Dynamic Tax Competition and Public-Sector Modernisation

Daniel Becker *

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This paper addresses the question whether increased mobility of capital enhances public-sector modernisation. Public-sector modernisation is modelled as the accumulation of knowledge that serves as an input in the government?s production of a consumption good that is redistributed to households. The tax competition model in the background is a dynamic model in which capital flight induced by taxation is a process that takes time. The speed with which firms can relocate capital to other jurisdictions is taken as a measure of the degree of capital mobility. The main result of the paper is a contradiction of the idea that the competitive pressure caused by increased capital mobility enhances public sector modernisation.

Keywords: public-sector modernisation, redistribution, dynamic tax competition, imperfect capital mobility

JEL-Classification: H11, H77, H54, O40

1 Introduction

Competition for mobile resources can lead to an inefficiently low provision of public goods and can therefore be harmful for the well-being of nations. This is the major lesson to be drawn from the tax-competition literature surveyed by Wilson [1999]. However, there are circumstances under which the underprovision result does not hold. For example, if the public sector's activities involve the waste of ressources - caused by rent-seeking politicians or by an inefficiently operating bureaucracy - tax competition can be beneficial as it promotes public-sector modernisation. See Edwards / Keen [1996], Rauscher [2000] and Keen / Kotsogiannis [2003] for models in which the public sector is seen as such a Leviathan that needs to be tamed.

In this paper, tax competition hampers public sector modernisation. Improvements in the efficiency of the public sector are modelled as lessening its reliance on tax revenue for the provision of public services. Hence, public-sector modernisation is not seen as the degree to which wasteful behaviour is repelled as in the literature just mentioned. The benevolent

* University of Rostock, Department of Economics, Ulmenstr. 69, D-18057 Rostock, Germany. Tel.: +49 381 - 498 4313, Fax.: +49 381 - 498 4312, email: daniel.becker@uni-rostock.de.

government in the model presented below redistributes income from capital-owners to worker-households. It does so by providing a private good. It can invest in its efficiency and thereby lower the tax revenue that is required to provide redistribution. Efficiency is modelled as a knowledge-stock which is used for the production of a publicly provided private good. The aim of this paper is to analyse public-sector modernisation as a dynamic process for a jurisdiction that is engaged in tax competition.

When public-sector modernisation is seen as an investment activity as in this paper, higher capital mobility is not helpful to achieve public sector efficiency. If capital is mobile, firms are able to shift capital to other jurisdictions. This loss of the tax base is the major disadvantage of capital taxation in open economies. Of course, the severity of this negative effect depends on the degree of capital mobility. Capital mobility in this paper weakens the ability of local governments to raise tax revenue that is needed for beneficial tasks such as the provision of redistribution and public-sector modernisation. I will show that the negative impact of inter-jurisdictional competition for capital applies to both the long-run level of efficiency but also on the speed of modernisation of the public sector.

The Leviathan models of tax competition cited above come to mixed result regarding the welfare effects of tax competition. However, in Wilson [2005], the mobility of the tax base is unambiguously welfare-improving. The reason is that the Leviathan in his model is identified as a bureaucracy that is responsible only for the provision of a public input. Bureaucrats are, however, interested in a budget that is as large as possible. They have to accept the tax system that is set by the residents (or a benevolent government), but can influence that tax base. When capital is mobile, they can strengthen the tax base by providing more public inputs. Cai / Treisman [2005] are more pessimistic about the usefulness of competition between governments. Their starting point is that the endowment differences we observe matter for this question. They show that poorly-endowed regions which are exposed to tax competition do not necessarily try to attract capital by providing favourable investment opportunities to firms. Instead, they might simply give up since they anticipate that they will never be able to succeed in a competition with better-endowed regions. In the end, capital mobility that triggers unequal competition can lead to worse behaviour of governments rather than being a discipline device.

This paper differs in two aspects from the previous literature on tax competition and government efficiency. The first difference is that the issue of public sector efficiency is detached from the question of taming a wasteful government. The welfare maximising government in this paper is not automatically one which public-sector efficiency has reached some optimal level. Instead, the efficiency of the public sector depends on the investment decisions taken by the benevolent government and develops over time. The second difference is that a dynamic modelling framework based on Wildasin [2003] is used to characterise different degrees of capital mobility.[1] Both the accumulation of public-sector knowledge and the re-location of capital in response to a change in capital taxation are dynamic processes and therefore a dynamic framework seems to be adequate.

The importance of dynamics for the tax competition literature has been pointed out by Wildasin [2003]. He presents a dynamic version of the "canonical" tax-competition model and analyses the dynamic reaction of the local capital stock to a change in capital

[1] There are surprisingly few models in the tax competition literature that deal with imperfect factor mobility, with Lee [1997] being one of the exemptions. Public sector modernisation, growth and tax competition is also analysed in Rauscher [2005], albeit in an endogenous growth model and with an alternative modelling of imperfect capital mobility. He finds that the effect of increased capital mobility on growth and on the behaviour of a Leviathan is ambiguous.

taxation. Whether the reaction of firms is immediate or not depends on the convexity of an adjustment-cost function that is common in macroeconomic models. Wildasin's dynamic model provides some support for static models of tax competition. The long-term effects in the dynamic model are similar to those known from static models. However, the decision whether to tax capital or not, and at which rate, differs under imperfect capital-mobility. When it takes time for capital to flee a jurisdiction, the trade-off between capital-taxation and the loss of tax base is altered. The adjustment speed in Wildasin [2003] can serve as a reasonable measure of the degree of capital mobility. This allows to consider not only the polar cases of autarky compared with perfect integration but also the more realistic intermediate cases.

The plan of the paper is as follows. Section 2 presents the structure of the model, including the dynamic approach to capital mobility and tax competition. Section 3 describes the decision problem the government faces in this dynamic environment, and solves it. The optimal path for public-sector efficiency and the associated optimal tax rate are determined. In addition, the range of parameters that allow a positive tax rate is identified. The interaction of capital mobility and public-sector modernisation is then analysed in more detail. Section 4 concludes.

