Corporate Tax Competition and the Decline of Public Investment

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Abstract

The government's choices of the corporate tax rate and public investment are interdependent. In particular, they both respond positively to the other. Therefore, international tax competition not only drives corporate tax rates to lower levels but might also affect negatively the stock of public capital. We build a general equilibrium model that illustrates the relation between the two variables. We then add an element of international tax competition. Our simulations show that when international tax competition drives the statutory tax rate down from 45% to 30%, public investment is reduced by 0.4% of output at the steady state. The short run effect is three times higher. The second part of our study displays an empirical analysis that corroborates the main outcome of the model. We estimate two policy functions for 21 OECD countries and find that corporate tax rate and public investment are endogenous. More precisely, a decline of 15% in the corporate tax rate reduces public investment by 0.6% to 1.1% of GDP. We also find evidence that international competition operates on both policy tools.

JEL Code: H0, H26, H54.

Keywords: tax competition, corporate tax, public investment, public capital.

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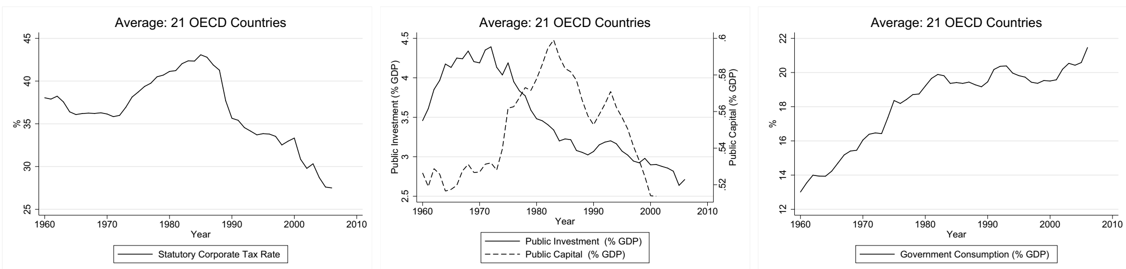
1 Introduction

Over the past 30 years, there has been a downward trend in two distinct government policy tools. On the one hand, statutory corporate tax rates have gone down in the majority of OECD countries from around 45% to 30%. On the other hand, public investment has declined from an average of 4.5% of GDP to below 3% of GDP. As a consequence, public capital stock has fallen by 10% of GDP (see Figure 1 below). In contrast, government consumption has increased during this period.

Figure 1: Corporate taxation and allocation of public spending in OECD countries



The decline in statutory corporate tax rate is a well documented phenomenon. It is usually attributed to international tax competition and a higher degree of capital and profit mobility.[1]

In contrast, the literature examining the downward trend in public investment is scarcer and far less compelling.[2] In a way, the decline of public investment and public capital stock is a puzzle. Bénassy-Quéré, Gobalraja, and Trannoy (2007), among others, show for instance that the location of multinational firms does not entirely depend on national tax policies but also on 'public infrastructure', partly because of its positive effect of the productivity of private capital. Under these circumstances, the relationship displayed in Figure 1 could appear counter-intuitive: in a more competitive environment we would indeed expect countries to increase their stock of public capital (at the expense of public consumption) in order to attract more private investment.

We argue that these two phenomenons are related. Firstly, we claim that there is an intrinsical relation between corporate tax and public investment, beyond the simple identity of the government budget constraint. On the one hand, if the tax rate is high, governments spend more in public investment, relative to government consumption . The intuition for this is the following. The

[1] See for instance Krogstrup (2004).

