Federal Tax-Transfer Policy and Intergovernmental Pre-Commitment*

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Abstract

Federal and state governments often differ in the capacity to pre-commit to expenditure and tax policy. Whether the implied sequence of public decisions has any efficiency implications is the subject of this paper. We resort to a setting which contrary to most of the literature does not exhibit a perfect tax-base overlap. We show that a federal government's pre-commitment capacity is welfare-improving. Efficiency, however, does not improve over all decision margins. The welfare-increasing policy entails a more distorted level of public consumption. Moreover, welfare may also improve if local governments are able to pre-commit towards the upper level. The rationale is that although federal transfers are formally unconditional they nevertheless entail a tax-price effect; thereby potentially counteracting incentives to engage in a "race to the bottom" in fiscal competition among local governments.

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1 Introduction

In most countries decentralized governments have the authority to decide on local taxes and expenditures. Independently of the degree of fiscal autonomy their policy choices are significantly influenced by the fiscal relations with the federal government. Reflecting efficiency and redistributive concerns the federal and local budgets are linked via a complex set of fiscal arrangements which include equalization payments, matching grants, and revenue-sharing systems. The way in which the federal tax-transfer system influences local policy depends on the specific formula used to allocate funds to local governments.[1] However, the incentive effects of the federal tax-transfer system are also related to the pre-commitment capacity by different levels of government. As shown recently, efficiency in local fiscal choices can be realized without resorting to formulaic (Pigouvian) transfers (Boadway and Keen, 1996 and Caplan et al., 2000). If only lump-sum transfers are at the federal government's disposal, inefficiencies which are rooted either in a tax-base overlap or in public consumption spill-overs can in fact be overcome depending on the governments' pre-commitment capacity.[2] The unorthodox efficiency results of federal transfer policy have been derived in fiscal settings with either a perfect tax base overlap (Boadway and Keen, 1996) or exclusive taxation by lower-level governments (Caplan et al., 2000). The paper deviates from these contributions (and from most existing analyses of federal policy making) by assuming that the federal and local taxing authority does not perfectly overlap as e.g. observed in Canada, Germany and the U.S. We assume a two-layer federal system with source-based capital taxation at the lower governmental level and labor taxation at the upper level of government. Since capital is mobile between local jurisdictions, the capital tax is distortionary from the perspective of local governments (Zodrow and Mieszkowski, 1986). The federal government decides on lump-sum transfers to local governments which, along with capital tax revenues, are spent on public consumption. The modelling choice mirrors the

[1]See Dahlby (1996) for an analysis of efficiency enhancing formulaic grants (Pigouvian grants). Equalizing transfers may become formulaic by conditioning them on a measure of local fiscal capacity. Besides their redistributive properties they are also capable of promoting efficiency - see e.g. Köthenbürger (2002).

[2]Boadway and Keen (1996) show that if the federal government is able to pre-commit, lump-sum transfers are sufficient to correct inefficiencies in local policy choices which relate to a tax base overlap. The efficiency result extends to environments with decentralized redistribution (Boadway et al., 1998) and heterogeneous regions if federal policy instruments are sufficiently differentiated (Sato, 2000). Reversely, if local governments are able to pre-commit, federal lump-sum transfers induce local governments to efficiently contribute to a global public good (Silva and Caplan, 1997 and Caplan et al., 2000).

tax/transfer assignment in a variety of federal states. The federal government makes unconditional transfers to state governments, most notably to undo horizontal imbalances in local public funds. Although conditional grants to correct inefficient incentives to compete for mobile capital are well understood in theory, their practical relevance is limited.[3] As to the allocation of tax instruments, in most countries the federal level has the income tax and the value-added tax. In a static setting both taxes primarily resort to labor income as we assume in the paper.[4] Local governments in contrast have access to a limited set of tax instruments. For instance, in Germany the only fiscally important local tax instrument is a source-based capital tax (Gewerbesteuer) (levied by municipalities). Furthermore, it appears to be a common feature of federations that states which are linked by a federal transfer system are engaged in fiscal competition at the same time - e.g. Canada, Germany, USA.

We are interested in comparing the tax and expenditure choices when either the federal or state governments are unable to pre-commit with the traditionally simultaneously determined policy choices. Existing literature is open as to which timing of public decisions is more suggestive in fiscal federalism. Based on institutional analysis[5], Hoyt and Jensen (1996) argue that U.S. states are able to pre-commit toward local governments. The ability reflects the constitutionally anchored state government supremacy over local governments. In contrast, states within the Russian federation are conjectured to be in a better position to pre-commit than the federal government (Keen, 1998). Furthermore, among Canadian provinces Ontario is argued to have the capacity to pre-commit since 40% of federal tax revenues stem from Ontario (Dahlby, 1996). In the European Union (EU) it is controversially debated whether Brussels has the ability to pre-commit toward member states. The "weakness" may reflect the bottom-up historical evolution of European institutions which has left significant political power with member states (Caplan et al., 2000).[6]

[3]Indeed, the European Union addresses inefficiencies inherent to tax competition by tax coordination agreements (involving e.g. information exchange among national fiscal authorities) rather than by the implementation of Pigouvian grants.

[4]The common tax base also includes capital income which, as a source of tax revenue, is of minor importance relative to labor income.

[5]Related econometric analysis is almost non-existent - the exception being Hayashi and Boadway (2001) who report mixed evidence as to whether the federal government pre-commits towards provincial governments in Canada.

[6]Two important political institutions in the EU are the European Commission (EC) and the European Council

Also, federal governments are often bound to equalize public funds across member states so as to enable households access to a minimum public service level irrespective of the place of residence in the federation.[7] The primacy often coerces federal government to accommodate state governments' finances ex-post; thereby undermining the federal pre-commitment ability (e.g. Boadway, 2004).

The paper's main results are as follows: If the federal government pre-commits towards local governments, efficiency may not improve over all public decision margins. The federal government optimally reduces transfers (and thus distortionary labor taxes) in order to strengthen local incentives to resort to capital taxation. Thereby, it exposes public expenditure levels more severely to a downward pressure in fiscal competition. Despite the fact that the efficiency effects of federal policy are countervailing, overall welfare increases.

If states can pre-commit, the welfare implications are ambiguous. The welfare differential is non-monotonically related to the degree of capital mobility. With a high capital mobility, capital taxes rise which inclines the federal government to rely less on distortionary labor taxes. The net effect on total tax revenues turns out to be positive, which leaves public good provision at a more efficient level. The rationale is that local government do not only compete for mobile capital, but also for federal transfers. The federal government allocates transfers dependent on the inequality of public consumption across states. If a state collects more tax revenues relative to the neighboring state (due to higher taxing effort), it forfeits transfers which undermines taxing incentives. With capital mobility the neighboring state also collects more capital tax revenues since capital moves to states which offer a more attractive tax policy. If capital mobility is sufficiently high, the neighboring state enjoys an increase in tax revenues which outweighs the increase in the tax-raising state.

of Ministers (consisting of member states' ministers widely representing national interests). The EC has a decisive role in legislature (e.g. EU budget legislation), but decisions taken by the EC generally need to find approval in the Council of Ministers. At least to some extent, EU decision-making suggestively resembles negotiations between member states which are pre-committed to national policies. The issue of policy commitment has received attention in the discussion on the credibility of the Stability and Growth Pact which is intended to impose fiscal discipline on member states' public finances, see von Hagen and Eichengreen (1996). Some European member states repeatedly violated the negotiated fiscal criteria possibly anticipating that the EC is not able to commit to the enforcement procedure (prescribing fines). In fact, these states have been successful in abandoning the enforcement procedure.

[7]The underlying principle of a "social citizenship" is constitutionally anchored e.g. in Canada and Germany.

In this situation federal transfers are re-shuffled to the tax-raising state - a positive transfer effect which counteracts the traditional tax competition effect.