2 The model

2.1 Households

Let us consider a federation with many small jurisdictions. A single jurisdiction cannot influence decisions in other jurisdictions. Each jurisdiction is inhabited by an immobile representative household that has no market power. The household's budget constraint is

$$C_t = w_t + G_t + A_t r - S_t, \tag{1}$$

where C_t is consumption, w_t is the wage rate, G_t is redistribution via a consumption good provided by the government and t is an index for time. Labour is inelastically supplied in a perfectly competitive labour-market and the size of households is normalized to one. There is an international capital market where a stock of accumulated savings A_t earns a return of r, expressed in terms of the numeraire good. All agents take the interest rate r as given. Capital is supplied by an integrated world capital market consisting of the accumulated savings of all countries. Therefore, A_t represents the share of the world capital stock held by domestic residents. To simplify matters, I assume that domestic households hold only shares of foreign firms and that local firms are exclusively owned by foreigners.[2] S_t represents current savings.

2.2 Government

The role of the government is to provide redistribution by means of G_t. Redistribution is more complex than simply transferring tax revenue from the foreign-owned firms to the worker-household: G_t is *produced* with a Cobb-Douglas-Technology

$$G_t = \frac{1}{\gamma} R_t^{\gamma} H_t^{1-\gamma} \text{ with } 0 < \gamma < 1 \text{ and } G_t \geq 0\,, \tag{2}$$

[2]Alternatively I could introduce foreign and domestic shares. However, this would necessitate to model the endogenous evolution of the allocation of savings to home and foreign firms.

where H_t is a stock of knowledge and R_t a flow of revenues devoted to the production of redistribution. Technology (2) plays a central role in this model. How much redistribution a government can provide depends not only on the tax revenue R_t devoted to redistribution, but also on the stock of H_t.

Public sector efficiency in this paper is measured by the level of H_t. It should be interpreted as the knowledge of the public sector about efficient technologies to transform tax revenue into a consumption good for redistribution. Without any knowledge, i.e. $H_t = 0$, the public sector is a black hole in which tax revenues vanish without any benefits for the citizens. A high level of H_t can be seen as an indicator of a very efficient public sector where at least the first units of tax revenue generate very high marginal benefits for the household. The development of H_t over time reflects the development of public sector efficiency.

Tax revenue is used to provide redistribution and to modernise the public sector. It is assumed that the government cannot tax the immobile factor labour, but imposes a source tax τ per unit on the local capital stock K_t. Public debt is ruled out for simplicity and therefore, the government's budget constraint is

$$\tau K_t = R_t + M_t \,, \tag{3}$$

where M_t is the investment in public efficiency or the modernisation effort at time t. Current public expenditure is financed by current capital tax revenue. Public sector efficiency develops according to

$$\dot{H}_t = M_t = \tau K_t - R_t, \;\; H_{t=0} = H_0 \geq 0. \tag{4}$$

Initially, the public sector's efficiency is H_0. If $H_0 = 0$, modernisation, i.e. accumulation of H_t, is a prerequisite for redistribution. Low levels of initial efficiency introduce a strong motive for modernisation. It is assumed that the public sector does not forget technologies and procedures to transform tax revenue into redistribution it has previously known. Thus, there is no depreciation in (4).

2.3 Private firms and the dynamics of taxation and capital accumulation

In the local jurisdiction, there are many identical firms. These can be represented by a representative firm that takes prices and decisions by the government as given. This firm produces with a constant-returns-to-scale production function $\tilde{F}(K_t, L)$. The decision to hire labour and capital is dominated by the aim to maximise the current value of future cash flows. Labour is normalised to one such that the production function can be written as $F(K_t)$. The wage rate is determined in a competitive labour market. It depends on the current capital stock only and is given by

$$w_t = F(K_t) - F'(K_t) K_t \,. \tag{5}$$

The development of the local capital stock depends on the investment decision of local firms. Investment is profitable if the net return of capital exceeds the external rate of return r or if $F'(K_t) - \tau \geqslant r$. Consider now a situation in which the capital stock has reached an initial level of K_0 and also assume that there is no capital taxation initially. At time $t = 0$, the government sets a time-invariant tax rate τ which comes as a surprise to the private sector.[3] Furthermore, it is assumed that the government can commit itself to its policy announcements. A positive

[3] One could argue that real-world governments decide about a path of tax rates. While this might be true, a model with a time-invariant tax rate generates dynamics that are tractable.

tax rate τ drives capital out of the jurisdiction as local firms have an incentive to disinvest. With perfect capital mobility, this adjustment of the local capital stock in response to capital taxation is immediate.

The focus of this paper is the evolution of public sector efficiency over time. The ability to raise tax revenue will be central for the ability to modernise the public-sector because modernisation is modelled as an investment activity. Even with a constant capital tax rate, the revenue is not constant if the capital stock evolves over time. Since public sector modernisation is modelled as an investment activity, the tax competition scenario in the background needs to consider dynamics, as in Wildasin [2003]. Wildasin models the development of the local capital stock in response to a time-invariant tax rate. If K_0 is the steady state level given initial circumstances in the economy , setting a positive tax rate τ implies that firms disinvest until the capital stock has reached its new steady state level. But this process takes time and, therefore, tax revenues for a given tax rate are the higher (in present-value terms) the slower is the process of adjustment. The speed of adjustment will be crucial for all results in this paper, where the government uses the revenues of capital taxation for redistribution and for public sector modernisation.

The speed of capital-stock adjustment in response to a change in the tax system depends on the curvature of the adjustment-cost function private firms face. The cost of investing one unit is one plus an adjustment cost m: $I_t + K_t m(I_t/K_t)$. Adjustment costs increase in the rate of investment I_t/K_t, and they are weakly convex ($m(0) = 0$, $m' > 0$, and $m'' \geqslant 0$). Adjustment costs are positive for both investment and disinvestment. A convex adjustment cost function with $m'' > 0$ implies that the capital stock does not jump immediately to its new steady state level when the tax rate on capital is changed, see for example Barro / Sala-i-Martin [1995, ch. 3.5]. The extreme case of immediate adjustment results only when adjustment costs are linear. The solid line in figure 1 shows the adjustment of the local capital stock in response to tax rate τ with $\tau > 0$ and adjustment costs $m > 0$.

