

Federal Taxation and the Role of International Capital Market Integration

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Abstract

The interrelations of taxation and federal structure have been extensively analysed from various perspectives. The present paper examines the combined effects of horizontal and vertical externalities for the case of capital taxation in a federation. It enhances the discussion by establishing a framework in which the degree of international capital market integration is parameterised and explicitly incorporated into the model. It is shown that the vertical externality will dominate the horizontal externality at the state level, if the country is strongly integrated into the international capital market, and vice versa. Additionally, the role of the strategic behaviour of the federal government, as well as the strategic interdependence of state and federal taxes, are analysed and incorporated into the model.

JEL classification: H55, O41

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1. Introduction

Taxation in a federation with several states and one federal government is generally characterised by two elements: competition for mobile tax bases between lower level jurisdictions and concurrent taxation of the same tax bases by lower level jurisdictions and the central government. The specific welfare effects of each element of federal taxation have been extensively analysed in the economics literature. Tax competition gives rise to horizontal externalities, as each lower level jurisdiction ignores the positive effect of a higher own tax rate on tax revenue of the other lower level jurisdictions. Tax rates will then be too low in equilibrium.¹ Concurrent taxation, on the other hand, gives rise to vertical tax externalities, as each lower level jurisdiction ignores the negative effect of a higher own tax rate on the central government's tax revenue, and vice versa. This leaves tax rates too high in equilibrium.²

The interrelations of taxation and federal structure have long been a topic of economic research. An early analysis of fiscal competition for tax bases was introduced by Tiebout (1956), who put forward the hypothesis that competition between regions for mobile tax bases could be welfare enhancing. Brennan and Buchanan (1977, 1980) also saw welfare-enhancing effects of tax competition, arguing that it could constrain governments that are revenue-maximising Leviathans. By contrast, Oates (1972) had put forward the proposition that tax competition could well be a source of inefficiencies. His work was later incorporated into formal models demonstrating that tax competition in fact gave rise to horizontal externalities, as each lower level jurisdiction ignored the positive effect of a higher own tax rate on tax revenue of other lower level jurisdictions.³

While horizontal tax competition has been extensively analysed, it was not until the work by Cassing and Hillman (1982), Flowers (1988) or Johnson (1988) that the effects of tax base overlap between different levels of government were examined. It was their work that first drew attention to the fact that concurrent taxation could act as a source of inefficiencies. These ideas have, however, only been explicitly recognized in the mid-nineties, when contributions by authors such as Boadway and Keen (1996) or Dahlby (1996)

¹See, for example, Wildasin (1989), or dePater and Myers (1994).

²See, for example, Wigger and Wartha (2004), or Makris (2006).

³See, for example, Wilson (1986) and Zodrow and Mieszkowski (1986), or Keen (1998).

managed to shift the focus to vertical fiscal externalities as a source of excessively high taxation.

Given that the two elements of federal taxation have opposite welfare effects, the question which effect may be dominant in a given setting has become of interest. A strand of literature then evolved which systematically explored the joint effects of horizontal and vertical externalities.⁴

Keen and Kotsogiannis (2002) studied these joint effects in the context of capital income taxation. They considered a model in which the supply of capital was determined by life-cycle savings and demonstrated that whether the horizontal tax externality dominated the vertical one or vice versa essentially hinged on the elasticity of savings with respect to the interest rate. If savings were elastic, the horizontal externality dominated the vertical one and tax rates of lower level jurisdictions were too low. For inelastic savings, the opposite held true.

The approach of the present paper is complementary to that of Keen and Kotsogiannis. Rather than considering life-cycle savings, it relates the supply of capital to the level of international capital market integration. The key element of the framework established in this paper is a concept that allows to parameterise the degree of international capital market integration, which is then incorporated into an efficiency-oriented analysis of capital taxation in a federation. It is shown that if the degree is low, that is, if the economy has only limited access to the international capital market, the horizontal externality will dominate the vertical one at the state level, whereas the opposite will hold true, if the degree is large. This result implies that in a federal system with limited access to the international capital market there will be undertaxation of capital income, whereas in a federal system with extensive access there will be overtaxation by lower level jurisdictions. It is further shown that the efficiency of federal taxation essentially hinges on the assumptions about the strategic behaviour of the federal government and on the relative behaviour of state and federal taxes.

The paper is set up as follows: The next section establishes the analytical framework and sketches the international interdependencies of capital movements and capital taxation. Section 3 analyses the possible vertical and horizontal externalities. Attention is first paid to the efficiency of state level

⁴Such work was carried out, for example, by Keen (1998) and Wrede (1996), or, more recently, by Wilson and Janeba (2005) and Fenge and Wrede (2007).

taxation, followed by an efficiency-oriented analysis of federal level taxation. With the help of a numerical example, section 4 will illustrate the theoretical results generated in the preceding section. Section 5 concludes.

2. The Model

The analytical framework is outlined in the proceeding section. The examined federation is a small country, whose public sector consists of a federal government and n identical states.

