the tax price of marginal public spending under expenditure optimization. The first-order condition is

$$\frac{u^i_g}{u^i_c} = 1 - \bar{z}^i_{g^i}. \tag{25}$$

Inserting the explicit form of the slope term $\bar{z}^i_{g^i}$ into the tax price shows that it coincides with the tax price under tax optimization. The first-order condition (25) is equivalent to (8).

A.2 Derivation of (11)

Tax policy Given (9) a rise in taxes by dT^i yields a change in transfers equal to $z^{i*}_{T^i} dT^i$. Expenditures residually rise by $(1+z^{i*}_{T^i})dT^i$ which gives a tax price of marginal public spending of $1/(1+z^{i*}_{T^i})$. The first-order condition thus becomes (11).

Expenditure policy Inserting (2) into (3), to express transfers to state i as an implicit function of policy variables in state i and state j, g^i and g^j, $\tilde{z}^i = \gamma(g^i - \tilde{z}^i, g^j - \tilde{z}^j)$. Now, a rise in expenditures by dg^i requires an adjustment in taxes at an amount $(1 - \tilde{z}^i_{g^i})dT^i$. The tax price is $1 - \tilde{z}^i_{g^i}$ and the first-order condition reads

$$\frac{u^i_g}{u^i_c} = 1 - \tilde{z}^i_{g^i}. \tag{26}$$

Implicit differentiation of $\tilde{z}^i$ and using $\tilde{z}^i_{T^j} = -\tilde{z}^j_{T^j}$, we have $\tilde{z}^i_{g^i} = z^i_{T^i}/(1+z^i_{T^i}+z^j_{T^j})$. Inserting the slope term into (26) and inserting (12) into the first-order condition under tax policy (11) shows that conditions (11) and (26) coincide.

A.3 Derivation of (20)

Tax policy Increasing the state tax by dT^i, the combined effect on state and federal taxes, $T^i + t^i$, is $(1 + t^i_{T^i})dT^i$. Expenditures change by $(1 + z^i_{T^i})dT^i$ which yields a tax price equal to $(1 + t^i_{T^i})/(1 + z^i_{T^i})$. The first-order condition is (20).

Expenditure policy As a first step insert (2) into the federal first-order condition (18), to substitute T^i for $g^i - \bar{z}^i$, where $\bar{z}^i = \gamma\left(g^i - \bar{z}^i, T^j\right)$. Differentiating the modified optimality condition w.r.t. t^i, t^j, and g^i yields the response $t^i_{g^i} = -u^i_{cc}(1-\bar{z}^i_{g^i})/(u^i_{cc}+u^j_{cc})$. The change in the combined tax burden to a rise in expenditures thus is $[1-\bar{z}^i_{g^i} - u^i_{cc}(1-\bar{z}^i_{g^i})/(u^i_{cc}+u^j_{cc})]dg^i$. The bracketed term represents the tax price of marginal public expenditures. Hence,

$$\frac{u^i_g}{u^i_c} = 1 - \bar{z}^i_{g^i} - u^i_{cc}(1 - \bar{z}^i_{g^i})/\left(u^i_{cc} + u^j_{cc}\right). \tag{27}$$

Noting that $\bar{z}^i_{g^i} = z^i_{T^i}/\left(1 + z^i_{T^i}\right)$, the first-order condition (27) equals the first-order condition under tax policy (20).

A.4 Derivation of (22)

Tax policy Given (9) the effect of a rise in taxes by dT^i on the combined tax burden $t^i + T^i$ is $[u^j_{cc}(1 - z^{j*}_{T^i})/(u^i_{cc} + u^j_{cc})]dT^i$. Expenditures change by $(1 + z^{i*}_{T^i})dT^i$. Since transfers are budget-balancing, $z^{i*}_{T^i} = -z^{j*}_{T^i}$ the tax price of marginal public expenditures simplifies to $1 - u^i_{cc}/(u^i_{cc} + u^j_{cc})$ and the resulting first-order condition is (22).