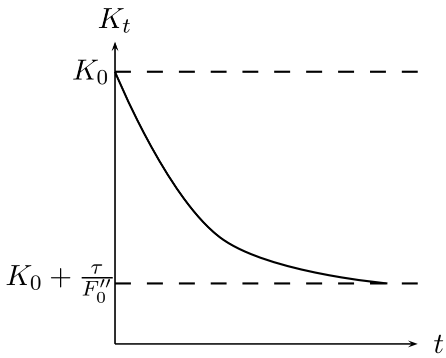

Figure 1: Adjustment of the capital stock to a tax rate $\tau > 0$

The algebraic representation of this adjustment of the capital stock in response to capital taxation, see Wildasin [2003, eqs. (5), (6)], is

$$K_t = K_0 + \tau \frac{dK_t}{d\tau} = K_0 + \frac{\tau}{F_0''} \left(1 - e^{\rho_2 t}\right) , \tag{6}$$

with the speed of adjustment, ρ_2, being

$$\rho_2 = \frac{r}{2} - \frac{1}{2}\sqrt{r^2 - \frac{4K_0 F_0''}{m''(\delta)}} < 0 . \tag{7}$$

If $\rho_2 \to 0$ approaches zero, capital is immobile. If $\rho_2 \to -\infty$, capital is perfectly mobile. In a steady state, the investment rate equals the depreciation rate δ. When adjustment costs per unit of investment are strongly convex, firms are reluctant to adjust the local capital stock immediately as this would imply very high adjustment costs.

The intensity of tax competition depends on the speed of adjustment of the local capital stock in response to capital taxation. Large negative values of ρ_2 imply that capital as a tax base is very elastic. Thus ρ_2 can be interpreted as a measure of the degree of capital mobility.[4]

Seen from the household's perspective, capital taxation has costs and benefits. Tax revenue is a prerequisite for redistribution. Furthermore, in this model, tax revenue is also needed to improve the efficiency of the public sector. On the other hand, capital taxation implies a lower local capital stock, lower marginal productivity of labour and therefore lower wages. When the adjustment of the capital stock in response to capital taxation is not immediate, the benefits of taxation occur immediately but the disadvantages need time to take effect. Trading-off the present value of benefits and costs can result in positive capital tax rates even when non-distorting lump-sum taxes are available, as has been shown by Wildasin [2003]. The reason is that the tax burden is shifted away from worker-households and towards foreign owners of the capital stock temporarily. While the economy adjusts, the government extracts quasi-rents from other jurisdictions.

3 The intensity of tax competition and public-sector modernisation

3.1 The problem

The task of the government in this model is to find the optimal tax rate and to split the resulting tax revenue optimally between modernisation and redistribution. Optimal policy will depend on the mobility of private capital.

The government's policy instruments are τ, M_t, G_t and R_t. It needs to take the technology (2), the budget constraint (3) and the equation of motion for public-sector efficiency (4) into account. The objective is to maximise the lifetime income of the jurisdiction's citizens. The optimisation problem therefore is

$$\max_{\tau, R_t} \int_0^\infty \left(w_t + \frac{1}{\gamma} R_t^\gamma H_t^{1-\gamma} \right) e^{-rt} dt\,, \tag{8}$$
$$\text{subject to } \dot{H}_t = \tau K_t - R_t \text{ and } H_{t=0} = H_0 \geq 0.$$

The present value of the household's income from saving over time, $\int_0^\infty (A_t r - S_t)\, e^{-rt} dt$, is not part of the objective function. The world interest rate serves as discount factor, as

[4] A potential problem with Wildasin's approach is that this adjustment cost function can be applied to closed economies as well. One might argue that adjustment costs should therefore not be used as a microfoundation for imperfect capital mobility that instead could to be caused by barriers to cross-border capital flows, see for example Persson / Tabellini [1992] or Lejour / Verbon [1997]. In this paper, it is assumed that it is costless to borrow and invest in the international capital market. Nevertheless, capital is not perfectly mobile in the sense that the process of capital flight is time-consuming.

Another possibility is to model the investment decision of the firm with investment in a second capital stock abroad as the alternative investment opportunity. Investment abroad then can be associated with a cost function similar to an adjustment cost function but representing the cost of overcoming barriers to capital. The resulting response of a firm is very similar to the one illustrated in figure 1. Calculations can be obtained on request.

households can borrow and lend on the international capital market. The government controls the supply of redistribution and (indirectly, via the capital stock) also the wage rate. Whatever the paths of w_t and G_t are, households will adjust their savings to maximise their lifetime utility of consumption. In this model, the government has no interest to intervene in the intertemporal consumption decision but maximises the income that is distributed over time to the household. Using this objective function instead of the discounted lifetime utility from consumption will simplify the algebra considerably and has the additional advantage that the government's decisions do not rely on the knowledge of the household's utility function.

Since in this paper I am only interested in the outcome of decentralised decisions about capital taxation and modernisation of the public sector with different degrees of capital mobility, I do not investigate the private consumption paths. Note that with a utility function that implies consumption smoothing additional income will be used for both current consumption and savings. This additional supply of savings in the international capital market will lead to an increase in the world capital stock. The assumption of small jurisdictions implies that the governments' decision to manipulate households income will not change supply and demand conditions in the international capital market.[5] Therefore the interest rate r remains constant.