The outline of the paper is as follows. The related literature is reviewed in Section 2. Section 3 introduces the model. The policy outcome in the case that both levels of government decide simultaneously on policy instruments is presented in Section 4. Section 5 examines the interaction between the federal and state level if the federal government pre-commits, while Section 6 discusses the efficiency implications if state governments pre-commit. Section 7 offers some conclusions.

2 Related Literature

An analytical treatment of federal-local policy interaction is provided in Boadway and Keen (1996), Boadway et al., (1998), Keen and Kotsogiannis (2002), and Boadway and Tremblay (2006). In contrast to the fiscal arrangement considered in this paper they assume an overlapping tax base.[8] Additionally assuming a pre-commitment ability by the federal government, Boadway and Keen and Boadway et al. unravel the irrelevance of decentralized policy making for resource allocation. With a tax base overlap the federal government replicates the unitary state outcome by appropriately setting the federal taxes and distributing federally and locally collected tax revenues across all levels of government (by means of federal transfers). If federal transfers are missing, Keen and Kotsogiannis show that the federal government in general does not replicate the unitary state policy outcome. The equilibrium may entail excessively high taxes on the overlapping tax base. More related to this paper, Hoyt and Jensen (1996) adopt the same tax assignment as we do. They find a positive welfare effect of a pre-commitment ability by the federal government. The implications for the efficiency of taxes and public expenditures are however not elaborated upon.[9]

A Stackelberg leadership by lower level governments is equivalent to a common agency model.

[8]In some of the contributions rents are taxed at an exogenously given rate. Strategic intergovernmental interaction takes place in the choice of taxes levied on the overlapping tax base.

[9]Hoyt (2001) considers decision-making in a federation if the tax bases may only partially overlap. Different to this paper, neither level of government can pre-commit when selecting policy instruments (simultaneous policy formation).

States formally act as principals which face a common agent (the federal government). The common agency approach is initiated by Bernheim and Whinston (1986) and is subsequently applied to issues of public finance by e.g. Dixit (1996), Dixit et al. (1997), and Rama and Tabellini (1998). In contrast to our contribution these papers address the interaction between private agents and the government rather than between different levels of government. Applying the common agency approach to fiscal federalism, Caplan et al. (2000) analyze local government's incentives to contribute to a global public good. Therein, a pre-commitment by states enables an efficient local policy if the federal government provides transfers so as to equalize *private* consumption across states.[10] The current analysis differs from the contribution by adopting a fiscal arrangement in which the public good is only locally consumed, the federal government is concerned about the allocation of *public* consumption across states, and both levels of government levy distortionary taxes.

The analysis also adds to the literature on soft budget constraints - see Kornai et al. (2003) for a review.[11] Formally elaborated by Dewatripont and Maskin (1995), a missing commitment ability by the government lies at the root of the soft budget constraint phenomenon. Enterprises form expectations that they will be bailed-out in case of insolvency which results in sub-optimal investment choices. Wildasin (1997) shows that when applied to fiscal federalism, bail-out expectations equally distort local policy. In order to qualify for a bail-out local government may sub-optimally choose local expenditures.[12] The current paper demonstrates that such strategic local incentives may well improve the efficiency of public good provision. The expectation of qualifying for federal funds in response to local taxation serves as a countervailing incentive to engage in a "race to the bottom" in tax competition.

[10] Köthenbürger (2004) also adopts a common agency approach to fiscal federalism in which, similar to Caplan et al. (2004) but in contrast to this paper, the federal government does not have access to a tax instrument. The federal transfer scheme is required to be self-financing.

[11] See Akai and Sato (2005) for a synthesis of the largely disconnected strands of literature on common agency (alternatively referred to as decentralized leadership) and soft-budget constraints.

[12] Qian and Roland (1998) analyze how soft local budget constraints affect incentives to bail-out failing enterprises. In line with Wildasin (1997) they find local governments to spend less on local public consumption out of own resources in an attempt to lure more transfers to their budget. Deducing the impact on overall welfare, the disincentive effect needs to be weighted against the potential benefit of providing less (ex-ante) inefficient bail-outs.

3 The Model

We consider a model with 2 identical states. State i ($i = 1, 2$) consists of a representative household and a representative firm. The former derives utility from a private good c^i, leisure ℓ^i, and a local public good g^i. Preferences are

$$U(c^i, \ell^i, g^i) = c^i + h(\ell^i) + b(g^i),$$

where $h(\cdot)$ and $b(\cdot)$ are strictly increasing and strictly concave. The time endowment is normalized to unity which implies labor supply $L^i = 1 - \ell^i$. Each household has a capital endowment $\tilde{k}$. Utility is maximized subject to the budget constraint

$$c^i = I^i + (w^i - \tau)L^i + r\tilde{k},$$

where I^i is income generated from a fixed factor (say land), w^i is the wage rate in state i, τ denotes the labor income tax rate, and r is the interest rate. The labor supply decision is characterized by the first-order condition[13]

$$w^i - \tau - h'(\ell^i) = 0. \tag{1}$$

The optimality condition implies that an increase in the net wage rate $w^i - \tau$ leads to an increase in labor supply.

Each state produces a single good with a constant returns to scale technology. Output can be used either for private or public consumption on a one-to-one basis. For analytical simplicity the technology is additively separable in labor l^i and capital k^i. We should note that the results developed in the paper are not specific to the assumption. In a note (available upon request) we outline the qualitative robustness of the results when accounting for complementarity between labor and capital in production.

Invoking a linear production technology would generate the peculiar result that capital completely flows to the region which offers the more favorable tax treatment. To preclude the "buy-out"

[13] Derivatives are indicated by $'$. Subscripts of functions denote partial derivatives.

result, we introduce land as a productive factor (Kuhn and Wooton, 1987). The production technology $f(B^i, l^i, k^i)$ satisfies $f^i_j >$ and $f^i_{jj} < 0$, $j \in \{B^i, l^i, k^i\}$, where B^i denotes the amount of productive land in state i. Furthermore, $f^i_{Bj} < 0$, $j \in \{l^i, k^i\}$, and $f^i_{lk} = 0$.

The representative firm in each state maximizes profits $\pi^i = f(k^i, l^i) - w^i l^i - (r + t^i)k^i$ with t^i as the source-based capital tax rate levied in state i.[14] The profit maximizing input choices deduce from the familiar first-order conditions

$$f^i_l = w^i \text{ and } f^i_k = r + t^i. \tag{2}$$

The factor market equilibrium follows from Eqs. (1), (2), the capital market clearing condition $k^1 + k^2 = 2\tilde{k}$, and the labor market clearing condition $l^i = L^i$.[15] The responses of l^i, k^i, r and w^i to a rise in capital or labor taxes are

$$\frac{\partial k^i}{\partial t^i} = \frac{1}{\Delta}, \quad \frac{\partial k^i}{\partial t^j} = \frac{-1}{\Delta}, \quad \frac{\partial r}{\partial t^i} = \frac{-f^j_{kk}}{\Delta}, \qquad i \neq j, \tag{3}$$

and

$$\frac{\partial l^i}{\partial \tau} = \frac{-1}{\sigma}, \quad \frac{\partial w^i}{\partial \tau} = \frac{f^i_{ll}}{\sigma}, \tag{4}$$

with $\Delta := f^1_{kk} + f^2_{kk} < 0$ and $\sigma := -h''(\ell^i) - f^i_{ll} > 0$. The comparative static results reflect the interplay of the additive separability of preferences and of the assumption $f^i_{lk} = 0$. They insulate the labor (capital) market from capital (labor) taxation.