2.1. Production

We consider a constant returns to scale production function, which is identical in all states and at least twice continuously differentiable. It displays diminishing returns to scale in its mobile input factor, capital. Production in state i , denoted as y_i , is then determined by

$$y_i = f(k_i) = f'(k_i)k_i + \pi_i, \quad (1)$$

where k_i is the amount of capital employed in state i . Assuming that firms are profit maximisers, $f'(k_i)k_i$ is then the income of capital employed in state i . π_i denotes the rental income accruing to the consumer living in state i from the immobile factor.

2.2. Households

In order to factor out equity considerations, let each state $i = 1, \dots, n$ be populated by a single representative consumer endowed with one unit of capital. Utility of the consumer in state i is determined by

$$u(c_i, g_i, G) = c_i + \Gamma(g_i, G), \quad (2)$$

where c_i is private consumption of consumer i , g_i is the amount of a local public good provided in state i and G is federal spending per state. $\Gamma(g_i, G)$ is a felicity function measuring the utility from local public good provision and federal spending, which satisfies the usual monotonicity and concavity assumptions. An individual's private consumption is constrained to

$$c_i = \rho + (1 - \theta)\pi_i, \quad (3)$$

in which ρ denotes the net return on capital (which will be seen to be equalised across states). Each state raises an (exogenous) tax rate $\theta \in [0, 1]$ on each unit of rental income π_i an individual generates.

2.3. Capital Mobility

Consumers can choose to invest their capital either in the state in which they live, in some other state of the federation, or they can invest in the international capital market. While capital mobility within the federation comes at no cost, it is assumed that international capital mobility is costly. More precisely, the corresponding cost function is defined as

$$C\left(\sigma, \left|n - \sum_i k_i\right|\right) = \frac{1}{2}\sigma\left(n - \sum_i k_i\right)^2, \quad \text{with } \sigma \in [0, \infty), \quad (4)$$

where $\sum_i k_i$ denotes the total capital employed in the federation. The capital available in the federation is given by n . If n falls short of the total amount of capital employed in the federation, the country is a net importer of capital. The cost of international capital mobility increases progressively with the difference between the total capital available and the total capital employed in the federation, assuming that the inherent risk of investing abroad will be the higher, the more capital is already employed in a country.

σ measures the degree of international capital mobility. It may be interpreted as a risk-premium demanded for international investment projects.⁵ It is assumed that σ is the same across countries.⁶ For $\sigma = 0$, the country is a small economy perfectly integrated into the international capital market. For $\sigma \rightarrow \infty$, the economy is closed and has no access to the international capital market. Hence, the more integrated into the international capital market a country is, the lower the cost of investing abroad.

The possibility of interstate and international investment gives rise to two non-arbitrage conditions. The interstate non-arbitrage condition is given by

$$\rho = f'(k_i) - \tau_i \quad \forall i, \quad (5)$$

⁵For the use of a similar term in the context of foreign indebtedness, see van der Ploeg (1996).

⁶Note that this implicit symmetry assumption may be dropped without further changing the analytical results, provided that the characteristic cost function is differentiable at all points. The analysis would, however, be rendered unnecessarily complicated.

in which $f'(k_i)$ is the marginal return on capital and $\tau_i = t_i + T$ is the aggregate tax burden imposed on the residents of one state by the local (t_i) and the federal (T) authorities. It can be inferred from (5) that the net return on capital will be the same for interstate investments, irrespective of what state an individual decides to invest in. Given decreasing returns to scale, rent-seeking investors will arbitrage away differences in net return on capital between states, that is, capital will move between jurisdictions until ρ is equal across all states.

Let the cost per additional unit of capital invested outside the federation amount to $\sigma(n - \sum_i k_i)$. The international non-arbitrage condition can then be denoted as

$$\rho = \bar{r} + \sigma \left(1 - \frac{n}{\sum_i k_i} \right) \quad \forall i, \quad (6)$$

where \bar{r} is the world market interest rate and $\frac{n}{\sum_i k_i}$ is the ratio between domestic capital endowment and capital employment. If the amount of capital employed in the federation is exceeded by its capital endowment, the net return on capital prevailing in the federation will fall short of the world market interest rate. It will only be beneficial to invest abroad as long as the world market interest net the cost of international investment exceeds the net return on capital generated from domestic investment.⁷ In equilibrium,

$$f'(k_i) - \tau_i = \bar{r} + \sigma \left(1 - \frac{n}{\sum_i k_i} \right) \quad \forall i.$$

Hence, all possibilities of arbitrage will be extinct and an investor will be indifferent between investing abroad or at home.

Two benchmark cases of international capital mobility shall now be established, which will be useful throughout the further analysis.

Lemma 1 Let τ_i be finite for all $i = 1, \dots, n$. Provided that $f'(k_i)$ is a bijective function of k_i , then:

⁷It is a valid objection to wonder why in a small country in which the world market interest is exogenous, the individual investor's choice would influence the net return on capital. Yet the latter can be solved by arguing that each investor, when facing the decision where to invest, will choose the most attractive investment opportunity first. For each additional unit of capital invested, a less "attractive" investment opportunity will be taken up, such that the implicit cost for each investor will in fact vary with each individual's investment decision.