[2] Some frequent explanations for the decline of public investment include: the increase of privatization, the increase of private-public partnerships, the smaller role of the government or, in the case of Europe, the need for fiscal stringency. Some of these explanations are not very convincing as argued by Mehrotra and Välilä (2006). First, under national accounts, the investment undertaken by public enterprizes counts as private investment. Only investment recorded and financed from the budget counts as public investment . Second, private and public partnership is a very recent phenomenon that could not account for the pattern observed since the 1970s. Furthermore, government consumption has increased during the same period for most OECD countries. See Balassone and Franco (2000).

existence of public capital creates rents for the firms. Part of these rents are appropriated by the government through the corporate taxation. In a way corporate taxation can be seen as a return on public investment. If the tax rate is at high levels, a government that cares about revenue (or cares about the distortions of raising revenue) tends to favour public investment, at the expenses of government consumption. On the other hand, the level of tax rate also depends positively on the level of public capital. The higher the level of public capital, the higher the rents for the firm. The firm is, therefore, able to support a higher tax burden on its profit. Both policy variables respond positively to each other and the two are jointly determined.

Given the endogenous relation between corporate tax rate and public investment, we argue that the increase in the international tax competition, that has been exogenously driving the corporate tax rate down over the past years, caused, as a side effect, the reduction of public investment.

To make our case, we first build a model where the decision-maker decides on a corporate tax policy, but also chooses how to allocate its public resource. In this respect, the government has two alternatives: it can either invest (and therefore increase the stock of public capital) or allocate its tax receipts into "unproductive" government consumption. Additionally, we consider an element of tax competition to assess the short and long run macroeconomic implications of a greater degree of corporate tax competition. We, then, perform an empirical analysis for 21 OECD countries for the period between 1966 and 2002.

In line with Pouget and Stéclebout-Orseau (2008), our model attempts to illustrate the interdependence between statutory tax rates and productive spending. We develop our analysis in a general equilibrium setting and in this way we aim to provide a realistic quantitative analysis. In our two-country model, governments can enlarge their tax base by deciding on a more accommodating corporate tax rate or by increasing the stock of productive public capital (or public infrastructures). Because the exact source of tax competition does not affect the main mechanism of the model, we focus on profit shifting as opposed to capital mobility. Due to the growing internalization of the corporate sector, particularly in Europe, multinational companies have increased their ability to change the location of their declared profit in response to tax rates differentials for tax avoidance purposes.[3] Our simulations indicate that, following a decline of 15% in tax rate (driven by increasing competition), public investment in steady state diminishes between 0.2% and 0.4% of output. This leads to a drop in the steady state public capital stock over output ranging from 4 to 11 percentage points. We also perform simulation on the transition between steady states and find that

[3] Bartelsman and Beetsma (2003) performed an empirical analysis based on OECD countries and estimate in their baseline scenario that 65% of the additional revenue from a unilateral tax increase is lost due to a decrease in the reported profit to the national tax authorities. See also Huizinga and Laeven (2007) who have calculated that the average semi-elasticity of reported profits with respect to the top statutory tax rate. In particular, Germany appears to have lost considerable tax revenues due to profit mobility -see Weichenrieder (2007). For other contributions on international tax competition and profit shifting, see Kind, Midelfart, and Schjelderup (2005), and Elitzur and Mintz (1996).

the short run impact on public investment can be up to three times larger than the long run effect. We also create different scenarios and challenge the robustness of the relationship. In all cases, international tax competition reduces the share of public spending allocated to public investment, therefore reducing the stock of public capital.

In the empirical part we estimate two endogenous policy functions of corporate tax rate and public investment that also respond to their foreign counterpart. Evidence confirms the endogeneity and the complementarity between the two tools: tax rate increases with the level of public investment and public investment increases with the tax rate. We find that a decline in tax rate of 15%, reduces public investment by 0.6% to 1.1% of GDP. Further evidence suggests that both tools are driven by competition, particularly te corporate tax rate.

The next section of this paper introduces the theoretical model by presenting the main assumptions and mechanisms in a partial equilibrium setting. In the third section we calibrate the model and present the quantitative results. The empirical analysis is presented in the fourth section. The last section concludes.