Incorporating optimal labor supply and factor demand choices and general equilibrium effects, we can write utility as a function of tax rates and public expenditures, $V^i(\tau, t^i, t^j, g^i)$. Noting that output is exhausted by factor payments, i.e. $c^i = f(k^i, l^i) - f^i_k k^i - \tau l^i + r\tilde{k}$, and making use of Eqs. (1) - (4)

$$V^i_\tau = -l^i, \quad V^i_{t^i} = -k^i (= -\tilde{k}) \quad \text{and} \quad V^i_{t^j} = 0, \quad i \neq j, \tag{5}$$

[14] For simplicity, the production factor land is omitted from notation in the subsequent analysis.

[15] The capital market clearing condition implies that capital is in fixed supply at the federal level. The assumption is intended to reflect the differential degree of capital mobility in a federation (being highest at the local level) in an analytically tractable way. If capital were in elastic supply for the federation as a whole, the labor tax would be set at a lower (same) level if $f^i_{lk} > 0$ ($f^i_{lk} = 0$) ceteris paribus; see Bucovetsky and Wilson (1991). The level effect on labor taxes applies to all decision-making scenarios considered in the paper; thereby suggestively not compromising the relative policy evaluation.

with symmetric capital tax rate choices. The result $V^i_{tj} = 0$ reflects the opposing effects a higher tax rate in state j has on interest income and land income in state i. The income changes nullify each other with symmetrically chosen capital taxes. Straightforwardly, $V^i_g = b'(g^i)$.

We consider a two-layer federal system: the federal level and the state level. State governments impose a source-based capital tax $\{t^i\}_{i=1,2}$. The tax revenues are recycled by providing a local public good $\{g^i\}_{i=1,2}$. The federal government provides transfers $\{s^i\}_{i=1,2}$ which are financed by a federally-uniform labor tax schedule τ.[16] The state and federal budget constraints thus are

$$g^i = s^i + t^i k^i \quad \text{and} \quad \tau \sum_{i=1,2} l^i = \sum_{i=1,2} s^i. \tag{6}$$

The federal transfer system features a gross equalization scheme (Boadway, 2004) in which transfers have a dual role: they equalize public consumption across states and transfer federal funds to lower-level governments in response to a vertical imbalance of tax revenues and expenditures.[17] Both levels of government are benevolent. State governments maximize the utility of the representative household whereas the federal government chooses its policy instruments to maximize the Benthamite welfare function $\sum_{i=1,2} V^i(\cdot)$.

Pareto-efficiency requires

$$t^1 = t^2, \quad \tau = 0, \quad \text{and} \quad b'(g^i) = 1. \tag{7}$$

Uniform capital taxes ensure production efficiency and a zero labor tax rate leaves the labor-leisure choice undistorted. Since capital is in fixed supply to the federation, a uniform capital tax is non-distortionary from society's perspective and revenues should only be raised through capital taxation. The rate should be set so as to finance the efficient amount of local public goods as

[16] Alternatively, $\{s^i\}_{i=1,2}$ can be interpreted as public services which are federally provided and which are perfect substitutes to the locally provided service. In the sequel we adhere to the "transfer view". Transfers will more likely be used for an interstate equalization of public funds and will thus exhibit the tax price effect characterized in section 6.

[17] In contrast, a net equalization scheme only involves horizontal transfers ($\tau \equiv 0$). Both types of equalization schemes are of importance in real-world intergovernmental relations - even within one federation. For instance, in Germany the municipal equalization system operates on a gross equalization basis while the equalization system at the state level (Länderfinanzausgleich) is organized as a net equalization scheme.

characterized by the Samuelson condition $b'(g^i) = 1$. As states are symmetric, we will look at symmetric Nash equilibria which inherently feature production efficiency.

4 Simultaneous Policy Choice

In this section, we characterize the policy outcome when both levels of government simultaneously decide on the policy instruments under their discretion (Nash-behavior). The decision sequence of the game is:

First Stage: Both levels of government choose their policy instruments $\{t^i, s^i, \tau\}_{i=1,2}$ simultaneously, i.e. they take the policy instruments which is under the discretion of other governments as given. They account for the effect of their decisions on the behavior of households and firms.

Second Stage: Firms and households decide on $\{k^i, l^i\}_{i=1,2}$ for given policy instruments $\{t^i, s^i, \tau\}_{i=1,2}$.

The game is solved by backward induction to identify a symmetric subgame-perfect equilibrium.

State Government State government i's problem is to

$$\max_{t^i} \quad V^i(\tau, t^i, t^j, t^i k^i + s^i)$$

subject to $k^i = k^i(t^i, t^j)$. The first-order condition for t^i becomes:[18]

$$V^i_{t^i} + V^i_g(t^i k^i_{t^i} + k^i) = 0. \tag{8}$$

Inserting (5) and rearranging yields:

$$b'(g^i) = \frac{1}{1+\epsilon^i} > 1 \quad \text{with} \quad \epsilon^i := k^i_{t^i}\frac{t^i}{k^i}. \tag{9}$$

The state's marginal cost of public funds (r.h.s. of Eq. (9); henceforth SMCPF) is greater than unity, as states perceive an outflow of capital if they increase their capital tax rate for a given tax rate of the other state. At an optimum the benefits of taxation given by the marginal utility of local public goods are equated to the marginal costs of taxation represented by the term $\frac{1}{1+\epsilon^i}$.

[18]Although corner solutions may exist, we only report on interior solutions to all optimization problems analyzed in the paper. Naturally, a corner solution does not exhibit strategic interaction in upper and lower level government policy choices which is however the issue addressed in the paper.

The state first-order condition (9), together with the state budget constraint (6), determines the reaction functions $\{t^i = t^i(s^i, \tau)\}_{i=1,2}$.

Federal Government Under the assumption of Nash behavior, the federal government's optimization problem is:

$$\max_{s^1, s^2, \tau} \quad \mathcal{L} = \sum_{i=1,2} V^i(\tau, t^i, t^j, t^i k^i + s^i) + \mu \sum_{i=1,2} \left(s^i - \tau l^i\right)$$

subject to $\{k^i = k^i(t^i, t^j)\}_{i=1,2\ i \neq j}$ and $\{l^i = l^i(\tau)\}_{i=1,2}$. μ denotes the Lagrangian multiplier associated with the federal budget constraint. The first-order conditions are

$$s^i: \quad V_g^i + \mu = 0 \quad \text{and} \quad \tau: \quad \sum_{i=1,2} V_\tau^i + \mu(-l^i - \tau l_\tau^i) = 0. \tag{10}$$

Making use of (5) and rearranging

$$b'(g^i) = \frac{1}{1 + \eta^i} > 1 \quad \text{with} \quad \eta^i := l_\tau^i \frac{\tau}{l^i}. \tag{11}$$

The federal government sets transfers and the tax rate so as to equate the marginal rate of substitution to the federal marginal cost of public funds (r.h.s. of Eq. (11); henceforth FMCPF). As labor taxes are distortionary ($l_\tau^i < 0$) the FMCPF exceed the social marginal rate of transformation $(= 1)$ which yields $b'(g^i) > 1$. Note, federal transfer policy equalizes the SMCPF and FMCPF; thereby aligning the tax base elasiticities ϵ^i and η^i.

The federal first-order conditions (11) and the federal budget constraint (6) define the reaction functions $\{s^i = s^i(t^i, t^j), \tau = \tau(t^i, t^j)\}_{i,j=1,2\ i \neq j}$.

The underprovision equilibrium is related to the existence of a positive horizontal fiscal externality. Capital leaves state i in response to a rise in its capital tax rate which, in turn, raises the tax base in the neighboring state - a positive effect external to state i's tax setting behavior (Wildasin, 1989). In its absence $\left(\epsilon^i \equiv 0\right)$ each state would provide the efficient amount of public goods leaving no rationale for the federal government to fiscally accommodate lower-level government finances $(\tau = 0)$.