- i. $k_i = (f')^{-1}(\bar{r} + \tau_i)$, if $\sigma = 0$
- ii. $\sum_i k_i = n$, if $\sigma \rightarrow \infty$

Proof:

- i. Obvious from (5) and (6).
- ii. The proof is by contradiction. To start with, assume that $\sum_i k_i \geq \text{constant} > n$ if $\sigma \rightarrow \infty$. Then, as τ_i is finite and as $f'(k_i) - \tau_i = \bar{r} + \sigma(1 - \frac{n}{\sum_i k_i})$ for all i , it follows that $f'(k_i) \rightarrow \infty$ for all i . As $f'' < 0$, this necessarily requires $k_i \rightarrow 0$ for all i , which contradicts $\sum_i k_i \geq \text{constant} > n$ for all i . Now assume that $\sum_i k_i \leq \text{constant} < n$ if $\sigma \rightarrow \infty$. Then, as τ_i is finite, it follows that $f'(k_i) \rightarrow -\infty$, which contradicts $f' > 0$. *Q.E.D.*

Figure 1 summarises the above discussion. The international net return on capital is depicted as a linear function increasing in K (which is equal to $\sum_i k_i$). Interstate net return on capital is a decreasing function of k_i . Arbitrage-seeking individuals will now have an incentive to invest inside the federation, as long as the interstate net return on capital exceeds the international one, and vice versa. Hence, for a given world market interest rate and a specific tax burden in every state of the federation, a certain total amount of capital (for example $K_0 < n$, implying that the country is a net exporter of capital) will be employed inside the federation. Consequently, $n - K_0$ of domestic capital will be employed abroad, which will redound to a specific equilibrium net return on capital ρ_0 .

Now, a tax hike will trigger a drop in the equilibrium net return on capital, yet that decrease in ρ will be disproportionately small. Assume first, for simplicity, that the federal tax is raised, which [via (5)] will lead to a simultaneous decrease in the net return on capital in every state of that federation. As a consequence, investors in the federation will have an incentive to remove their capital and invest abroad instead. Although that rise in international investment activity has no impact on \bar{r} , for each additional unit of capital invested outside the federation, the incurred cost will increase (such that ρ falls). In the same time, marginal productivity of capital inside the

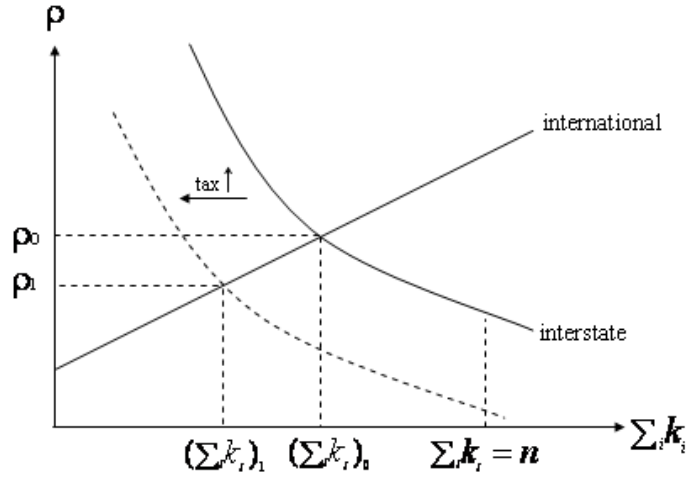


Figure 1: Non-Arbitrage Equilibrium

federation will again approach the initial level and domestic investment will again pick up. In conclusion, the arbitrage opportunities arising due to the federal tax hike will lead to a new equilibrium in which a larger share of total domestic capital is employed internationally and the net return on capital settles at a lower level than before. Note that if a single state decides to raise its tax, not only will international investment become more attractive, investors will also have an incentive to relocate their capital into the other states of the federation. In both cases, the drop in net return on capital will be disproportionately small in comparison to the change in tax burden.

Figure 2 displays the benchmark cases of $\sigma = 0$ and $\sigma \rightarrow \infty$ graphically.