2 The Model

The general equilibrium model consists of two countries denoted A and B. National governments decide on a tax rate levied on the benefits of the corporate sector and allocate their tax receipts either to "productive" public investment or public consumption. The corporate sector is introduced through a single representative multinational firm producing a homogeneous good in both countries.

Capital is perfectly mobile between the two countries and the firm can borrow at a world interest rate. Since the two national tax bases are not consolidated, the corporate sector has the ability to shift profit in order to reduce its overall tax burden. However, these operations entail some costs. We assume perfect foresight and no uncertainty.

2.1 The Households

In each country i ($i \in \{A; B\}$), a representative household derives its utility from both private consumption and public spending. The instantaneous utility function at time t is given by:

$$U_t^i = \ln c_t^i + \xi \ln g_t^i + \gamma \ln P_t^i \tag{1}$$

The utility derived from public spending depends first on government consumption, g_t^i, which covers all current expenditures with no direct productive purposes. Additionally, the household's utility depends on the stock of public capital, denoted P_t^i. This stock represents a wide range of public infrastructures, such as roads or bridges, that are valuated by the representative household but also used in the production process (see below). Therefore, in line with Keen and Marchand (1997), our model relies on a clear-cut distinction between productive and non-productive government spending. Parameters ξ and γ tell us that the representative household can valuate differently these two categories of public spending.

In each country, the representative household takes public variables as given and maximizes the present discounted value of the lifetime utility of private consumption: $\hat{U}(c_t^i) = \sum_{t=0}^{\infty} \beta^t \ln c_t^i$, β being the discount factor. The household's budget constraint is therefore described by:

$$c_t^i + I_t^i = w_t^i + r_t^k B_t^i + \Upsilon_t^i - \bar{t} \tag{2}$$

In each period, household's resources are either consumed (c_t^i) or saved by holding shares of the private sector (I_t^i). We assume that the representative household supplies one unit of labour inelastically and wage rate is set at w_t^i. Total net resources depend also on the total amount of private capital owned by the household, denoted B_t^i, which yields a gross return of r_t^k and whose law of motion (assume that the depreciation rate of private capital is δ) is:

$$B_{t+1}^i = (1-\delta)B_t^i + I_t^i \tag{3}$$

The household receives also dividends earned by the private sector: Υ_t^i (which will be defined later on). Besides, a lump sum tax on personal income, $\bar{t}$, is levied in order to finance public policy. Note that this specific tax rate will be considered exogenous in this model. Maximizing $\hat{U}(c_t^i)$ subject to (2) gives us the consumption pattern of the representative household, which is determined by the following Euler condition (we define $r_t = r_t^k - \delta$ as the net interest rate):

$$c_{t+1}^i = c_t^i(1 + r_{t+1})\beta \tag{4}$$

2.2 The Corporate Sector

A single multinational firm operating in the two countries represents the private sector. It produces a homogeneous private good according to the following production function:

$$y_t^i = F(k_t^i, P_t^i, n_t^i) = k_t^{i\alpha} P_t^{i\theta} n_t^{i(1-\alpha-\theta)} \tag{5}$$

The labor input, n_t^i, is considered to be immobile between the two countries. By contrast, capital is perfectly mobile and k_t^i describes the total quantity of capital used in country i. Public capital stock is included in the production function and, therefore, increases the marginal productivity of capital. P_t^i is considered as given by the firm. The production technology is identical in the two countries.

A source-based corporate tax is applied on the declared profit of the representative firm in the two countries. Therefore, the aggregated net profit of the corporate sector is as follows:

$$\Pi_t^{Tot} = (1-\tau_t^A)\Gamma_t^A + (1-\tau_t^B)\Gamma_t^B - r_t(k_t^A + k_t^B) - \psi(S_t)$$

$$\text{with: } \begin{cases} \Gamma_t^A = F(k_t^A, P_t^A) - n_t^A w_t^A - \delta k_t^A - s_t \\ \Gamma_t^B = F(k_t^B, P_t^B) - n_t^B w_t^B - \delta k_t^B + s_t \end{cases} \tag{6}$$