5 Sequential Policy Choice: Pre-Commitment by the Federal Government

In this section, we analyze whether the inefficiency of the public sector is attenuated when the federal government has the capacity to pre-commit toward state governments (centralized leadership). The sequence of decisions now becomes:

First Stage: The federal government chooses $\{s^i, \tau\}_{i=1,2}$. It anticipates the reaction of the state governments as well as the reaction of households and firms.

Second Stage: State i decides on its policy variable t^i taking the policy choice of the federal government $\{s^i, \tau\}_{i=1,2}$ and the neighboring state government t^j as a given. It anticipates the reaction of households and firms.

Third Stage: For given policy variables $\{s^i, t^i, \tau\}_{i=1,2}$, households and firms choose $\{k^i, l^i\}_{i=1,2}$.

Again, the game is solved by backward induction in order to identify a symmetric subgame-perfect equilibrium.

State Government The optimal policy choice of state i is $t^i = t^i(s^i, \tau)$. Inferring the slope of the reaction function we differentiate the state first-order condition (9) and the state budget constraint (6) with respect to t^i and the federal policy instruments s^i and τ:

$$\frac{\partial t^i}{\partial \tau} = 0 \quad \text{and} \quad \frac{\partial t^i}{\partial s^i} = \frac{b''(g^i)}{\frac{\partial}{\partial t^i}\left(\frac{1}{1+\epsilon^i}\right) - b''(g^i) g^i_{t^i}} < 0. \tag{12}$$

A change in the federal tax rate does not affect the choice of t^i, i.e. state i's best-response effectively is $t^i = t^i(s^i)$. To sign state i's reaction to a marginal increase in transfers, note that $g^i_{t^i} = t^i k^i_{t^i} + k^i$ is positive by the optimizing behavior of the states.[19] Additionally, observe that the SMCPF is increasing in t^i.[20] This together with the assumption $b''(g^i) < 0$ implies that state i's capital tax

[19]Given by $V^i_{t^i} = -k^i < 0$ (Eq. (5)) and $V^i_g > 0$, $g^i_{t^i} = t^i k^i_{t^i} + k^i > 0$ in equilibrium - Eq. (8).

[20]To verify the monotonicity result, note that $\frac{\partial}{\partial t^i}\left(\frac{1}{1+\epsilon^i}\right)$ is unambiguously positive if $k^i_{t^i t^i} \leq 0$. Using Eq. (3) the second derivative of k^i with respect to t^i becomes $k^i_{t^i t^i} = -\frac{1}{\Delta^2}\frac{\partial}{\partial t^i}\Delta$ which is zero if $\frac{\partial}{\partial t^i}\Delta = 0$. Differentiating Δ with respect to t^i gives $\frac{\partial}{\partial t^i}\Delta = f^i_{kkk} k^i_{t^i} + f^j_{kkk} k^j_{t^i}$ $(i \neq j)$. Since $k^i_{t^i} = -k^j_{t^i}$, $\frac{\partial}{\partial t^i}\Delta = 0$ in a symmetric equilibrium. Hence, $k^i_{t^i t^i} = 0$ and $\frac{\partial}{\partial t^i}\left(\frac{1}{1+\epsilon^i}\right)$ is unambiguously positive.

rate is decreasing in the amount of transfers received.

Federal Government The federal government solves:

$$\max_{s^1,s^2,\tau} \quad \mathcal{L} = \sum_{i=1,2} V^i(\tau, t^i, t^j, t^i k^i + s^i) + \mu \sum_{i=1,2} \left(s^i - \tau l^i\right)$$

subject to $\{k^i = k^i(t^i, t^j)\}_{i=1,2\ i\neq j}$, $\{l^i = l^i(\tau)\}_{i=1,2}$, and $\{t^i = t^i(s^i)\}_{i=1,2}$. The first-order conditions are

$$s^i: \quad V^i_g + V^j_{t^i} t^j_{s^i} + V^j_g g^j_{t^i} t^i_{s^i} + \mu = 0 \quad \text{and} \quad \tau: \quad \sum_{i=1,2} \left(V^i_\tau + \mu(-l^i - \tau l^i_\tau)\right) = 0, \qquad i \neq j, \quad (13)$$

which have already been simplified using $\left(V^i_{t^i} + V^i_g g^i_{t^i}\right) t^i_{s^i} = 0$ (by Eq. (8)). Imposing symmetry, inserting Eq. (5) and rearranging, the first-order conditions reduce to

$$b'(g^i)(1 + g^j_{t^i} t^i_{s^i}) = \frac{1}{1+\eta^i} > 1, \qquad i \neq j. \quad (14)$$

Unlike the case of Nash-behavior the federal government anticipates a reduction in t^i when raising s^i. The induced inflow of capital in state j increases tax revenues in state j as captured by the term $g^j_{t^i} t^i_{s^i}$. Since the federal government considers the substitution of own state tax revenues by federal transfers (financed by distortionary labor taxes) as undesirable, the strategic effect increases the marginal cost of labor taxation; yielding a lower labor tax (and thus transfers) and by Eq. (12) a higher capital tax. Denoting (t^c, τ^c, s^c) and (t^N, τ^N, s^N) the optimal policy under centralized leadership and Nash-behavior, respectively, we can state the following result:

Proposition 1: *Under centralized leadership the tax mix becomes more efficient relative to the Nash outcome, i.e.* $t^c > t^N$ *and* $\tau^c < \tau^N$.

At this point it might be informative to relate the result to the analysis in Boadway and Keen (1996) and Boadway et al. (1998). In these contributions the federal government can replicate the unitary nation optimum by pre-committing to its policy. Besides the assumption of pre-commitment, the result is driven by a perfect tax base overlap.[21] Setting a federal tax rate, which, when summed

[21] The modelling choice implies that federal and local taxes are perfect substitutes in the private agents' decision problem. This is substantially different to our analysis where both taxes do not interact - see Eq. (12).

up with the local tax, yields the overall level of taxation chosen in a unitary state, the federal government can mitigate any inefficiency in local tax policy.

With vertical tax base independency, the federal government is only indirectly able to control lower level governments' policy choices (via the state reaction function). The unitary state outcome of a zero labor tax would eliminate labor supply distortions, but in the presence of decentralized capital taxation would also expose the public expenditure level to a downward pressure exerted by fiscal competition among states. Weighting both effects the federal government provides transfers (and therefore uses labor taxes) up to the point where the FMCPF, adjusted for the adverse impact on state capital taxes, is equated to the SMCPF.

The implication for the level of public good provision is:

Proposition 2: *Under centralized leadership local public good provision decreases relative to the Nash level, i.e.* $g^c < g^N$*.*

Proof: The proof involves a comparison of the SMCPF evaluated at (t^N, τ^N) and at (t^c, τ^c), respectively. Based on the first-order condition (9) we then infer how public spending levels will adjust. Note first that

$$\left.\frac{1}{1+\epsilon^i}\right|_{(t^c,\tau^c)} > \left.\frac{1}{1+\epsilon^i}\right|_{(t^N,\tau^N)}.$$

To verify the inequality note that the SMCPF is independent of τ since $f_{lk} \equiv 0$. Also, the SMCPF is increasing in t - see fn. (20). Following the first-order condition $b'(g^i) = \frac{1}{1+\epsilon^i}$ (Eq. (9)) the inequality implies

$$\left. b'(g^i)\right|_{(t^c,\tau^c)} > \left. b'(g^i)\right|_{(t^N,\tau^N)}.$$

By the strict concavity of $b(g^i)$, we can conclude that g^i decreases relative to the Nash-level, i.e. $g^c < g^N$. □

Public consumption becomes more downward distorted in the centralized leadership game. A lower amount of labor-tax financed transfers exposes public consumption levels more to states' incentives to compete for mobile capital - with the familiar consequence of a downward distortion in public consumption.