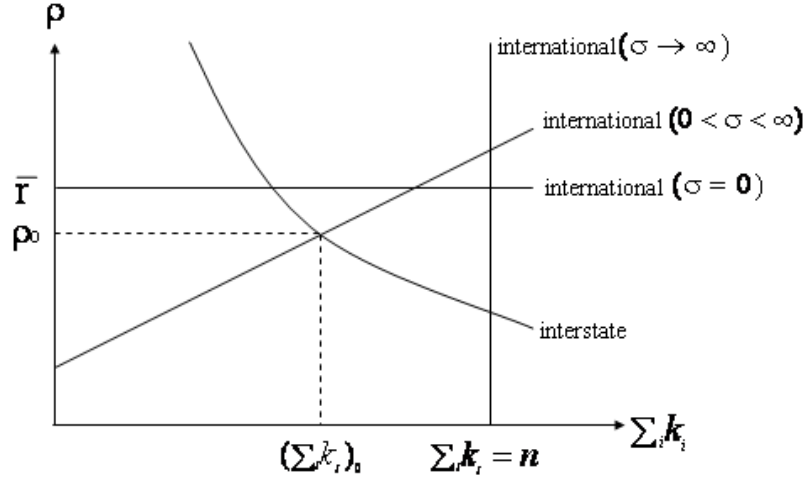


Figure 2: Non-Arbitrage Equilibrium - Benchmark Cases

In the first case, an individual will incur no cost of relocating investments between countries. The amount employed inside the federation will then be such that the equilibrium net return on capital equals the world market interest. In the latter case, all domestic capital is employed inside the federation and no capital will enter the country, such that $K = n$, irrespective of national tax policies or capital productivity.

2.4. Policy Implications

Equation (5) implicitly defines k_i as a function $k_i = k_i(\rho + \tau_i)$, with $k_i'(\rho + \tau_i) = \frac{1}{f_i''}$, in which $f_i'' := f''(k_i)$. Then, equation (6) implicitly defines ρ as a

function $\rho = \rho(\tau_1, \dots, \tau_n)$ and for $\tau_1 = \tau_2 = \dots = \tau_n = \tau$ (applying the implicit function theorem)

$$\frac{\partial \rho}{\partial \tau} = \frac{\sigma}{nk^2 f'' - n\sigma} \leq 0, \quad (7)$$

with $\frac{\partial \rho}{\partial \tau} = 0$, as $\sigma = 0$, and $\frac{\partial \rho}{\partial \tau} \rightarrow -\frac{1}{n}$, as $\sigma \rightarrow \infty$.

Let each individual receive a rental income π_i from the possession of a fixed factor defined by

$$\pi_i = f(k_i) - f'(k_i)k_i,$$

which then denotes the amount by which the capital product exceeds its remuneration. In it, $k_i = k_i(\rho + \tau_i)$, which implies that $\pi_i = \pi_i(\rho + \tau_i)$, with $\pi'_i = -k_i$. Thus,

$$\frac{\partial \pi_i}{\partial \tau_i} = -k_i \left(\frac{\partial \rho}{\partial \tau_i} + 1 \right).$$

Hence, the change in rental income due to a shift in τ_i is given by the effect of that shift on k_i and by the impact of the tax-induced change in ρ (that is, $\frac{\partial \rho}{\partial \tau_i}$) on k_i .

2.5. Government

The federal and state authorities are now incorporated into the model. A two-leveled federation is considered, in which the federal government is complemented by state-level governments. Both are assumed to be benevolent.

The n states compete for mobile tax base, therein engaging in Nash competition. The benevolent state tries to maximise the welfare of its constituents, irrespective of the possible impact its actions may have on citizens of other states. Consequently, each state i maximises

$$u_i = \rho + (1 - \theta)\pi_i + \Gamma(g_i, G),$$

subject to

$$g_i = t_i k_i + \theta \pi_i$$

and

$$G = \frac{1}{n}T \sum_i k_i$$

by choice of t_i and g_i . Each state government derives its revenue from the taxation of capital (k_i) and rents (π_i). It redistributes that revenue among its constituents by means of the supply of the state public good.

Contrary to the states, the benevolent and omniscient federal government maximises the welfare of all consumers in all states $i = 1, \dots, n$ across its jurisdiction. That is, it maximises

$$u_i = \rho + (1 - \theta)\pi_i + \Gamma(g_i, G),$$

subject to

$$g_i = t_i k_i + \theta \pi_i$$

and

$$G = \frac{1}{n}T \sum_i k_i$$

for each representative consumer by choice of G and T . The federal government derives its revenue from the taxation of capital and redistributes tax revenues evenly across all states.

3. Horizontal and Vertical Externalities

The model gives rise to vertical, as well as horizontal externalities. With each local government neglecting the impact its tax decisions have on the budget of the other local entities, it triggers a horizontal externality. A vertical externality arises from perfect tax base overlap. With an omniscient federal government, only a bottom-up vertical externality will arise, given that each state underestimates the loss of tax revenue the federal government incurs due to a rise in taxation at the state level.

The analysis is carried out as follows: First, the state level is considered. It is examined whether under the outlined structure, states will excessively tax capital. Proceeding to the federal level, the same question is asked, allowing for the federal government to either engage in Nash competition or act as a Stackelberg leader. Throughout the analysis, reference is made to the benchmark cases outlined in Lemma 1.