3.2 Solving the model

The current-value Hamiltonian $\mathscr{H}$ for the government's decision problem is

$$\mathscr{H} = w_t + \frac{1}{\gamma} R_t^{\gamma} H_t^{1-\gamma} + \mu_t (\tau K_t - R_t) . \tag{9}$$

Hestenes' Theorem[6] states that the following conditions hold for an optimal policy $\{\tau, R_t\}$:

$$\begin{aligned} \frac{\partial \mathscr{H}}{\partial R_t} &= R_t^{\gamma-1} H_t^{1-\gamma} - \mu_t = 0 , && (10) \\ \dot{\mu}_t &= \mu_t r - \frac{\partial \mathscr{H}}{\partial H_t} = \mu_t r - \frac{1-\gamma}{\gamma} \left(\frac{R_t}{H_t} \right)^{\gamma} , && (11) \\ \frac{d}{d\tau} \int_0^{\infty} w_t e^{-rt} dt &= -\frac{d}{d\tau} \int_0^{\infty} \left(\frac{1}{\gamma} R_t^{\gamma} H_t^{1-\gamma} + \mu_t (\tau K_t - R_t) \right) e^{-rt} dt . && (12) \end{aligned}$$

Before I calculate the optimal tax rate from (12), I solve for the dynamics of the model for a given tax rate τ that can take any value. From (10), it follows that

$$R_t = \mu_t^{\frac{1}{\gamma-1}} H_t . \tag{13}$$

[5]Note that the very common assumption of small *and identical* jurisdictions is not taken. If jurisdictions were symmetric, all jurisdictions would set the same tax rate simultaneously, implying that the relative attractiveness of jurisdictions would not change and *ex post*, capital would not flee the country. In a symmetric model, this would imply that the market-clearing interest rate would be lowered by the simultaneous decision to change capital taxation. The assumption of smallness for each jurisdictions is meant in the sense that the demand and supply conditions in the international capital market are not influenced by the decision of the individual government, neither ex ante nor ex post.

Makris [2005] is one of the few papers in the tax competition literature that deal with the endogeneity of the interest rate seriously. Makris is concerned with the question whether decentralised decision making implies too low or too high capital tax rates and what the coordinated tax rate should be.

Alternatively, see the jurisdiction that is analysed in the model as the only one that decides about its capital tax rate while the others remain passive.

[6]As τ is time-invariant, it is not a control-variable in the maximisation of (9) but a "control parameter". For this kind of policy variables, Hestenes' Theorem applies, see Takayama [1985, ch. 8.C].

This is the optimal flow of revenues devoted to the production of redistribution.[7] Using (13) in (4) and (11) gives the following non-linear and non-homogeneous system of differential equations:

$$
\begin{aligned}
\dot{H}_t &= -\mu_t^{\frac{1}{\gamma-1}} H_t + \tau K_t\,, && (14a)\\
\dot{\mu}_t &= r\mu_t - \frac{1-\gamma}{\gamma}\mu_t^{\frac{\gamma}{\gamma-1}}\,, && (14b)
\end{aligned}
$$

where K_t is given by (6). Note that the shadow price μ_t of investment in efficiency is a function of μ_t itself and of the input mix R_t/H_t in the governments technology to produce G_t, see (11). Optimal policy (13) on the other hand implies that the input mix is a function of the shadow price. In equation (14b), one can see that (11) and (13) together imply that the the shadow price of investment in efficiency, i.e. the input mix, is independent of both H_t and R_t. This is due to the assumption of a Cobb-Douglas technology with constant returns to scale.

There exists a steady state of system (14) when time goes to infinity. One possible solution method would be to linearise (14) around this steady state. The disadvantage of this approach would be that the solution would only be valid in the neighbourhood of the steady state. To avoid this limitation, the method used in Boadway [1979], and also in Wildasin [2003], is employed. The idea of this method can be described as follows. Assume that the system is initially in a steady state. The system of "variational equations" which is derived by differentiation of (14) with respect to the policy parameter τ then has *constant* coefficients. The values of these coefficients are found by using μ_0 und H_0 from the initial steady state. The resulting system can then be solved and the response of the state variable H_t to a variation of the policy parameter τ be found.

Let's assume that the system was initially in a steady state. From (14b), with $\dot{\mu}_t = 0$, it follows that in the initial steady state,

$$
\mu_0 = \left(\frac{1-\gamma}{r\gamma}\right)^{1-\gamma}. \qquad (15)
$$

Assuming an initial steady state implies that the input mix R_t/H_t has reached some optimal level that reflects a trade-off between the future and the presence. The input mix in the initial situation is

$$
\frac{R_0}{H_0} = \frac{r\gamma}{1-\gamma}.
$$

A high return of households' savings in the international capital market makes investment in future benefits, i.e. in public-sector efficiency, relatively unattractive. This implies a relatively low level of H_t in the optimal input mix. A high output elasticity of current tax revenue R_t has a similar effect.

The system of variational equations that needs to be solved for the effect of a change in the tax rate τ on the evoloution of public-sector efficiency and its shadow price is[8]

$$
\begin{pmatrix} \frac{d\dot{H}_t}{d\tau} \\ \frac{d\dot{\mu}_t}{d\tau} \end{pmatrix} = \begin{bmatrix} -\frac{r\gamma}{1-\gamma} & 0 \\ 0 & \frac{r}{1-\gamma} \end{bmatrix} \begin{pmatrix} \frac{dH_t}{d\tau} \\ \frac{d\mu_t}{d\tau} \end{pmatrix} + \begin{bmatrix} K_0 + \frac{\tau}{F_0''}\left(1-e^{\rho_2 t}\right) \\ 0 \end{bmatrix}. \qquad (16)
$$

[7] The sufficiency of all optimality conditions is discussed in the appendix.

[8] The change in capital tax revenue caused by a change in τ is $\frac{d(\tau K_t)}{d\tau} = \tau\frac{dK_t}{d\tau} + K_0$.

To see the effect of a change in capital taxation on the efficiency H_t of the public sector, system (16) has to be solved for $dH_t/d\tau$. It is saddle-point stable, as the eigenvalues are $\frac{r}{1-\gamma} > 0$ and $-\frac{r\gamma}{1-\gamma} < 0$. With the boundary conditions $\lim_{t\to\infty} \mu_t = \mu_0$ and $\lim_{t\to 0} dH_t/d\tau = 0$, the solution of (16) is

$$\frac{dH_t}{d\tau} = \frac{1-\gamma}{r\gamma}\left(K_0 + \frac{\tau}{F_0''}\right)\left(1 - e^{\frac{-r\gamma}{1-\gamma}t}\right) - \frac{1-\gamma}{\rho_2(1-\gamma)+r\gamma}\frac{\tau}{F_0''}\left(e^{\rho_2 t} - e^{\frac{-r\gamma}{1-\gamma}t}\right) \tag{17a}$$

$$\frac{d\mu_t}{d\tau} = 0 \tag{17b}$$

The public sector's input mix remains unchanged by the additional revenues that are generated by a change in the tax rate. This can be seen from (17b), together with (13), that states that the shadow price of investment in public-sector efficiency remains unchanged at the level given by (15) when the tax rate in capital is changed.[9] An optimal input mix implies that the marginal products of producing G_t with more public-sector efficiency or more current tax revenue, respectively are equal. But when additional tax revenue can be spent on either R_t or investment in H_t, the same trade-off needs to be considered by the government. The public sector divides the additional tax revenues such that the input mix remains unchanged. This is due to the assumption of constant returns to scale and simplifies the algebra below substantially.