In equilibrium, the total amount of tax revenues decreases, but taxes are more efficiently collected. In spite of the efficiency trade-off, the welfare effect is ambiguous in sign. The federal government is able to replicate the policy outcome under Nash-behavior by setting $\tau^c = \tau^N$. Consequently, revealed by the policy preference of the federal government ($\tau^c < \tau^N$), welfare improves relative to welfare under Nash behavior.

6 Sequential Policy Choice: Pre-Commitment by State Governments

In this section, states governments have the ability to pre-commit toward the federal government (decentralized leadership). The sequence of decisions becomes:

First Stage: States simultaneously select the capital tax rate $\{t^i\}_{i=1,2}$, i.e. each state takes the tax rate of the other state government as a given. Both states take the reaction of the federal government and private agents into account.

Second Stage: The federal level determines its policy variables $\{s^i, \tau\}_{i=1,2}$ for given states' policy choices $\{t^i\}_{i=1,2}$. It anticipates the reaction of households and firms.

Third Stage: Households and firms determine $\{k^i, l^i\}_{i=1,2}$ for given policy at the federal and state level $\{s^i, t^i, \tau\}_{i=1,2}$.

The game is again solved by backward induction to identify a subgame perfect equilibrium.

Federal Government At stage 2 federal policy is characterized by the reaction functions $\{s^i = s^i(t^i, t^j), \tau = \tau(t^i, t^j)\}_{i,j=1,2\ i \neq j}$. Differentiating the federal first-order condition (11) and the federal budget constraint (6) with respect to t^i and the federal policy instruments:[22]

$$\begin{aligned}
\frac{\partial s^i}{\partial t^i} &= \frac{\beta(t^i k^i_{t^i} + k^i) + \alpha}{|A|}, &(15)\\
\frac{\partial s^j}{\partial t^i} &= \frac{\beta t^j k^j_{t^i} - \alpha}{|A|}, &(16)\\
\frac{\partial \tau}{\partial t^i} &= \frac{b''(g^i)b''(g^j)t^j k^j_{t^i} + b''(g^i)b''(g^j)(t^i k^i_{t^i} + k^i)}{|A|}, &(17)
\end{aligned}$$

where

$$\begin{aligned}
\alpha &:= -b''(g^i)(t^i k^i_{t^i} + k^i)\frac{\partial}{\partial \tau}\frac{1}{1+\eta^j} + b''(g^j)t^j k^j_{t^i}\frac{\partial}{\partial \tau}\frac{1}{1+\eta^i} \qquad \text{and} &(18)\\
\beta &:= b''(g^i)b''(g^j)\sum_{n=1}^{2}(l^n + \tau l^n_\tau). &(19)
\end{aligned}$$

Throughout the rest of the paper we invoke two assumptions:

$$\left|\epsilon^i\right| < 1 \quad \text{and} \quad \frac{\partial}{\partial \tau}\frac{1}{1+\eta^i} > 0. \tag{A}$$

$\left|\epsilon^i\right| < 1$ states that state governments are on the upward-sloping part of their Laffer-curve (with respect to capital tax revenues).[23] The second assumption relates to the monotonicity of the FMCPF. A sufficient condition for the FMCPF to be strictly increasing in τ is that $h'(\ell^i)$ is strictly convex and f^i_l is strictly concave in l^i.[24]

Owing to the optimality of federal choices $|A|$ is negative which, when combined with assumption (A), signs τ_{t^i} negative.[25] In contrast, the transfer response is ambiguous in sign. Although federal funds are formally unconditional, transfer are no longer perceived to be lump-sum. States realize that transfers are set after states have chosen tax policy and, therefore, become implicitly conditioned on their own capital tax rate choices. The way state governments expect tax policy to

[22]Appendix A.1 contains the derivation of the comparative static results.

[23]In the first two games (Nash-behavior and centralized leadership) $\left|\epsilon^i\right| < 1$ is inherent to an equilibrium with a positive capital tax rate - Eq. (9). Since transfers are now endogenous to state behavior, a state government rationally takes the effect of its policy choice on both own tax revenue and transfers into account when selecting the tax rate. In equilibrium this may involve $\left|\epsilon^i\right| > 1$.

[24]Formally, a sufficient condition for $\frac{\partial}{\partial \tau}\frac{1}{1+\eta^i} > 0$ is $l^i_{\tau\tau} < 0$. Using Eq. (4), a sufficient condition for the latter inequality to hold is $h'''(\ell^i) > 0$ and $f^i_{lll} < 0$.

[25]Contrary to the previous section, the best-response in taxes (now in federal taxes) is non-zero. The reason is that a rise in capital taxes increases g^i and thereby lowers $b'(g^i)$. Keeping s^i constant, the federal first-order condition (11) requires a downward adjustment in the FMCPF (accomplished by a reduction in τ) when the marginal benefit of spending $b'(g^i)$ falls.

characterization		$\frac{\partial s^i}{\partial t^i}$	$\frac{\partial s^j}{\partial t^i}$	$\frac{\partial \tau}{\partial t^i}$
Case (i):	$\alpha > 0$	$-$	$+-$	$-$
Case (ii):	$\alpha < 0$ and $\beta(t^i k^i_{t^i} + k^i) > \lvert\alpha\rvert$	$-$	$-$	$-$
Case (iii):	$\alpha < 0$ and $\beta(t^i k^i_{t^i} + k^i) < \lvert\alpha\rvert$	$+$	$-$	$-$
Case (iv):	$\alpha < 0$ and $\beta(t^i k^i_{t^i} + k^i) = \lvert\alpha\rvert$	0	$-$	$-$
Case (v):	$\alpha = 0$	$-$	$-$	$-$

Table 1: Decentralized leadership: comparative static analysis.

influence the allocation of federal transfers depends on the sign of α. If policy instruments are symmetrically chosen the sign of α follows from the sign of $g^i_{t^i} - g^j_{t^i}$ (Eq. (18)). $g^i_{t^i} = t^i k^i_{t^i} + k^i$ measures state i's own tax-revenue effect due to an increase in the capital tax, whereas $g^j_{t^i} = t^j k^j_{t^i}$ represents the corresponding cross tax-revenue effect. Illustratively, a positive α (case (i) in table 1) indicates a low capital reallocation due to a higher capital tax in state i. The increase in tax revenues in state j is lower than the corresponding rise in state i's tax revenues. Thus, $b'(g^j) > b'(g^i)$. The federal government's concern for horizontal equalization (Eq. (10)) entails a decreases in s^i which may go along with an increase in s^j.

A complete characterization of how the comparative static analysis relates to α is provided in Table 1.

State Government State government i solves:

$$\max_{t^i} \quad V^i(\tau, t^i, t^j, t^i k^i + s^i)$$

subject to $k^i = k^i(t^i, t^j)$, $s^i = s^i(t^i, t^j)$ and $\tau = \tau(t^i, t^j)$. The first-order condition is

$$V^i_{t^i} + V^i_\tau \tau_{t^i} + V^i_g (t^i k^i_{t^i} + k^i + s^i_{t^i}) = 0. \tag{20}$$

Besides the direct effects of state i's tax policy on its constituent's private and public consumption, state i's taxing incentives are augmented by two strategic effects. State i also takes into account how the induced change in the federal policy variables affects utility derived from private consumption, $V^i_\tau \tau_{t^i} > 0$, and utility derived from local public good provision, $V^i_g s^i_{t^i}$. If $V^i_\tau \tau_{t^i} + V^i_g s^i_{t^i} \neq 0$, capital taxes in the decentralized leadership game differ from capital taxes chosen under a Nash conjecture. Denoting (t^d, τ^d, s^d) as the prevailing policy choices Proposition 3 relates the strategic effects to the sign of α.