3.1. Are State Taxes Too High or Too Low?

Taxation at the state level shall first be examined. Assuming that states engage in Nash competition, the resulting equilibrium is characterised by each state i setting the optimal tax given the decision of all other states. Equilibrium is by assumption defined by symmetric strategies, so that from the maximisation problem as outlined in section 2.5. it follows that:

$$\begin{aligned} \frac{\partial h}{\partial t} = \frac{\partial u}{\partial t_i} \Big|_{t_i=t, v_i} &= \frac{\partial \rho}{\partial \tau} + (1 - \theta)\pi' \left(\frac{\partial \rho}{\partial \tau} + 1 \right) \\ &+ \Gamma_g \left[k + (tk' + \theta\pi') \left(\frac{\partial \rho}{\partial \tau} + 1 \right) \right] \\ &+ \Gamma_G \frac{1}{n} Tk' \left(n \frac{\partial \rho}{\partial \tau} + 1 \right) = 0. \end{aligned} \quad (8)$$

The consideration of a coordinated tax hike will help understand whether Nash competition among the states leads to inefficient equilibrium taxation. By simultaneously increasing taxes in all states we have

$$\begin{aligned} \frac{dh}{dt} &= n \frac{\partial \rho}{\partial \tau} + (1 - \theta)\pi' \left(n \frac{\partial \rho}{\partial \tau} + 1 \right) \\ &+ \Gamma_g \left[k + (tk' + \theta\pi') \left(n \frac{\partial \rho}{\partial \tau} + 1 \right) \right] \\ &+ \Gamma_G Tk' \left(n \frac{\partial \rho}{\partial \tau} + 1 \right). \end{aligned} \quad (9)$$

The sign of (9) is now of interest. If it is zero, it indicates that state taxation is in fact efficient. If it is positive, the horizontal externality is likely to be dominant, whereas (9) being less than zero points towards a dominant vertical externality. Subtract (8) from (9) to have

$$\begin{aligned} \frac{du}{dt} = \frac{dh}{dt} - \frac{\partial h}{\partial t} &= \overbrace{\left[1 + (1 - \theta)\pi' + \Gamma_g(tk' + \theta\pi') \right] (n - 1) \frac{\partial \rho}{\partial \tau}}^{\text{horizontal externality}} \\ &+ \underbrace{\Gamma_G Tk' (n - 1) \left(\frac{\partial \rho}{\partial \tau} + \frac{1}{n} \right)}_{\text{vertical externality}}. \end{aligned} \quad (10)$$

That is, starting from a symmetric equilibrium, a simultaneous increase in capital taxation in all states will trigger several effects. The state government anticipates the impact the higher tax burden has on its citizens' rental income and utility derived from state public good supply. Meanwhile, it neglects the potential effects in other states, thereby triggering a horizontal externality, which points to inefficiently low taxation. In the same time, the optimising state government does not fully account for the drop in federal public good supply caused by the decrease in federal tax base, such that taxation tends to be inefficiently high, as depicted by the second term in (10).

With the horizontal externality pointing towards state taxes being too low and the vertical externality pointing towards state taxes being too high, the sign of (10) is ambiguous. In order to gain some further insight, the two benchmark cases established in Lemma 1 will again be referred to. Assume first for σ to be zero. As a consequence, (7) will be zero, so that (10) becomes

$$\frac{du}{dt} = \Gamma_G T k' \frac{n-1}{n} < 0,$$

implying that for a given tax hike, the utility of the representative consumer will fall. Hence, in the case of perfect integration into the international capital market, the vertical externality dominates the horizontal externality.

This result can be easily grasped intuitively: If capital is perfectly mobile, non-arbitrage leads to an increase in state taxes having no impact on the rental income of the constituents in the entire federation. Given that the cost of international capital mobility is equal to zero, the reduction in net return on capital due to an increased tax burden can be simply offset by relocating capital abroad, thereby generating returns at the exogenous rate \bar{r} . The withdrawal of capital will in the meantime increase capital productivity in the states up to a point at which the net return on capital settles again where it is equal to the world market interest. That is, if capital is perfectly mobile, the equilibrium net return on capital will equal the world market interest \bar{r} in all states of the federation. Thus, the tax policy in state i has no impact on the net return on capital and, subsequently, no impact on tax revenue of state j . As a consequence, the horizontal externality will vanish and the vertical externality remains. This dominant bottom-up vertical externality is why the overall tax level is inefficiently high in the case of perfect integration into the international capital market. It will be the stronger, the greater k' , that is, the greater the tax base reduction due to the increase in capital

taxation.

The second case is that of a closed economy, in which capital supply equals capital demand, which implies that all the effects of a tax hike will be fully incurred within the federation. Hence, $\sigma \rightarrow \infty$, which implies that $\frac{\partial \rho}{\partial \tau} \rightarrow -\frac{1}{n}$ and $k = 1$. By use of (9), it follows that $\frac{dh}{dt} = -1 + \Gamma_g$, where Γ_g is the elasticity of consumer utility with respect to federal spending. The horizontal externality will then dominate if $\Gamma_g > 1$. So when is this the case?