Expenditure policy Inserting (2) into (3), to express transfers to state i as an implicit function of policy variables in state i and state j, g^i and g^j, $\tilde{z}^i = \gamma(g^i - \tilde{z}^i, g^j - \tilde{z}^j)$. Next, insert (2) into the federal first-order condition (18), to substitute T^i and T^j for $g^i - \tilde{z}^i$ and $g^j - \tilde{z}^j$. Differentiating the modified optimality condition w.r.t. t^i, t^j, and g^i yields the response $t^i_{g^i} = -u^i_{cc}/(u^i_{cc} + u^j_{cc}) - \tilde{z}^i_{g^i}$. Now, a rise in expenditures by dg^i yields a change in the tax burden of $(1 + t^i_{g^i} - \tilde{z}^i_{g^i})dg^i$. The tax price is $1 + t^i_{g^i} - \tilde{z}^i_{g^i}$ and consequently, the first-order condition becomes

$$\frac{u^i_g}{u^i_c} = 1 + t^i_{g^i} - \tilde{z}^i_{g^i}. \tag{28}$$

Finally, inserting the tax response $t^i_{g^i}$ into (28) shows that the first-order conditions under tax and expenditure optimization, (22) and (28), coincide.

B Appendix

B.1 Derivation of (13)

A rise in T^j when state i sets expenditures yields a change in $v^i(T^j)$ is

$$\frac{dv^i(T^j)}{dT^j} = u^i_c z^{*i}_{T^j}, \tag{29}$$

where the term has been simplified by invoking the envelope theorem. Inserting (8), (12) and noting that transfer payments must balance the budget, the expression (29) simplifies to

$$\frac{dv^i(T^j)}{dT^j} = u^i_g z^i_{T^j}. \tag{30}$$

B.2 Derivation of (14)

Marginally increasing T^j when state i optimizes over expenditures implies a change in utility $v^i(g^j)$ which is equal to

$$\frac{dv^i(g^j)}{dg^j} = u^i_c \tilde{z}^i_{g^j}. \tag{31}$$

$\tilde{z}^i = \gamma(g^i - \tilde{z}^i, g^j - \tilde{z}^j)$ implicitly defines transfer payments to state i as a function of expenditure levels in both states. Implicit differentiation and using $\tilde{z}^i_{T^j} = -\tilde{z}^j_{T^j}$ yields $\tilde{z}^i_{g^i} = z^i_{T^i}/(1 + z^i_{T^i} + z^j_{T^j})$. Inserting the expression and (11) into (31) and noting that transfers are self-financing

$$\frac{dv^i(g^j)}{dg^j} = u^i_g \frac{z^i_{T^j}}{1 + z^j_{T^j}}. \tag{32}$$

B.3 Derivation of (34)

Invoking the envelope theorem, the change in utility when state i optimizes over expenditures is

$$\frac{dv^i(T^j)}{dT^j} = -u^i_c(t^i_{T^j} + z^{*i}_{T^j}). \tag{33}$$

Noting, following (16), that $t^i_{T^j} = -t^j_{T^j}$ and $z^i_{T^j} = -z^j_{T^j}$ and inserting (19) and (12) into (33), the utility change becomes

$$\frac{dv^i(T^j)}{dT^j} = -u^i_c \frac{1 + z^i_{T^i} + z^j_{T^j}}{1 + z^i_{T^i}} \frac{u^j_{cc}}{u^i_{cc} + u^j_{cc}}. \tag{34}$$

B.4 Derivation of (24)