Proposition 3: *If $\alpha > (<)\ 0$, the tax mix under decentralized leadership is less (more) efficient relative to the tax mix under Nash behavior, i.e. $t^d < (>)\ t^N$ and $\tau^d > (<)\ \tau^N$. If $\alpha = 0$, the tax mix under decentralized leadership and Nash behavior is identical, i.e. $t^d = t^N$ and $\tau^d = \tau^N$.*

The proof is relegated to the appendix. The term α is decisive in signing the tax differential $t^d - t^N$ which by Eq. (17) and (A) is inversely related to the tax differential $\tau^d - \tau^N$. In a symmetric equilibrium Eq. (18) yields

$$\begin{aligned} \text{sign}\{\alpha\} &= \text{sign}\{t^i k^i_{t^i} + k^i - t^j k^j_{t^i}\} \\ &= -\text{sign}\{|\epsilon^i| - 0.5\}, \end{aligned}$$

where the last step follows from inserting $k^i_{t^i} = -k^j_{t^i}$ (Eq. (3)) and rearranging. The term α is positive (negative) provided the elasticity of the capital tax base $|\epsilon^i|$ is below (above) 0.5. Proposition 3 implies that a low tax base elasticity leads to a less efficient tax mix, while a sufficiently high elasticity leads to more efficient taxing incentives under decentralized leadership. The result is intriguingly related to the federal transfer response. Recall, a rise in public consumption in state i following an increase in the capital tax rate induces an inequality in public consumption in both states. To correct it, the federal government cuts back on transfers to the tax raising state. With capital mobility the neighboring state equally enjoys an increase in the tax base which counteracts the imbalance of public consumption. If the relocation of capital (i.e. $|\epsilon^i|$) is sufficiently high, state i may still forfeit transfers (case (*ii*) in table 1), but at a relatively low level. With a moderate retrenchment of transfers, state i benefits from a capital tax higher than the Nash-level as more own-source tax revenues induce a reduced labor tax burden. Increasing $|\epsilon^i|$ further, the cross-budget effect becomes strong enough such that state i does not forfeit transfers (case (*iv*)) or even receives more federal funds (case (*iii*)). Now, the transfer response weakly reinforces the impact of the federal tax response to tax mobile capital at a higher rate.[26]

The implications for local public good provision are presented in Proposition 4.

Proposition 4: *If $\alpha > (<)\ 0$, local public good provision decreases (increases) relative to the Nash level of g, i.e. $g^d < (>)\ g^N$. If $\alpha = 0$, local public good provision is unaltered, i.e. $g^d = g^N$.*

Proof: The proof involves a comparison of the FMCPF evaluated at (t^N, τ^N) and at (t^d, τ^d), respectively. Based on the first-order condition (11) we then infer how public spending levels will adjust. Note first that labor supply, and thus the FMCPF, is independent of capital taxes if symmetrically chosen. Symmetric capital tax rate changes influence the interest rate which has no effect on labor supply behavior - see (1). By (A) the FMCPF is positively affected by τ which yields

$$\left.\frac{1}{1+\eta^i}\right|_{(t^d,\tau^d)} \gtreqless \left.\frac{1}{1+\eta^i}\right|_{(t^N,\tau^N)} \text{ if } \tau^d \gtreqless \tau^N.$$

Now, following the first-order condition $b'(g^i) = \frac{1}{1+\eta^i}$ (Eq. (11)) the comparison implies

$$b'(g^i)\big|_{(t^c,\tau^c)} \gtreqless b'(g^i)\big|_{(t^N,\tau^N)} \text{ if } \tau^d \gtreqless \tau^N.$$

By the strict concavity of $b(g^i)$, we can conclude that

$$g^d \lesseqgtr g^N \text{ if } \tau^d \gtreqless \tau^N.$$

Relating the labor tax differential $\tau^d - \tau^N$ to α, as stipulated by Proposition 3, completes the proof.

□

In contrast to the finding under centralized leadership a more efficient tax structure translates into a more efficient provision of local public goods. Proposition 3 and 4 thus readily allows us to

[26]It is instructive to analyze the interplay of the own and cross tax revenue effect in a federation with an arbitrary number of symmetric states $n \geq 2$. The influence of local tax policy on a single neighbor state's tax revenues becomes smaller when n rises, and it is negligible in the limit $n \to \infty$ (small open state). Since the own tax revenue effect is positive, state anticipates a stark drop in transfers in response to a higher capital tax when $n \to \infty$. In particular, transfers are adjusted so as to allocate the additional tax revenues equally across all states which leaves a small open state with almost no taxing incentives. Hence, in the limit the capital tax differential will satisfy $t^d - t^N < 0$. More generally, the reasoning suggests that the interval of elasticity values supporting $t^d - t^N > 0$ is decreasing in n and is empty for $n \to \infty$.

infer the welfare differential (relative to simultaneous policy formation). When $\alpha > (<)\ 0$ efficiency deteriorates (improves) over all decision margins which yields lower (higher) welfare.

The welfare result can be rationalized by the concept of fiscal externalities. The total effect of an incremental rise in t^i on indirect utility V^j is given by

$$\frac{dV^j}{dt^i} = V^j_\tau \tau_{t^i} + V^j_g s^j_{t^i} + V^j_g t^j k^j_{t^i}, \quad i \neq j. \tag{21}$$

The third term on the r.h.s. of Eq. (21) represents the positive horizontal fiscal externality responsible for an inefficiently low taxation of capital in tax competition (Wildasin, 1989), whereas the first two terms constitute the effect on neighbor's utility through the induced change in the federal policy instruments τ and s^j. Since the effects are mediated via the federal budget, the effect may be termed a bottom-up-top-down vertical fiscal externality.[27] Invoking Eqs. (5), (16) and (17) the vertical effects can be rewritten to

$$V^j_\tau \tau_{t^i} + V^j_g s^j_{t^i} = b''(g^i) b''(g^j)(l^j + \tau l^j_\tau)(g^i_{t^i} - g^j_{t^i}) + \alpha, \quad i \neq j.$$

If $\alpha > 0$, the expression becomes positive.[28] Thus, in addition to the positive horizontal fiscal externality a rise in the capital tax rate implies a positive vertical externality leading to an even larger discrepancy between the social and private cost of taxation. Thus, $t^d < t^N$. Conversely, for $\alpha < 0$ the horizontal fiscal externality is counteracted by a negative vertical externality which yields $t^d > t^N$. With $\alpha = 0$ the vertical externality vanishes and $t^d = t^N$.[29]

The policy outcome is reminiscent of some well-known results in economics: the *Rotten Kid Theorem* (Becker, 1981), the *Samaritan Dilemma* (Buchanan, 1975) and the *Tragedy of the Commons*.

The Rotten Kid Theorem states that selfish kids anticipate the altruistic parents' behavior. The parents make transfers to the kids after having observed their actions. Thereby the selfish kids

[27] The terminology is in analogy to the terminology suggested by Keen (1998) who classifies vertical budget interdependencies into a bottom-up vertical externality (state policy affects the federal budget) and into a top-down vertical externality (federal policy affects the state budget).

[28] Recall, $\alpha \lesseqgtr 0 \Leftrightarrow g^i_{t^i} - g^j_{t^i} \lesseqgtr 0$. Furthermore, the federal government selects a labor tax rate at which the federal tax revenue hill is up-ward sloping, i.e. $l^j + \tau l^j_\tau > 0$ - see Eq. (10).

[29] The vertical externality is an innate characteristic of the common agency framework adopted in this section. Unlike in analyses of fiscal federalism the literature on common agency refers to the horizontal externality as a direct externality and the vertical one as an indirect externality (Martimore and Stole, 2003).

internalize spill-overs within the family and act in the interest of the parent. In the decentralized leadership game considered here, the federal government is the parent and lower level governments play the role of selfish kids. When $\alpha < 0$ our result constitutes a weaker version of the theorem since the selfish kids only partly act in the interest of the parent. The kids' strategic incentives increase welfare, but do not yield efficiency.