It follows from (8) that

$$\Gamma_g = \frac{1 + (1 - \theta)(n - 1)}{n + (\frac{t}{f''} - \theta)(n - 1)}.$$

Therefore, provided that $n + (\frac{t}{f''} - \theta)(n - 1) > 0$, it follows that $\Gamma_g > 1$, if and only if, $1 + (1 - \theta)(n - 1) > n + (\frac{t}{f''} - \theta)(n - 1)$. From this inequality it can be inferred that $\Gamma_g > 1$ if $t > 0$, such that, consequently, $\frac{dh}{dt} = \Gamma_g - 1 > 0$. Hence, the horizontal externality will dominate, if the country is isolated from the international capital market, and if $t > 0$. The intuition behind this is straightforward: Given that $\sigma \rightarrow \infty$ implies that the economy is closed, the federal tax base becomes independent of the taxes raised by the states, such that the vertical externality will approach zero. With respect to the tax burden, it can be inferred that t will be positive, if the tax rate on rental income is sufficiently small. This aspect can be easily grasped by the fact that if rental income is not taxed at all, state governments must raise a tax on capital in order for sufficient income to be generated for the provision of public goods. Under the assumption of decreasing marginal utility of public good provision, the utility derived from the first supplied unit will approach infinity, such that states will always have an incentive to provide at least a certain amount of public goods.

Now, as the preceding discussion showed, for $\sigma = 0$, the vertical externality dominates the horizontal externality, and for $\sigma \rightarrow \infty$, the horizontal externality dominates the vertical one. Hence, assuming that σ is continuous, there must exist some optimal degree of integration into the international capital market, such that both externalities vanish.

It can be concluded:

Proposition 1 *Consider a Nash equilibrium with symmetric strategies of the states. Then:*

- i. *The vertical externality will dominate the horizontal externality (there will be overtaxation at the state level), if the federation is strongly integrated into the international capital market (σ small).*
- ii. *The horizontal externality will dominate the vertical externality (there will be undertaxation at the state level), if σ is large and if state taxes satisfy $t > 0$.*
- iii. *There is some $\hat{\sigma} \in [0, \infty)$, such that both externalities will vanish, if $\sigma = \hat{\sigma}$.*

Remark: $t > 0$ if θ is small.

With reference to Keen and Kotsogiannis (2002), it can be further examined how the discussion will change, if the states fully tax rental income. Set $\theta = 1$ and let:

$$\frac{dh}{dt} - n \frac{\partial h}{\partial t} = (1 - n) \Gamma_g t k' > 0, \quad (11)$$

which will only be the case if $t > 0$. Hence:

Proposition 2 *Let states fully tax rental income ($\theta = 1$). Then:*

- i. *The horizontal externality dominates the vertical externality, if $t > 0$.*

3.2. Are Federal Taxes Too High or Too Low?

Similar to the state governments, the federal government intends to maximise the welfare of all individuals within its jurisdiction. Under the assumption that states engage in Nash competition, the first order condition is given by

$$\begin{aligned} \frac{\partial u}{\partial T} = & n \frac{\partial \rho}{\partial \tau} + (1 - \theta) \pi' \left(n \frac{\partial \rho}{\partial \tau} + 1 \right) \\ & + \Gamma_g (t k' + \theta \pi') \left(n \frac{\partial \rho}{\partial \tau} + 1 \right) \\ & + \Gamma_G \left[k + T k' \left(n \frac{\partial \rho}{\partial \tau} + 1 \right) \right] = 0. \end{aligned} \quad (12)$$

Just as before, horizontal and vertical effects point in opposite directions. With state tax-setting as established in the preceding section, two cases can

now be distinguished with respect to the assumed strategic behaviour of the federal government.

In the first case, the federal government plays Nash. It will then maximise the utility of each individual by choosing its best-response T , taking the equilibrium state taxes as given. That is, given the shortcomings of state tax-setting, the federal government will impose an optimal capital tax, which implies:

Proposition 3 *Consider a Nash equilibrium with symmetric strategies of the states. Then:*

- i. *A federal government engaging in Nash competition will set its tax T optimal given state taxation.*

The second case is characterised by the assumption that the federal government has a first-mover advantage. State and federal governments will then engage in a sequential game, with the latter choosing an optimal T , allowing for the states to subsequently set their taxes in a Nash game while taking T as given. The federal decision makers must then choose T with respect to $t = t(T)$, which is implicitly defined by the first-order-conditions of the states. They will thus maximise the utility $u = u[T, t(T)]$ of a representative individual by setting

$$\frac{du}{dT} = \frac{\partial u}{\partial t} t'(T) + \frac{\partial u}{\partial T} = 0. \quad (13)$$

In (13), the first term on the right-hand side denotes the change in utility an individual incurs due to a shift in optimal-response state taxes triggered by a possible variation in federal taxation. The second term denotes the direct change in utility due to a federal tax hike as depicted by (12). The optimising federal government will now aim for (13) to be fulfilled, implying that the decision-makers might deem it optimal to set a tax by deviating from the optimality condition given by (12). The question is then, whether an increase in T will lead to a welfare improvement while holding fixed t at the equilibrium level. The answer is yes, if $\frac{\partial u}{\partial T} > 0$, which requires $\frac{\partial u}{\partial t} t'(T) < 0$ in order for (13) to be fulfilled. On the contrary, the answer is no, if $\frac{\partial u}{\partial T} < 0$, which requires $\frac{\partial u}{\partial t} t'(T) > 0$. In other words: If states engage in Nash competition and the federal government acts as a Stackelberg leader,

it can be inferred that there is overtaxation (undertaxation) at the federal level if $\frac{\partial u}{\partial t}$ and $t'(T)$ are of opposite (equal) signs. More precisely, if federal and state taxes are strategic substitutes [$t'(T) < 0$], then federal taxes will be too low (too high) if state taxes are too low (too high). The reverse is the case if state and federal taxes are strategic complements.⁸ These results can be easily grasped intuitively: Assuming that state taxes are too low, the optimising federal government will aim to offset the inefficiencies induced by the states. It will thus set an excessively high (low) federal tax, if state and federal taxes are strategic complements (substitutes) with the goal to provide an incentive for states to subsequently set their taxes optimal.