The path of public-sector efficiency is

$$H_t = H_0 + \frac{dH_t}{d\tau} = H_0 + \frac{1-\gamma}{r\gamma}\left(K_0 + \frac{\tau}{F_0''}\right)\left(1 - e^{\frac{-r\gamma}{1-\gamma}t}\right) - \frac{1-\gamma}{\rho_2(1-\gamma)+r\gamma}\frac{\tau}{F_0''}\left(e^{\rho_2 t} - e^{\frac{-r\gamma}{1-\gamma}t}\right) \tag{18}$$

This yields the first intermediate result. In the long-run, for $t \to \infty$, with a starting value of $H_{t=0} = H_0$, public-sector efficiency reaches

$$H_\infty = \lim_{t\to\infty}\left(H_0 + \tau\frac{dH_t}{d\tau}\right) = H_0 + \tau\frac{1-\gamma}{r\gamma}\left(K_0 + \frac{\tau}{F_0''}\right). \tag{19}$$

Note that the long term level of public-sector efficiency is *not* independent of its initial level. This is due to the assumption above that public-sector efficiency has reached a steady state initially, given initial taxation in the jurisdiction. The change in taxation $d\tau$ in $t = 0$ is used - if positive - to finance a higher level of public-sector efficiency than previously. The steady state level H_∞ of public-sector efficiency depends on the tax rate τ, on parameters γ and r and on the initial situation. Capital mobility has an influence on H_∞ only insofar as it has an impact on the optimal tax policy.

However, this is not true for the evolution of public-sector efficiency over time. The mobility of private capital ρ_2 plays a role that is beyond its influence on the optimal tax rate. This can be seen from (17a). Before this dependency and the transitional dynamics can be fully characterised, the optimal tax rate τ needs to be found. From an economic point of view, the optimal tax rate can either be positive or negative. I will discuss the necessary conditions for a positive tax rate in more detail below. Result (19) states that the long-term level of the stock of public-sector efficiency depends solely on the tax revenue a government raises, on parameters of the production technology for redistribution, and on its initial level. Investment in public-sector efficiency is costly from the perspective of the household as tax revenue is a prerequisite. The investment opportunity alternative to tax payments from the households point of view is to save and earn a return r. Higher rates of interest in the

[9] Solution (17b) could also have been found directly by noting μ is independent of τ in (14b).

international capital market therefore let a government choose a lower stock of capital in the long run. Furthermore, a high output-elasticity of H_t in the public production technology (2) makes investment in public-sector efficiency attractive and vice versa. Once the steady state level of public-sector efficiency is reached, tax revenue is entirely used as a flow input in the production of redistribution.

The tax rate τ in this model is time-invariant. Technically spoken, the government sets a parameter to find the maximum of the objective function. Using the results (13) and (17) in (12), the optimal tax rate when capital is imperfectly mobile ($0 < |\rho_2| < \infty$) can be calculated as

$$\tau = \frac{F_0'' K_0}{z} \left(1 + \frac{z \left(r - \rho_2 \right)}{\rho_2} \right), \tag{20}$$

where $z = \left(\frac{1-\gamma}{r\gamma} \right)^{1-\gamma} \left(2 - \gamma \right) > 0$. Interestingly, the tax rate τ does not depend on the initial value of public sector efficiency H_0. On the other hand, the initial capital stock K_0 is crucial for the question whether capital should be taxed (further). With $F_0'' K_0 < 0$, the necessary condition for the optimal tax rate being positive then is

$$\rho_2 < \frac{zr}{z-1}. \tag{21}$$

As can be seen from table 1, this condition is fulfilled for most combinations of r and γ as ρ_2 is negative per definition. For example, if $\gamma = 0.7$ and $r = 0.1$, the actual capital mobility needs to smaller than $0,19885$. As ρ_2 is negative, the optimal tax rate is unambiguously positive. Only for a very extreme interest rate r, there is a possibility that the taxation of capital is against the interest of households. In the following, I will assume that parameters are such that the optimal tax rate is positive, regardless of the exact value of ρ_2 and therefore for any possible degree of capital mobility.[10]

	$r = 0.01$	$r = 0.05$	$r = 0.1$	$r = 1$
γ	ρ_2	ρ_2	ρ_2	ρ_2
< 0,9	< 0,0350	< 0,31118	< 0,99565	< -7,548
< 0,8	< 0,0178	< 0,12626	< 0,32658	< -10,04
< 0,7	< 0,0133	< 0,08386	< 0,19885	< 122,83
< 0,6	< 0,0115	< 0,06697	< 0,15025	< 6,2522
< 0,5	< 0,0107	< 0,05876	< 0,12671	< 3,0000
< 0,4	< 0,0103	< 0,05442	< 0,11404	< 1,9609
< 0,3	< 0,0101	< 0,05208	< 0,10694	< 1,4816
< 0,2	< 0,0100	< 0,05085	< 0,10299	< 1,2244
< 0,1	< 0,0100	< 0,05025	< 0,10093	< 1,0786

Table 1: The necessary mobility of capital ρ_2 for various combinations of γ and r such that the tax rate is positive. The entries in the table state the upper bound for the actual capital mobility ρ_2. Most combinations of r and γ are consistent with a positive tax rate τ for any (negative) value of ρ_2. All entries rounded off to four decimal places.