Γ_t^i represents the declared profits of the firm in country i , and therefore its corporate tax base. We assume that the firm can deduce capital depreciation from the taxable profits.[4] We define $s_t > 0$ (respect. < 0) the total amount of profit shifted form country A to country B (respect. from B to A). These profit manipulations are costly to the firm since national tax authorities seek to prevent tax evasion (for instance, transfer pricing distortions have to be justified). The function $\psi(s_t)$ capturing this cost is convex: $\psi(0) = 0$, $\psi_s(s_t) > 0$ and $\psi_{ss}(s_t) > 0$.[5] Following Kolmar and Wagener (2007), we use the following functional form: $\psi(S_t) = b(s_t)^2$.

By maximizing 6 with respect to k_t^i, w_t^i and s_t, we obtain the equations describing the behaviour of the corporate sector. The allocation of capital in each country depends on the following first order condition:

$$F_K(k_t^{i*}, P_t^i, n_t^i) = \upsilon_t^i + \delta \text{ with: } \upsilon_t^i = \frac{r_t}{(1-\tau_t^i)} \tag{7}$$

The total amount of capital used in country i is such that its marginal productivity equals the gross cost of capital (which includes the cost of depreciation). Net cost of capital in a given country, υ_t^i, increases with interest rates and corporate tax rate. Besides, because of the perfect mobility of capital, a unique interest rate applies in the two countries. When the government increases the total stock of public capital, P_t^i, this automatically increases k_t^{i*} due to its positive effect on marginal productivity of capital.

As one unit of labour is inelastically supplied in the two countries, the firm's decision on labor consists on the choice of the wage rate according to the following condition:

$$F_n(k_t^i, g_t^i, n_t^{i*}) = w_t^{i*} \tag{8}$$

[4]Modeling this way implies that the statutory tax rate is equivalent to the effective marginal tax rate. If we allow the firm to deduce the financial cost of capital, the effective marginal tax rate would then be zero. This alternative is less realistic and it does not change the mechanism of the model. The relation between public capital and tax rate depends mainly on the statutory tax rate.

[5]This cost should be interpreted as the probability of being audit by the authorities, not being able to justify the transfer prices, and consequently being fined. We, therefore, assume that the marginal cost of tax evasion increases with the total amount of profit shifted.

At last, the firm's decision on paper profit responds to the tax rate differential. Because $\psi_s(s_t) > 0$, profit will be shifted from A to B if $\tau_A - \tau_B > 0$. Profit-shifting flows are decreasing with the marginal cost associated to these operations:

$$\psi_s(s_t^*) = \tau_t^A - \tau_t^B \Leftrightarrow s_t^* = \frac{\tau_t^A - \tau_t^B}{2b} \tag{9}$$

2.3 The government

The objective function of the government is given by (10).

$$V(P_t^i, g_t^i) = \sum_{t=0}^{\infty} \beta^t \left(\xi \ln g_t^i + \gamma \ln P_t^i\right) \tag{10}$$

The purpose of the government is to maximize the present discounted value of the household lifetime utility derived from public spending. In our model, the decision maker aims to increase public spending ultimately and, therefore, behaves like a leviathan. This assumption should be seen as a shortcut. The alternative would be to have two types of distortive taxation and a decision-maker maximising the consumer's utility. However, as we want to study the dynamic model, we would need to approach this issue through the optimal dynamic taxation theory, which we want to avoid, since it would lead us well beyond the scope of our study. To show that the main mechanism of the model holds in a broader setting, in Appendix 2 we display a static model with optimal policy and two distortionary taxes.[6]

Public resources in country i depend on the personal and corporate income tax revenue. Corporate tax revenue R_t^i depends on a statutory tax rate and the corporate tax base (i.e. the declared profit of the firm in country i).