Propositions 4 and 5 summarise the discussion:

Proposition 4 *Let federal and state taxes be strategic substitutes [ie. $t'(T) < 0$]. Then, in a Stackelberg equilibrium with symmetric strategies of the states:*

- i. *Federal taxes are higher than in a Nash equilibrium, if the vertical externality dominates the horizontal externality at the state level (state taxes being too high).*
- ii. *Federal taxes are lower than in a Nash equilibrium, if the horizontal externality dominates the vertical externality at the state level (state taxes being too low).*

Proposition 5 *Let federal and state taxes be strategic complements [ie. $t'(T) > 0$]. Then, in a Stackelberg equilibrium with symmetric strategies of the states (ie. $t_i = t$ for all i):*

- i. *Federal taxes are higher than in a Nash equilibrium, if state taxes are too low (the horizontal externality dominates the vertical externality).*
- ii. *Federal taxes are lower than in a Nash equilibrium, if state taxes t_i are too high (the vertical externality dominates the horizontal externality).*

⁸Note for the sake of completeness that federal taxation will be efficient if state taxes are efficient ($\frac{\partial u}{\partial t} = 0$).

4. Numerical Example

The results generated in the previous sections are now illustrated with the help of a numerical example. Let

- i. $f(k) = k^\alpha$,
such that $f' = \alpha k^{\alpha-1}$ and $f'' = \alpha(\alpha - 1)k^{\alpha-2}$
- ii. $\pi = (1 - \alpha)k^\alpha$
- iii. $\frac{\partial \rho}{\partial \tau} = \frac{\sigma}{n\alpha(\alpha - 1)k^{\alpha-1} - n\sigma}$
- iv. $\Gamma(g, G) = \beta(\ln g + \ln G)$
such that $\Gamma_g = \frac{\beta}{g}$ and $\Gamma_G = \frac{\beta}{G}$.

Let further $\alpha = 0.25$, $\beta = 0.1$, $n = 10$, $r = 0.125$.

Simulation of a symmetric Nash equilibrium yields the numerical results as depicted in Table 1.⁹ The simulation distinguishes three cases with respect to capital market integration, that is, the two benchmark cases of perfect integration ($\sigma = 0$) and an isolated country (with $\sigma = 10^9$), as well as the case of “optimal” capital market integration, in which the proposed value for σ is realised for which the externalities vanish.

σ	k^*	t^*	T^*	k^{opt}	t^{opt}	T^{opt}
0	1.176	0.054	0.042	1.352	0.037	0.037
$0.02 = \hat{\sigma}$	0.980	0.066	0.066	0.980	0.066	0.066
10^9	1.000	0.068	0.100	1.000	0.100	0.100

Table 1: Nash Simulation

The results depicted by Table 1 show that for a high value of σ , $k = 1$. That is, if the economy is closed, all capital will be employed inside the

⁹Note that in Table 1 an asterisk denotes the best response in Nash competition, while the superscript “opt” denotes the optimal values the parameters should take for an efficient solution to be reached.

federation. In comparison to the optimal values, state taxes will be too low. By contrast, if the country is perfectly integrated into the capital market ($\sigma = 0$), then state taxes will be excessively high and the country is a net importer of capital. In both cases, the federal government is assumed to play Nash and set its tax optimal given state taxation. If σ takes its optimal value, the federation is a net exporter of capital and the realised taxes coincide with their optimal values. The results of the Nash simulation are thus largely in correspondence with Propositions 1 and 3.

If the federal government acts as a Stackelberg leader, the simulation will yield the results as displayed in Table 2, distinguishing the same three cases for σ as above.¹⁰

σ	t^*	T^*	$T^s(sub)$	$T^s(com)$	t^{opt}	T^{opt}
0	0.054	0.042	0.052	0.037	0.037	0.037
$0.02=\hat{\sigma}$	0.066	0.066	0.066	0.066	0.066	0.066
30	0.067	0.094	0.068	0.095	0.094	0.094

Table 2: Stackelberg Simulation

States are assumed to play Nash by setting t^* . T^* depicts the values for the federal government setting its tax optimal given t^* . Hence, if the federal government has a first-mover advantage and state and federal taxes act as strategic substitutes, the realised federal tax will fall short of its optimal value T^* , if states are excessively low, and vice versa. On the contrary, in the case of strategic complementarity, federal taxation will be (slightly) too high, if state taxes are excessively low, and vice versa. Hence, the numerical example supports Propositions 4 and 5.