The government in this model can tax capital in order to provide redistribution to households. In addition to the trade-off between capital flight and redistribution, it has to take

[10] There also exists an upper bound for the tax rate. The capital stock needs to be non-negative in the long run or $K_0 + \frac{\tau}{F_0''} \geqslant 0$. I assume inner solutions.

into account that the amount of redistribution depends on its modernisation effort. Hence the complicated role of the technical parameter γ in the tax rate formula. Note that

$$\lim_{\gamma\to 1}\tau = \frac{K_0 F_0'' r}{\rho_2} > 0\,. \tag{22}$$

With γ approaching 1, the relevance of the capital good H_t for the production of the capital good vanishes. The above stated tax rate is identical to the tax rate in Wildasin [2003, eq. (9)]. In Wildasin's paper, the government redistributes tax revenue directly to households. The tax rate (20) in comparison to (22) reflects the additional considerations because of the need to accumulate knowledge in the public sector.

3.3 Capital mobility and public-sector modernisation

Does increased mobility of capital enhance public-sector modernisation? Is tax competition conducive to an efficient public sector? This is the central question in this paper.

The effect of capital mobility on the accumulation of public-sector efficiency H_t is twofold. There is an direct effect of the degree of capital mobility ρ_2, as can be seen in (17). And there is an indirect effect working through τ, as can be seen in (20).

Higher capital mobility leads governments to choose lower tax rates. This can be seen by differentiation of (20) with respect to ρ_2:

$$\frac{d\tau}{d\rho_2} = -\frac{r K_0 F_0''}{\rho_2^2} > 0\ . \tag{23}$$

Note that higher capital mobility is captured by $d\rho_2 < 0$. This result is straightforward: higher capital mobility makes it easier (less costly) for foreign capital owners to flee jurisdictions that try to redistribute from foreigners to local households. The capital stock, labour productivity and wages shrink quicker and this lets governments be relatively reluctant to rely on capital taxation for the purpose of redistribution.

Higher capital mobility does also imply that the long-run level of public-sector efficiency is lower. Differentiation of (19) with respect to ρ_2 leads to

$$\frac{dH_\infty}{d\rho_2} = \frac{1-\gamma}{r\gamma}\left(K_0 + \frac{\tau}{F_0''}\right)\frac{d\tau}{d\rho_2} > 0\ . \tag{24}$$

The intuition for this is that the accumulation of public-sector efficiency is an indirect form of redistribution of tax revenue towards households. The opportunity costs of redistribution are lower wages. This negative effect is stronger with higher capital mobility.

The intensity of tax competition is negatively related to public-sector efficiency not only in the long run but also on the adjustment path. Differentiation of $H_t = H_0 + \tau\frac{dH_t}{d\tau}$ with respect to ρ_2, where the dependency of the tax rate τ on the degree of capital mobility ρ_2 needs to be taken into account, leads to[11]

$$\frac{dH_t}{d\rho_2} > 0\ \forall t > 0\ \text{if}\ \rho_2 < -\frac{r\gamma}{1-\gamma}\,. \tag{25}$$

Higher capital mobility ($d\rho_2 < 0$) implies that the path of public-sector efficiency is lower. The qualification in (25) restricts this statement to situations where capital mobility is higher than some minimum threshhold.

[11] See the appendix for the details.

Figure 2a on the following page illustrates two numerical examples for the evolution of public-sector efficiency H_t with relatively low (dashed line) and high (solid line) capital mobility. Parameters have been chosen such that τ is positive in both cases.[12] Higher capital mobility implies both a lower steady state level of H_t and less investment in efficiency during the transition phase.

Figure 2b on the next page shows the impact $dH_t/d\rho$ of a further variation of capital mobility on the path of public-sector efficiency for the same parameter values.[13] The numerical examples suggest, that, if capital mobility is already high, increasing it further ($d\rho_2 < 0$) has only a very modest consequence for the path of H_t. This would mean that increasing the capital mobility further has little impact for jurisdictions that already engaged in a relatively intense competition for mobile capital. The opposite would be true in a situation with low capital mobility. Of course numerical examples or "drawing with numbers" are not a good substitute for a proper econometric analysis, but they illustrate the nature of the dynamic process analysed in this paper.

Market integration in the form of higher capital mobility therefore hampers public-sector modernisation. The intuition for this result is that public-sector modernisation is modelled as an investment activity that needs to be funded by tax revenues. Higher capital mobility discourages taxation and tax revenues that are needed to pursue public-sector modernisation.

[12] The Parameters are as follows: For both scenarios: Initial public sector efficiency: $H_0 = 0$, private production funktion: $F(K) = 50K^{0.3}$, $\gamma = 0.9$, $r = 0.01$, $K_0 = 10$. For the scenario "high mobility": $\rho_2 = -1.0185$, $\tau = 0.619$. For the scenario "low mobility": $\rho_2 = -0.0975$, $\tau = 0.813$. A "Maple 9.5"-workfile that has been used to do the calculations and plots is available on request.

[13] Figure 2b on the following page plots the derivative of the H_t-path (18) with respect to ρ_2. The dependency of the tax rate (20) on ρ_2 has been taken into account.