$$\begin{gathered} g_t^i + p_t^i = \bar{t} + R_t^i(P_t^i, \tau_t^i, \tau_t^j) \\ \text{with: } R_t^i(P_t^i, \tau_t^i, \tau_t^j) = \tau_t^i \Gamma_t^i = \tau_t^i [F(k_t^{i*}, P_t^i, n_t^i) - \delta k_t^{i*} - w_t^{i*} \pm s_t^*] \end{gathered} \tag{11}$$

The second constraint the government faces is the law of motion equation of public capital stock (δ_p is the rate of depreciation) :

$$P_t^i = (1 - \delta_p) P_{t-1}^i + p_t^i \tag{12}$$

We consider that the governments anticipate the outcome of their choice on the decisions of the private sector. In this sense governments know that both their decision on tax rate and public capital affect the firm's choice of capital (7), labour (8) and profit shifting (9) and, therefore,

[6] An alternative way to interpret the government's problem is to think the government maximizes consumer's lifetime utility, but is limited on the amount of taxes it can collect ($\bar{t}$). If the consumers have strong preferences for the public goods, the supply of public goods is always below optimum. The level of consumption is very high and its marginal benefit too low compared to both public goods. In this case the government's problem collapses to (10).

the corporate revenue. Public decision consists of the choice of a statutory tax rate, τ_t^i and a decision on public resources allocation between public investment and government consumption. Each government decides simultaneously and non-cooperatively. The Lagrangian associated with the government allocation problem is:

$$L = \sum_{t=0}^{\infty} \beta^t \{\xi \ln \left[\bar{t} + R_t^i(P_t^i, \tau_t^i, \tau_t^j) - p_t^i\right] + \gamma \ln P_t^i - \lambda_t \left[P_{t+1}^i - (1-\delta_p)P_t^i - p_t^i\right]\} \tag{13}$$

Not surprisingly, the government chooses τ_t^i in order to maximize its corporate tax revenue:

$$\frac{\partial R_t^i(P_t^i, \tau_t^i, \tau_t^j)}{\partial \tau_t^i} = 0 \tag{14}$$

Since a corporate tax rate policy is decided simultaneously and non-cooperatively by the two countries, tax equilibrium between A and B is, thus, the outcome of a Nash game. Using (14) we obtain the reaction functions of the two countries (see Appendix 1):

$$\begin{cases} \frac{\tau_t^A}{b} = \frac{\tau_t^B}{2b} + \frac{\partial \bar{\Gamma}_t(\tau_t^A; P_t^A)}{\partial \tau_t^A} \\ \frac{\tau_t^B}{b} = \frac{\tau_t^A}{2b} + \frac{\partial \bar{\Gamma}_t(\tau_t^B; P_t^B)}{\partial \tau_t^B} \end{cases} \tag{15}$$

A corporate tax policy stance has two major determinants. Firstly, each government attempts to maximize the revenue of its "productive" tax base, denoted $\bar{\Gamma}(.)$. This consists of the tax base that would be only determined through the allocation of capital:

$$\bar{\Gamma}(\tau_t^i; k_t^i; P_t^i) = \tau_t^i \left\{ (\theta+\alpha) P_t^{i\,\frac{\theta}{1-\alpha}} \left[\frac{\alpha(1-\tau_t^i)}{r_t + \delta^p(1-\tau_t^i)}\right]^{\frac{\alpha}{1-\alpha}} - \delta P_t^{i\,\frac{\theta}{1-\alpha}} \left[\frac{\alpha(1-\tau_t^i)}{r_t + \delta^p(1-\tau_t^i)}\right]^{\frac{1}{1-\alpha}} \right\} \tag{16}$$

As one can observe on Figure 2, the revenue derived from this fraction of the tax base follows the pattern of a traditional Laffer curve with respect to the corporate tax rate and is maximized for $\tau_i^{\max}$. When $\tau_t^i > \tau_{\max}^i$, any corporate tax hike would entail a net loss, because the marginal revenue would be offset by the shrinking of the tax base.