When state i optimizes over taxes, the envelope theorem implies

$$\frac{dv^i(g^j)}{dg^j} = -u^i_c(t^i_{g^j} + \tilde{z}^i_{g^j}). \tag{35}$$

To characterize both responses, insert (2) into (3), to express transfers to state i as an implicit function of policy variables in state i and state j, g^i and g^j, $\tilde{z}^i = \gamma(g^i - \tilde{z}^i, g^j - \tilde{z}^j)$. Next, insert (2) into the federal first-order condition (18), to substitute T^i and T^j for $g^i - \tilde{z}^i$ and $g^j - \tilde{z}^j$. Differentiating the modified federal optimality condition w.r.t. t^i, t^j, and g^j yields the response $t^j_{g^j} = -u^j_{cc}/(u^i_{cc} + u^j_{cc}) - \tilde{z}^j_{g^j}$. Substituting $t^i_{g^j} = -t^j_{g^j}$ in (35) by the slope term and noting that transfers are self-financing yields

$$\frac{dv^i(g^j)}{dg^j} = -u^i_c \frac{u^j_{cc}}{u^i_{cc} + u^j_{cc}} < 0. \tag{36}$$

C Appendix

Consider 2 symmetric states. In each region, the representative household is endowed with both factors of production: capital K and a fixed factor (e.g. inelastically supplied labor) which is normalized to unity. The income of the household is given by $c = w + rK$ where w is the wage rate and r the interest rate. Households derive utility from private consumption c and from a local public good g provided by the federal government. The utility function is[23]

$$U(c, g) = u(c) + u(g) \tag{37}$$

Regional output can be transformed on a one-to-one basis either in a private good c or a local public good g. The production technology $f(k)$ exhibits constant returns to scale. Firms are

[23] We adopt the same utility function as in the paper. The additive structure is without loss of generality.

assumed to be profit-maximizer. Profits are given by

$$\pi = f(k) - w - (r + T)k. \tag{38}$$

Capital employment k is taxed at source at a rate T. Firms maximize (38) with respect to k, which leads to the first-order condition

$$f'(k) = r + T. \tag{39}$$

(39) implicitly defines regional capital employment as a function of the tax rate T and the interest rate r. The wage rate w equals $f(k) - f'(k)k$. Regional consumption is thus given by

$$c = f(k) + r(K - k) - Tk. \tag{40}$$

Capital is perfectly mobile and is allocated to the region where it earns the highest net-of-tax rate of return. The capital market equilibrium is characterized by the first-order condition (39) and the capital market clearing condition

$$k^1 + k^2 = 2K. \tag{41}$$

(39) and (41) define capital employment and the interest rate as a function of both states' tax rate, $k^i(T^i, T^j$ and $r(T^i, T^j)$. The responses of k^i and k^j to a change in t^i are given by

$$k^i_{T^i} = \Delta^{-1} \quad \text{and} \quad k^j_{T^i} = -\Delta^{-1} \quad \text{with } \Delta \ := \ f''(k^i) + f''(k^j) < 0. \tag{42}$$

Tax revenues Tk are recycled by providing a public consumption good g whose price is normalized at unity:

$$g = Tk. \tag{43}$$

C.1 Tax Optimization by State j

Assume first that state i optimizes over taxes. State i solves

$$\max_{T^i} \quad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (40), (42) \text{ and } (43), \tag{44}$$

taking T^j as given. Differentiating w.r.t. T^i the first-order condition is

$$u^i_c(f'(k^i)k^i_{T^i} + r_{T^i}(K - k^i) - rk^i_{T^i} - k^i - T^i k^i_{T^i}) + u^i_g(T^i k^i_{T^i} + k^i) = 0 \tag{45}$$

Evaluated at a symmetric equilibrium ($k^i = K$) and inserting (39) yields

$$-u^i_c k^i + u^i_g(T^i k^i_{T^i} + k^i) = 0. \tag{46}$$

Consider state i optimizes over expenditures. Inserting the public budget constraint into $k^i(T^i, T^j)$ to express capital employment as a function of expenditures g^i and taxes T^j gives $\tilde{k}^i(g^i/\tilde{k}^i, T^j)$ and $\tilde{r}(g^i/\tilde{k}^i, T^j)$. The slope of $\tilde{k}^i$ w.r.t. g^i is

$$\tilde{k}^i_{g^i} = \frac{k^i_{T^i}/\tilde{k}^i}{1 + k^i_{T^i} g^i/(\tilde{k}^i)^2}. \tag{47}$$