For $\alpha > 0$ the decentralized leadership game is related to the literature on the Samaritan Dilemma. State governments strategically lower their own fiscal effort anticipating the "altruistic" preference of the federal government to provide transfers when locally collected tax revenues decline. The inability of the federal government to commit not to help states out establishes a Samaritan Dilemma in our framework.

Additionally, when $\alpha > 0$, the result resembles the Tragedy of the Commons here developed in the context of fiscal federalism. The federal budget constitutes a common pool resource which is over-utilized by lower level governments. The tax differential $\tau^d - \tau^N > 0$ reflects the incentive to shift some of the burden of financing local expenditures to residents of the neighboring state (via uniform labor taxation).[30]

It is also informative to compare the federal policy outcomes with the traditional tax competition outcome (Zodrow and Mieszkowski, 1986); i.e. an equilibrium in which the federal government exogenously does not intervene ($\tau \equiv 0$ and $\{s^i \equiv 0\}_{i=1,2}$). Straightforwardly, invoking a revealed preference argument, the federal government improves upon the traditional tax competition outcome both with simultaneous decision-making and with a federal pre-commitment capacity. A state pre-commitment capacity generates higher welfare than tax competition only if the tax base elasticity is not too low. Concretely, if $|\epsilon| = 0.5$ welfare in the tax competition equilibrium is lower than in the equilibrium with a state pre-commitment. The reason is that 0.5 is the threshold value pertaining to the welfare comparison with simultaneous decision-making (which improves upon the tax competition outcome). The argument implies that the relevant elasticity threshold is below 0.5.

[30] See also the literature on pork-barrel spending (Weingast et al., 1981). They assume that the cost of providing local services is shared nationally by all taxpayers. Local governments over-provide public services which reflects the possibility to export some of the tax burden to non-residents. In deriving the result they do not resort to an optimizing federal government.

However, the traditional tax competition outcome is not welfare-inferior for all elasticity values. Intuitively, for $|\epsilon| \rightarrow 0$ the inefficiency inherent to the tax competition equilibrium becomes small. In contrast, with decentralized leadership the own tax-revenue effect $t^i k^i_{t^i} + k^i$ is large (as $k^i_{t^i} < 0$ is small), while the cross tax-revenue effect $t^j k^j_{t^i}$ becomes negligible (as $k^j_{t^i} = -k^i_{t^i}$ is small). A tax rate hike thus induces a stark rise in state i's public funds, relative to the neighbor state. Due to the federal government's concern for horizontal equity the imbalance yields a severe loss of transfers in state i. Consequently, state i's incentives to tax capital are weak when $|\epsilon| \rightarrow 0$, resulting in pronounced efficiency losses.

7 Conclusion

This paper analyzes how the pre-commitment ability of government entities affects the efficiency of resource allocation. The analysis demonstrates that if states are able to pre-commit, the capital tax rate can be higher or lower relative to the capital tax rate chosen under the Nash-conjecture. The prospect to receive more federal funds may increase capital taxes above the level which prevails in tax competition. In contrast, capital taxes are unambiguously chosen at a higher, but still inefficient level if the federal level can pre-commit. On the expenditure side, public good consumption choices exhibit a reinforced tendency to "race to the bottom" (relative to simultaneous decision-making).

Contrasted with the traditional tax competition equilibrium the paper shows that a federal intervention robustly (i.e. irrespective of the governments' pre-commitment capacity) improves welfare upon tax competition when incentives to compete for mobile capital are sufficiently strong (high capital tax base elasticity).

The analysis does not resort to corrective grants to address the tax competition externality. The design of corrective policy when state governments cannot pre-commit is well explored in existing literature - see e.g. Wildasin (1989). If state governments are however able to pre-commit, a corrective grant will be neutral for state policy. Selecting fiscal instruments after state taxes are chosen leaves no rationale for the federal government to implement corrective policies. As states correctly anticipate federal policy incentives, the policy outcome of the augmented decentralized leadership game (including corrective grants) will coincide with the one delineated above.[31]

The paper's results are of relevance for the design of tax coordination schemes which are frequently recommended as a remedy to inefficient tax competition among EU member states. If member states have the capacity to pre-commit, capital tax choices are inefficient which creates demand for policy coordination. The analysis suggests that the rationale for tax coordination significantly changes as it now also involves to redeem incentives to engage in transfer competition. Each state's incentive to deviate from the agreed tax rate (or interval) is guided by how the capital tax base (as typically considered) and federal transfers react to a downward deviation in capital taxes.[32] It is left to future research how these considerations jointly affect the design of a tax coordination agreement which is voluntarily respected by e.g. EU member states.

A Appendix

A.1 Slope of the Reaction Functions

In this part of the appendix we derive the slopes of the reaction functions $s^i = s^i(t^i, t^j)$, $s^j = s^j(t^i, t^j)$, and $\tau = \tau(t^i, t^j)$. Therefore, Eq. (11) (for both states) and the federal budget constraint $s^1 + s^2 = \tau(l^1 + l^2)$ are differentiated with respect to t^i which yields in matrix notation:

$$\begin{pmatrix} b''(g^i) & 0 & -\frac{\partial}{\partial \tau}\frac{l^i}{l^i+\tau l^i_\tau} \\ 0 & b''(g^j) & -\frac{\partial}{\partial \tau}\frac{l^j}{l^j+\tau l^j_\tau} \\ 1 & 1 & -\sum_{n=1}^{2}(l^n + \tau l^n_\tau) \end{pmatrix} \begin{pmatrix} ds^i \\ ds^j \\ d\tau \end{pmatrix} = \begin{pmatrix} -b''(g^i)(t^i k^i_{t^i} + k^i)dt^i \\ -b''(g^j)t^j k^j_{t^i} dt^i \\ 0 \end{pmatrix}$$

Applying Cramer's Rule:

$$\frac{\partial s^i}{\partial t^i} = \frac{|A^1|}{|A|}, \quad \frac{\partial s^j}{\partial t^i} = \frac{|A^2|}{|A|} \quad \text{and} \quad \frac{\partial \tau}{\partial t^i} = \frac{|A^3|}{|A|}, \tag{22}$$

[31] Differently, if the federal government is able to commit to corrective policy, but in particular not to equalizing transfers, corrective grants are effective in changing state taxing incentives. See Köthenbüerger (2006) for a motivation of a partial commitment capacity by the federal government. Therein it is shown that not only the type of the equilibrium externality changes (compared with the traditional normative prescription), but also the way how the corrective grant needs to reflect the equilibrium externality.

[32] See Huizinga and Nielsen (2003) for an analysis of self-enforcing tax coordination agreements if only incentives to compete for mobile tax bases are to be redeemed.

where

$$
\begin{aligned}
|A| &= b''(g^i)\left(-b''(g^j)\sum_{n=1}^{2}(l^n+\tau l^n_\tau)+\frac{\partial}{\partial\tau}\frac{1}{1+\eta^j}\right)+b''(g^j)\frac{\partial}{\partial\tau}\frac{1}{1+\eta^i}<0,\\
|A^1| &= -b''(g^i)(t^ik^i_{t^i}+k^i)\left(-b''(g^j)\sum_{n=1}^{2}(l^n+\tau l^n_\tau)+\frac{\partial}{\partial\tau}\frac{1}{1+\eta^j}\right)\\
&\quad +\frac{\partial}{\partial\tau}\frac{1}{1+\eta^i}b''(g^j)t^jk^j_{t^i},\\
|A^2| &= b''(g^i)b''(g^j)t^jk^j_{t^i}\sum_{n=1}^{2}(l^n+\tau l^n_\tau)+b''(g^i)(t^ik^i_{t^i}+k^i)\frac{\partial}{\partial\tau}\frac{1}{1+\eta^j}\\
&\quad -\frac{\partial}{\partial\tau}\frac{1}{1+\eta^i}b''(g^j)t^jk^j_{t^i},\quad \text{and}\\
|A^3| &= b''(g^i)b''(g^j)t^jk^j_{t^i}+b''(g^i)b''(g^j)(t^ik^i_{t^i}+k^i)>0.
\end{aligned}
\tag{23}
$$