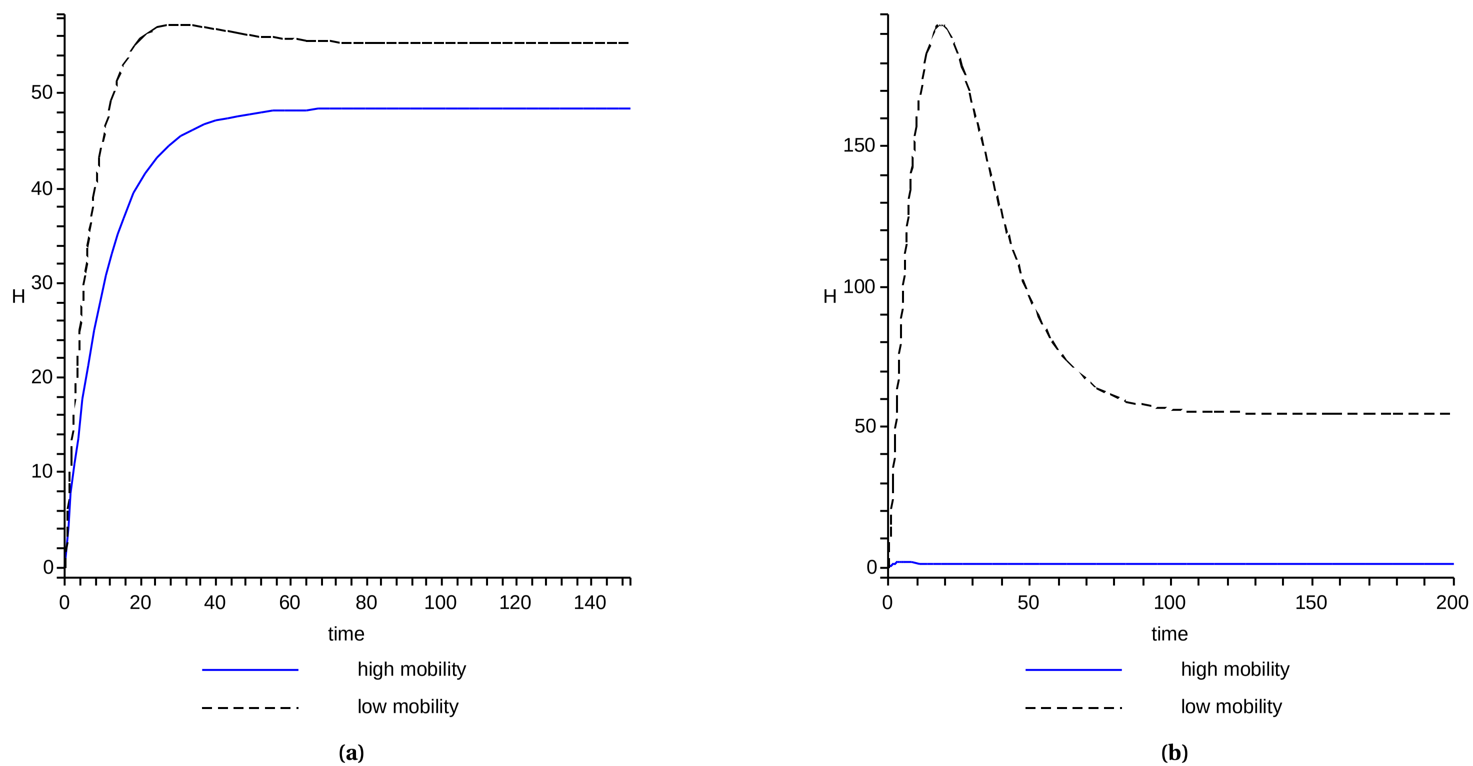

Figure 2: (a) The evolution of public-sector efficiency with high and low capital mobility. (b) The effect of a variation of capital mobility on the path of public-sector efficiency, for initially high and low capital mobility.

4 Concluding Remarks

This paper tries to answer the question whether the competitive pressure induced by capital tax competition enhance the efficiency of the public sector. Public-sector efficiency is modelled as a capital or knowledge stock. Thus public-sector modernisation becomes an investment activity that is financed by tax revenues. The main result of the paper is that the presence of tax competition hampers public-sector modernisation because it limits a government's ability to raise tax revenue.

A key assumption of the model is that private agents are caught by surprise by the government's decision to tax capital and that it can commit itself to this policy announcement. This is not very realistic. As long as the capital stock in the jurisdiction has some positive level, there is an incentive to deviate from this announcement and tax capital further. Rational investors would foresee that the announcement of a tax policy in $t = 0$ is not time-consistent. With rational expectations, a credible policy announcement must not depend on initial conditions as in this model, see Taylor [2000, sect. 2.1]. In a model with time-consistent tax policy, tax policy would need to be formulated as a rule that shows how taxation adjusts to a changing economic environment.

There is no lump-sum redistribution in this model. This simplifies the model and can be justified by the politic resistance that per-head taxation usually provokes or for theoretical reasons. Most importantly, the existence of a second channel for redistribution would not change the results qualitatively: It would still make sense to invest in public sector efficiency as this investment strengthens the link between tax revenue and redistribution. The trade-off between costs and benefits would be qualitatively the same.

Another simplifying assumption is that households do not own parts of the local capital stock. It ensures that households do not suffer from the fact that the net return of local capital is lower than the world interest rate during the transition phase after an surprising rise in capital taxation. Nevertheless, this setup is not very realistic. A possible justification is that the government might simply not be interested in the well-being of capital-owners albeit in the model presented above, there is no heterogeneity. An alternative modelling strategy would be to introduce a parameter that represents the share of the local capital stock that is owned by foreign households. The higher the share of domestic ownership, the lower the optimal tax rate would be.

Public services benefit only households in this model. But of course the public sector provides also infrastructure and other public inputs that enter the private sector's production function. In a dynamic context, public inputs can be a potential source of sustained growth. Futagami et al. [1993] analyse a model in which a public capital stock serves as an input to private production. Extending their analysis by a tax competition scenario and a public sector that can operate at various levels of efficiency seems to be promising.

The major lesson that can be drawn from this paper is that interjurisdictional tax competition is not useful for the goal of an efficient public sector. When public-sector efficiency is plagued by egoistic politicians or lazy bureaucrats, tax competition among jurisdictions might serve as a disciplining device. But when low efficiency is caused by underinvestment, as in this paper, competition and efficiency are no complements. Coordinated tax policy can then help to improve public sector efficiency.