State i solves

$$\max_{g^i} \quad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (40), (43) \text{ and } (47), \tag{48}$$

taking T^j as given. Differentiating (48) w.r.t. g^i gives

$$u^i_c(f'(\tilde{k}^i)\tilde{k}^i_{g^i} + \tilde{r}_{g^i}(K - \tilde{k}^i) - \tilde{r}\tilde{k}^i_{g^i} - 1) + u^i_g = 0. \tag{49}$$

Evaluated at a symmetric equilibrium ($k^i = K$) and inserting (39), the first-order condition simplifies to

$$u^i_c(T^i\tilde{k}^i_{g^i} - 1) + u^i_g = 0. \tag{50}$$

Inserting (47) and noting (43), the first-order condition (50) coincides with (46). Thus, given that state j optimizes over taxes, expenditure and tax optimization by state i yield identical policy incentives.

C.2 Expenditure Optimization by State j

Consider state i optimizes over taxes. Inserting the public budget constraint by state j into $k^i(T^i, T^j)$ to express capital employment in state i as a function of taxes T^i and expenditures g^j gives $k^{*i}(T^i, g^j/k^{*j})$ and $r^*(T^i, g^j/k^{*j})$. The slope of k^{*i} w.r.t. T^i is

$$k^{*i}_{T^i} \quad = \quad \frac{k^i_{T^i}}{1 - k^i_{T^j} g^j/(k^{*i})^2}. \tag{51}$$

State i solves

$$\max_{T^i} \quad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (40), (43) \text{ and } (51), \tag{52}$$

taking g^j as given. Differentiating (52) w.r.t. T^i gives

$$u^i_c(f'(k^{*i})k^{*i}_{T^i} + r^*_{T^i}(K - k^{*i}) - r^*k^{*i}_{T^i} - k^{*i} - T^i k^{*i}_{T^i}) + u^i_g(T^i k^{*i}_{T^i} + k^{*i}) = 0. \tag{53}$$

Evaluated at a symmetric equilibrium ($k^{*i} = K$) and inserting (39) yields

$$u^i_c(-k^{*i}) + u^i_g(T^i k^{*i}_{T^i} + k^{*i}) = 0. \tag{54}$$

Consider state i optimizes over expenditures. Inserting the public budget constraint by state j into $k^i(T^i, T^j)$ to express capital employment in state i as a function of expenditures g^i and expenditures g^j gives $\bar{k}^i(g^i/\bar{k}^i, g^j/\bar{k}^j)$ and $\bar{r}(g^i/\bar{k}^i, g^j/\bar{k}^j)$. The slope of $\bar{k}^i$ w.r.t. g^i is

$$\bar{k}^i_{g^i} = \frac{k^i_{T^i}/\bar{k}^i}{1 + k^i_{T^i} g^i/(\bar{k}^i)^2 - k^i_{T^j} g^j/(\bar{k}^j)^2}. \tag{55}$$

State i solves

$$\max_{g^i} \qquad U^i(c, g) \quad \text{s.t.} \quad \text{Eqs.} \quad (40), (43) \text{ and } (55), \tag{56}$$

taking g^j as given. Differentiating (56) w.r.t. g^i

$$u^i_c(f'(\bar{k}^i)\bar{k}^i_{g^i} + \bar{r}_{g^i}(K - \bar{k}^i) - \bar{r}\bar{k}^i_{g^i} - 1) + u^i_g = 0. \tag{57}$$

Evaluated at a symmetric equilibrium ($\bar{k}^i = K$) and inserting (39) the first-order condition reduces to

$$u^i_c(T^i \bar{k}^i_{g^i} - 1) + u^i_g = 0. \tag{58}$$

Inserting (55) into (58) and rearranging gives

$$-u^i_c(k^i + k^i_{T^i}) + u^i_g(k^i + T^i k^i_{T^i} - T^j k^j_{T^j}) = 0. \tag{59}$$

To compare the first-order condition (59) with the first-order condition (54) insert the capital response (51) into (54) which reveals that both first-order conditions coincide. Thus, given that state j optimizes over expenditures, expenditure and tax optimization by state i yield identical policy incentives.