The second determinant of a corporate tax policy is easily observed on (15): tax rate in a given country is clearly responding to its partner's tax rate. These strategic interactions describe a race to the bottom phenomenon which is entirely dependent on profit mobility. When b is low, the multinational firm can engage profit shifting operations forcing the two countries to compete more (see Figure 3). On the other hand, if profit shifting operations were no longer affordable ($b \to +\infty$), strategic interactions would disappear and corporate tax rates would be set at $\tau_{\max}^i$.

Having described in details the nature of tax competition in this model, we can now analyze the determination of the stock of public capital in our model, given by the following first order

Figure 2: "Productive" tax base

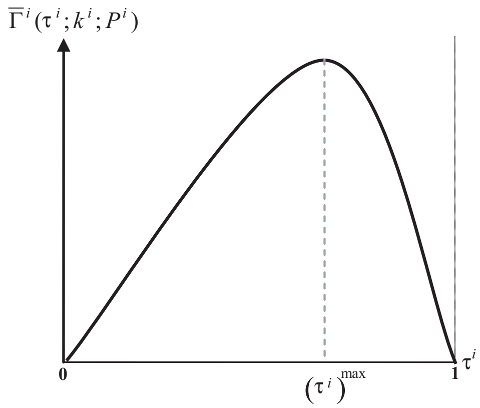
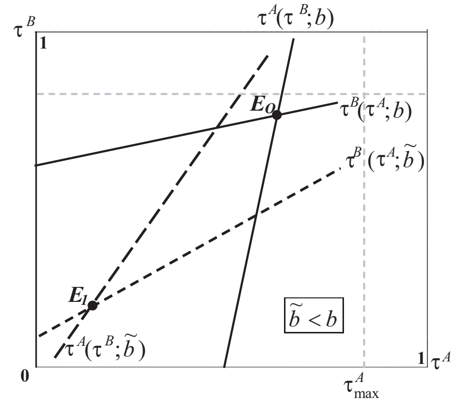


Figure 3: Tax rate equilibrium



condition:

$$\frac{\xi}{g_t^i} = \beta[\frac{\gamma}{P_{t+1}^i} + \frac{\partial R_{t+1}^i(P_{t+1}^i, \tau_{t+1}^i, \tau_{t+1}^j)}{\partial P_{t+1}^i}\frac{\xi}{g_{t+1}^i} + (1-\delta_p)\frac{\xi}{g_{t+1}^i}] \tag{17}$$

When maximizing (13) with respect to p_t^i we obtain: $\lambda_t = \xi/g_t^i$, so that the Lagrange multiplier can be interpreted as the marginal cost of public investment in t (in terms of households foregone utility of consumption of the public good). The right hand side represents the discounted benefits of investing on public capital. It is composed of the direct benefit of public capital on the representative household utility (γ/P_{t+1}^i). The second component of the benefit refers to the anticipated effect of public capital stock on the tax revenue: investing more on public capital, will drive the multinational firm to install more capital, thus bringing extra revenues in the future. This revenue may then be used to supply a general public good to the population. The third component reflects the fact that public capital is a durable good so these two effects carry on to the following periods after depreciation is accounted for.

Using (4) and re-writing (17) at the steady state, we obtain:

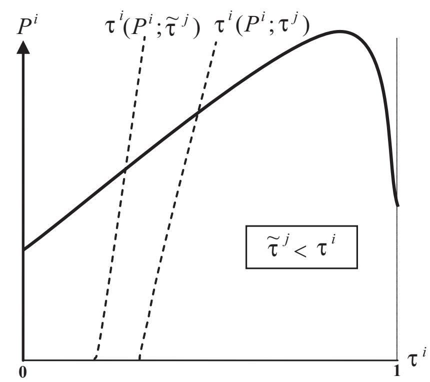
$$\frac{\partial R^i(P^i, \tau^i, \tau^j)}{\partial P^i} + \frac{\gamma}{\xi}\frac{g^i}{P^i} = r + \delta_p \tag{18}$$

The interpretation of (18) is very simple. The marginal benefit of an increase of public capital stock depends on its positive effect on corporate tax revenue and the marginal utility that the representative household derives from this public policy (which is of course decreasing with P^i). The gross marginal cost increases with the interest rate and the depreciation rate of public capital stock.