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Appendix

Calculation of the tax rate

Start with equation (12):

$$\frac{d}{d\tau}\int_0^\infty w_t e^{-rt}dt = -\frac{d}{d\tau}\int_0^\infty\left(\frac{1}{\gamma}R_t^\gamma H_t^{1-\gamma}+\mu_t(\tau K_t - R_t)\right)e^{-rt}dt$$

The wage rate w_t depends on the current capital stock K_t but not on the tax rate τ directly. The impact of taxation on the wage rate therefore is $dw_t/d\tau = dw_t/dK_t = -F_0''K_0 dK_t/d\tau = -K_0\left(1-e^{\rho_2 t}\right)$. The LHS of (12) then can be written $-K_0\int_0^\infty\left(1-e^{\rho_2 t}\right)e^{-rt}dt = -K_0\int_0^\infty e^{-rt}dt - K_0\int_0^\infty -e^{(\rho_2-r)t}dt$. Calculation of these integrals[14] then gives for the LHS of (12): $-K_0\left(1/r - 1/(r-\rho_2)\right) = \left(\rho_2 K_0\right)/\left(r(r-\rho_2)\right) < 0$

Substitution of (13), (15) and rearranging then gives

$$\begin{aligned}-\frac{\rho_2 K_0}{r(r-\rho_2)} &= \frac{d}{d\tau}\int_0^\infty\left(\frac{1-\gamma}{\gamma}\left(\frac{1-\gamma}{r\gamma}\right)^{-\gamma}H_t+\left(\frac{1-\gamma}{r\gamma}\right)^{1-\gamma}\tau K_t\right)e^{-rt}dt\\ &= \int_0^\infty\left(\frac{1-\gamma}{\gamma}\left(\frac{1-\gamma}{r\gamma}\right)^{-\gamma}\frac{dH_t}{d\tau}+\left(\frac{1-\gamma}{r\gamma}\right)^{1-\gamma}\frac{d(\tau K_t)}{d\tau}\right)e^{-rt}dt\end{aligned}$$

Note first that $\int_0^\infty\frac{dH_t}{d\tau}e^{-rt} = \frac{1}{r\left(\frac{r\gamma}{1-\gamma}+r\right)}\left(K_0+\frac{\tau}{F_0''}\frac{-\rho_2}{r-\rho_2}\right)$. Furthermore, $\frac{d(\tau K_t)}{d\tau} = \tau\frac{dK_t}{d\tau}+K_0$. This allows to calculate that $\int_0^\infty\left(\left(\frac{1-\gamma}{r\gamma}\right)^{1-\gamma}\left(\tau\frac{dK_t}{d\tau}+K_0\right)\right)e^{-rt}dt =$ $\left(\frac{r\gamma}{1-\gamma}\right)^{\gamma-1}\left(\frac{K_0}{r}+\frac{\tau}{F_0''}\frac{-\rho_2}{r(r-\rho_2)}\right)$. Collecting terms, the following remains as an equation to solve for τ:

$$\begin{aligned}-\frac{\rho_2 K_0}{r(r-\rho_2)} &= \frac{1-\gamma}{\gamma}\left(\frac{r\gamma}{1-\gamma}\right)^{\gamma}\frac{1}{r\left(\frac{r\gamma}{1-\gamma}+r\right)}\left(K_0+\frac{\tau}{F_0''}\frac{-\rho_2}{r-\rho_2}\right)\\ &\quad+\left(\frac{r\gamma}{1-\gamma}\right)^{\gamma-1}\left(\frac{K_0}{r}+\frac{\tau}{F_0''}\frac{-\rho_2}{r(r-\rho_2)}\right)\end{aligned}$$

From this, with $z=\left(\frac{1-\gamma}{r\gamma}\right)^{1-\gamma}(2-\gamma)$, the optimal tax rate (20) follows.

[14] Note that $\int_0^\infty e^{-xt}dt, x>0 \leftrightarrow \frac{1}{-x}e^{-xt}]_0^\infty = 0-\frac{1}{-x}e^0 = \frac{1}{x}$.

Concavity check

The necessary conditions for optimal policy $\{\tau, R_t\}$ discussed in the main text can be shown to be sufficient for an optimal policy when some concavity-conditions are met. See Takayama [1985, Theorem 8.C.5].

What needs to be checked is whether the functions $w_t + \frac{1}{\gamma} R_t^{\gamma} H_t^{1-\gamma}$ and $\tau K_t - R_t$ are concave in R_t and H_t. For the first of these, the quadratic form is

$$\begin{bmatrix} -(1-\gamma)R_t^{\gamma} H_t^{-\gamma-1} & (1-\gamma)R_t^{\gamma-1} H_t^{-\gamma} \\ (1-\gamma)R_t^{\gamma-1} H_t^{-\gamma} & (\gamma-1)R_t^{\gamma-2} H_t^{1-\gamma} \end{bmatrix}.$$

For the second, the quadratic form is $\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$, as it is independent of H_t and linear in R_t. Both of them are negative-semidefinite and therefore, the sufficiency conditions are met.

Calculation of (25)

There is a direct effect and an indirect effect (via the tax rate) of a variation of ρ_2 on the path of H_t.

Direct effect: For a given tax rate τ,one can calculate that

$$\frac{dH_t}{d\tau} = \tau \left(\frac{(1-\gamma)^2 \left(e^{\rho_2 t} - e^{-\frac{r\gamma}{1-\gamma} t}\right) \tau}{F_0'' \left(\rho_2(1-\gamma) + r\gamma\right)^2} - \frac{(1-\gamma)\, t e^{\rho_2 t} \tau}{F_0'' \left(\rho_2(1-\gamma) + r\gamma\right)} \right).$$

The necessary condition for this effect being > 0 is

$$e^{\rho_2 t} \left(1 - t\left(\rho_2 + \frac{r\gamma}{1-\gamma}\right)\right) < e^{-\frac{r\gamma}{1-\gamma} t}.$$

This condition is met if $\rho_2 + \frac{r\gamma}{1-\gamma} < 0$.

To evaluate the indirect effect of a change in the tax rate caused by a change in capital mobility, note first that $\frac{d\tau}{d\rho_2} > 0$, see (23). On the other hand,

$$\frac{dH_t}{d\tau} = \frac{(1-\gamma)\left(1 - e^{-\frac{r\gamma}{1-\gamma} t}\right)}{r\gamma} \left(K_0 + \frac{\tau}{F_0''}\right) - \frac{(1-\gamma)\, 2\tau \left(e^{\rho_2} - e^{-\frac{r\gamma}{1-\gamma} t}\right)}{F_0'' \left(\rho_2 (1-\gamma) + r\gamma\right)}.$$

With $\rho_2 + \frac{r\gamma}{1-\gamma} < 0$, this is positive such that both the indirect and the direct effect $\frac{dH_t}{d\rho_2}$ are positive as shown in (25).

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