Given by the second-order conditions of the federal optimization problem $|A|<0$. The sign of $|A^3|$ is strictly positive since $t^jk^j_{t^i}>0$ and by assumption (A) $t^ik^i_{t^i}+k^i>0$. Helpful in signing $|A^1|$ and $|A^2|$ we rewrite both determinants as:

$$
|A^1| = \beta(t^ik^i_{t^i}+k^i)+\alpha \qquad \text{and} \qquad |A^2| = \beta(t^jk^j_{t^i})-\alpha, \tag{24}
$$

with

$$
\begin{aligned}
\alpha &:= -b''(g^i)(t^ik^i_{t^i}+k^i)\frac{\partial}{\partial\tau}\frac{1}{1+\eta^j}+b''(g^j)t^jk^j_{t^i}\frac{\partial}{\partial\tau}\frac{1}{1+\eta^i} \qquad \text{and}\\
\beta &:= b''(g^i)b''(g^j)\sum_{n=1}^{2}(l^n+\tau l^n_\tau).
\end{aligned}
$$

The sign of $|A^1|$ and $|A^2|$ depends on the sign and magnitude of α and β and is thus ambiguous. Using Eqs. (23) and (24) the slopes of the best-response functions (22) are:

$$
\begin{aligned}
\frac{\partial s^i}{\partial t^i} &= \frac{\beta(t^ik^i_{t^i}+k^i)+\alpha}{|A|},\\
\frac{\partial s^j}{\partial t^i} &= \frac{\beta t^jk^j_{t^i}-\alpha}{|A|},\\
\frac{\partial \tau}{\partial t^i} &= \frac{b''(g^i)b''(g^j)t^jk^j_{t^i}+b''(g^i)b''(g^j)(t^ik^i_{t^i}+k^i)}{|A|}<0.
\end{aligned}
$$

A.2 Proof of Proposition 3

Proposition 3 is proved by establishing two lemmata. Lemma 1 states conditions for t^d to be greater, equal, or lower than t^N. Lemma 2 presents a refined condition pertaining to cases (i), (ii), and (v) listed in table 1.

Lemma 1: *If $s^i_{t^i} \geq 0$ the capital tax rate under decentralized leadership exceeds the capital tax rate under both-sided Nash behavior, i.e. $t^d > t^N$. If $s^i_{t^i} < 0$, the effect on the tax rate t^i is given by*

$$-l^i \tau_{t^i} \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} \left| b'(g^i) s^i_{t^i} \right| \Rightarrow t^d \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} t^N. \tag{25}$$

Proof: The optimal state behavior is characterized by Eq. (20). Thus, starting from the Nash outcome t^N, as characterized by Eq. (9), state i's incentive to deviate from t^N depends on the terms $V^i_g s^i_{t^i}$ and $V^i_\tau \tau_{t^i}$. By Eq. (5) $V^i_\tau \tau_{t^i} = -l^i \tau_{t^i}$ which following Eq. (17) is positive. Note, $V^i_g s^i_{t^i} = b'(g^i) s^i_{t^i}$. If $b'(g^i) s^i_{t^i}$ is non-negative (case (iii) and (iv)), state i can increase after-tax labor income as well as local public good provision by setting $t^d > t^N$. To prove the second assertion, consider the opposite case. If $s^i_{t^i} < 0$ and $-l^i \tau_{t^i} > (<) \left| b'(g^i) s^i_{t^i} \right|$, state i can improve utility of the representative household by choosing $t^d > (<)\ t^N$. For the special case $s^i_{t^i} < 0$ and $-l^i \tau_{t^i} = \left| b'(g^i) s^i_{t^i} \right|$ the opposite effects nullify each other and $t^d = t^N$. □

For case (iii) and (iv) $\tau_{t^i} < 0$ and $s^i_{t^i} \geq 0$. Thus, Lemma 1 predicts $t^d > t^N$. In case (iv), $\tau_{t^i} < 0$ and $s^i_{t^i} = 0$ and consequently $t^d > t^N$. In case (i), (ii), and (v), the transfer and labor tax response are opposite in sign. Lemma 2 provides a condition which allows us to sign the net-effect in these three cases.

Lemma 2: *In case (i), (ii), and (v), condition (25) is equivalent to the condition*

$$\frac{1}{2}\beta(t^i k^i_{t^i} + k^i - t^j k^j_{t^i}) + \alpha \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} 0 \Rightarrow t^d \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} t^N. \tag{26}$$

Proof: Substituting Eqs. (15) and (17) into condition (25) yields

$$-l^i \frac{b''(g^i)b''(g^j)t^j k^j_{t^i} + b''(g^i)b''(g^j)(t^i k^i_{t^i} + k^i)}{|A|} \quad \lesseqqgtr \quad b'(g^i) \left| \frac{\beta(t^i k^i_{t^i} + k^i) + \alpha}{|A|} \right| .$$

Multiplying by $-|A| > 0$ gives

$$l^i \left(b''(g^i)b''(g^j)t^j k^j_{t^i} + b''(g^i)b''(g^j)(t^i k^i_{t^i} + k^i) \right) \quad \lesseqqgtr \quad b'(g^i) \left| \beta(t^i k^i_{t^i} + k^i) + \alpha \right| . \tag{27}$$

Using the fact that in equilibrium $b'(g^i) = \frac{1}{1+\eta^i}$ (see Eq. (11)) and rearranging condition (27) leads to

$$\frac{1}{2}\beta(t^i k^i_{t^i} + k^i + t^j k^j_{t^i}) \quad \lesseqqgtr \quad \left| \beta(t^i k^i_{t^i} + k^i) + \alpha \right| \tag{28}$$

with $\beta > 0$ as given by Eq. (19). Since in case (i), (ii), and (v), $\beta(t^i k^i_{t^i} + k^i) + \alpha > 0$, inequality (28) can be rewritten to

$$0 \quad \lesseqqgtr \quad \frac{1}{2}\beta(t^i k^i_{t^i} + k^i - t^j k^j_{t^i}) + \alpha.$$

Note, the inequality is equivalent to

$$-l^i \tau_{t^i} \quad \lesseqqgtr \quad \left| b'(g^i) s^i_{t^i} \right|$$

and to the corresponding tax rates given by condition (25) in Lemma 1. □

In case (i), $t^i k^i_{t^i} + k^i > t^j k^j_{t^i}$, which gives $\alpha > 0$. Consequently, implied by Lemma 2 state i chooses $t^d < t^N$. The decrease in s^i, following a marginal increase in t^i, dominates the positive effect of a lower labor tax rate. In case (ii), $t^i k^i_{t^i} + k^i < t^j k^j_{t^i}$ and, thus, $\alpha < 0$. Lemma 2 predicts a tax rate choice $t^d > t^N$. In case (v), $t^i k^i_{t^i} + k^i = t^j k^j_{t^i}$ and, thus, $\alpha = 0$. Consequently, $t^d = t^N$.

To infer how the federal government sets labor taxes and transfers in a symmetric equilibrium, we evaluate how the FMCPF and the marginal benefit of transfer spending have changed due to an adjustment in capital taxes (relative to the Nash outcome). First observe that at stage 2 of the game the FMCPF is independent of the level of t^d, since capital taxes are symmetric and income changes emanating from interest rate adjustments relative to the Nash outcome do not affect labor supply behavior - see (1). Furthermore, given $s = s^N$, $b'(g) \gtreqqless b'(g^N)$ if $t^d \lesseqqgtr t^N$. Thus, following (11) and (A), the federal government will choose $s^d \gtreqqless s^N$ and $\tau^d \gtreqqless \tau^N$ if $t^d \lesseqqgtr t^N$. This completes the proof of Proposition 3.

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