The results correspond with what the theoretical model suggested. That is, the likely effects of fiscal externalities are largely dependent on the assumptions about the strategic behaviour of state and federal governments, as well as on the assumptions about the relative behaviour of federal and

¹⁰Note that in Table 2 the superscript “S” refers to the solution for the federal government acting as a Stackelberg leader. The extension “(sub)” refers to the case of strategic substitutability of state and federal taxes, while the extension “(com)” denotes that federal and state taxes are strategic complements. For reference, the optimal and the Nash solutions are given as well.

state taxes. The degree of international capital market integration functions by curbing the extent to which a change in τ causes a vertical or a horizontal externality respectively.

5. Summary and Concluding Remarks

The previous discussion showed that the inefficiencies of taxation in a federal system are potentially related to the extent to which a country is integrated into the international financial market. It was shown that a strong degree of integration will lead to the vertical externality dominating the horizontal one at the state level. State taxes will thus be too high. The horizontal externality will, on the other hand, dominate at the state level, if the economy has only limited access to the international capital market.

The results can be further specified with respect to the assumptions about the strategic behaviour of the federal government. That is, given the above results, a Nash federal government will impose an optimal tax burden given state taxation. If the federal government has a first-mover advantage, the result hinges on the efficiency of state taxes, as well as on the characterisation of federal and state taxes as strategic substitutes or complements. In the former case, an excessively low state capital tax implies that federal taxation will be too low, and vice versa. In the latter case, federal taxes will be excessively high if the rate at which the states tax capital is inefficiently low.

The applied model yields a concise depiction of the impact of international capital market integration on optimal taxation strategies of state and federal governments. Nevertheless, the analysed structure is subject to some limitations, especially given the simplified model world economy considered.

For one, the model does not allow for any heterogeneity among the citizens. The consideration is limited to a single representative consumer, which allows for efficiency considerations only. The federal government does not differentiate with respect to indigence or structural differences. Yet, heterogeneity in preferences and needs within a state or a federation (as modeled by Rizzo (2005), for example) may distort the results in such that the federal government distributing its wealth evenly across the states may itself create inefficiencies. Not allowing for heterogeneity in fact enables for some simplifying assumptions made in the models.

While possible interactions of the different federal levels are incorporated

into the model, the latter is restricted to a single-economy analysis. No attention is paid to possible policy changes abroad triggered by a change in capital taxation at home. An extension to the model could stem from the analysis of a two- or multiple-economy world, into which the strategic interaction between countries is incorporated. The federal government itself could thus be subject to tax competition with other countries, thereby triggering another horizontal externality. In addition, if the assumption of symmetric cost functions is dropped, an analysis of the interaction of high- and low risk countries could be a topic for further model specification.

An assumption in the discussion of federal taxation is the prevalence of complete and perfect information of all players. The extension of the model to decisions under uncertainty might yield meaningful results. Moreover, how would the situation change if the states did not simply take the federal decision as given, but had a chance to react to the tax set by the federal government? The occurrence of cooperative solutions could also lead to a difference in results.

The overall structure of the tax system is kept fairly concise. More complex tax instruments, such as the possibility of tax deductibility or earned income tax credits, which could be of some relevance to the real world, are not incorporated.

Research ought to be extended with respect to the central assumptions made in the paper. Empirical work carried out so far gives some information on how realistic specific assumptions may be. The Leviathan-debate remains a subject of discussion.¹¹ Whether or not the federal government acts as a Stackelberg leader or engages in Nash competition has not yet been satisfyingly examined.¹² The question which externality dominates in a given setting is lacking a systematic analysis.¹³ Some studies exist that point to

¹¹In an early empirical contribution, Oates (1985) tested the Leviathan-hypothesis. It proved difficult to find empirical evidence of whether tax competition led to an increase or a decrease in welfare, given that Leviathan, as well as benevolent-state views predict for increasing competition between governments to reduce the size of government [see also Wilson (1999)]. The Leviathan-debate has since been largely dominated by theoretical and political-economy argumentation, as, for example, in Keen and Edwards (1996).

¹²Some theoretical arguments on that question can be found in Keen (1998). In an empirical piece, Revelli (2003) found no proof of strategic interaction between upper and lower level tax-setting in England.

¹³In an empirical examination of Swiss data (assuming benevolence of the government to be assured by the existence of direct democracy elements), Brülhart and Jametti (2006)

upper and lower level taxes being strategic complements.¹⁴ The existing work is, however, too little in order for general results to be derived and ought to be extended.

observed that the vertical externality leaving tax rates too low in comparison to the social optimum in fact dominates.

¹⁴See, for example, Hayashi and Boadway (2001) on Canadian federal and province business taxes, or Goodspeed (2000) on a survey of 13 OECD countries. Esteller-Moré and Solé-Ollé (2001, 2002), too, described a positive responsiveness of lower-level tax rates to upper-level taxation in the US and Canada.

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