The analyze how policy incentives differ when state j sets expenditures rather than taxes, we compare (46) and (54). In symmetric equilibrium ($k^{*i} = k^i$) the conditions differ by the response of capital to changes in the policy variable. Following (51)

$$k^{*i}_{T^i} = \frac{k^i_{T^i}}{1 + k^j_{T^j} T^j/k^j},$$

where the equality follows from using the public budget constraint (43) and the fact that the capital market clears, i.e. $k^i_{T^j} = -k^j_{T^j}$. The capital response $k^{*i}_{T^i}$ differs from $k^i_{T^i}$ by the term $1/(1 + k^j_{T^j} T^j/k^j)$ which is state j's tax price of marginal public expenditures when state j optimizes over taxes and state i optimizes over expenditures - see (46). It exceeds unity and thus the capital response $k^{*i}_{T^i}$ is larger in absolute terms relative to $k^i_{T^i}$. The tax price of marginal public expenditures is hence higher when state j optimizes over expenditures rather than taxes.

Lemma A1: *State i's incentives to provide public goods are less pronounced when state j optimizes over expenditures rather than capital taxes.*

The intuition for the result is that following a rise in state i's tax rate capital moves from state i to state j. The inflow of capital leads to a rise in expenditures when state j sets taxes, but leads to a reduction in taxes when state j sets expenditures. In the latter case even more capital will move to state j in response to a tax hike in state i. State i's tax price of marginal public expenditures will hence be higher.

C.3 Equilibrium Choice of Policy Variable

To infer into the choice of policy variable, we first characterize the best-response of state i given that state j optimizes over taxes. Consider state i initially optimizes over taxes and switches to expenditure optimization. Given Lemma A1 the tax price of marginal public expenditures in state j rises and, given global stability of the equilibrium, state j's tax rate will be lower in the new second-stage equilibrium. The effect on state i's utility can be computed by defining $v^i(T^j)$ as state i's utility evaluated at state i's policy which satisfies the first-order condition (46). Using (39) the change in utility to a rise in state j's tax rate is

$$\frac{dv^i(T^j)}{dT^j} = u_c^i T^i k_{T^j}^{*i}. \tag{60}$$

The sign of the utility change is positive since $k_{T^j}^{*i} = -k_{T^j}^{*j} > 0$ - see (51). Since T^j decreases, state i experiences a loss in utility when deviating. Thus,

Lemma A2: *Assume that state j optimizes over taxes. State i's best-response is to optimize over capital taxes.*

Differently, assume state j optimizes over expenditures. When state i switches from tax to expenditure optimization state j's tax price of marginal public expenditures goes up. Owing to global stability state j's level of expenditures and thus taxes will be lower in the new symmetric equilibrium. Denoting state i's utility evaluated at the policy satisfying the first-order condition (54) by $v^i(g^j)$, the change in utility emanating from a rise in g^j is

$$\frac{dv^i(g^j)}{dg^j} = u_c^i T^i \tilde{k}_{g^j}^i. \tag{61}$$

The term has already been simplified by using (39). Since g^j is set a lower level and $\tilde{k}_{g^j}^i = -\tilde{k}_{g^j}^j$, state i's utility drops following the deviation.

Lemma A3: *Assume that state j optimizes over expenditures. State i's best-response is to optimize over capital taxes.*

Following Lemma A2 and A3, state i has a dominant strategy: optimizing over taxes is a best-response irrespective of the choice of policy variable by state j. Consequently,

Proposition A1: *The subgame-perfect equilibrium of the policy selection game entails both states to optimize over capital taxes.*

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