We can observe by the first order conditions (14) and (17) that the two instruments used by the decision maker in order to collect corporate tax revenue are interdependent. We illustrate this partial equilibrium relationship for country A on the Figure 4 below. Except for extreme values of τ_t^A, the stock of public capital is increasing with the statutory tax rate. This pattern directly depends on how strong is the impact of public capital on total corporate tax revenue $(\partial R^i(P^i, \tau^i, \tau^j)/\partial P^i)$, which obviously declines when tax rate takes lower values. Note that total capital stock remains positive even when tax rate is equal to zero (indeed, as we can clearly see on (18), public capital stock does provide a satisfaction to the representative household besides increasing future tax revenue, so, it does not disappear even in the absence of corporate taxation).

On the other hand, tax rate depends positively on the level of public capital. The higher the public capital, the higher the rents, so the higher the governments will set their tax rate. Nevertheless, tax rate appears to be less reactive to public capital stock. In our model the tax policy stance relies mostly on the level of tax competition and on the partner country's tax rate.

Figure 4: Government's first order conditions



The endogenous relation between public capital and corporate tax rate, which we describe above, is not model specific. Under the "leviathan" assumption, the government uses corporate tax rate to maximize tax receipts and public investment partially to maximize future tax revenue. If we assumed a perfectly benevolent government using two types of distortionary taxes to raise revenue, a very similar intuition would hold. Firstly, the government would use a combination of taxes to minimize the distortions needed to raise a certain amount of revenue. Public capital would, nevertheless, still create rents and it would guarantee that part of the future revenue would be non-distortionary. Thus, the higher the corporate tax rate, the higher the level of non-distortionary revenue generated by a certain level of rents, so the higher the optimal level of public capital stock.

2.4 Market Clearing

In order to close the model we need three additional conditions. First we have the market clearing condition for both capital and goods markets:

$$\begin{cases} b_t^A + b_t^B = k_t^A + k_t^B \\ y_t^A + y_t^B = c_t^A + c_t^B + g_t^A + g_t^B + p_t^A + p_t^B + I_t^A + I_t^B + b(s_t)^2 \end{cases} \tag{19}$$

Total capital used by the firm equals to the amount of capital held by the households. Total production in the two countries must equal to the total private and public consumption, private and public investment and the cost of profit shifting. Finally, we need a final equation to pin down the consumption level of each country.

$$c_t^i + I_t^i = w_t^i + r_t b_t^i - \bar{t} + \Upsilon_t^{i\,7} \tag{20}$$

3 Quantitative Analysis

3.1 Calibration

In this section we analyze the quantitative implications of corporate tax competition for public capital and public investment. The model is calibrated for an annual frequency. Table 1 shows the values of the parameters and the implied steady state values for key variables.

The calibration of the first four parameters is quite standard. The discount factor is such that the annual real interest rate is 3.5%. In line with Kamps (2006), the annual rate of depreciation of public capital is 5%. Its private counterpart is set at 8%. The elasticity of output with respect to private capital is 0.26. The parameter θ is more controversial. Estimates of the elasticity of output with respect to public capital range from 0 to 0.80. We set the value to 0.08 following a meta-analysis study of Bom and Ligthart (2008).

The last three coefficients are calibrated in order to obtain realistic steady state values for some variables. The relative preference for the two types of public goods, γ/ξ, is such that public capital stock as a share of output in equilibrium is 0.55. The lump sump tax $\bar{t}$ is such that the government consumption in the economy is close to 22 percent of output. As we do not have any estimates of the cost parameter of profit shifting, b is set such that the corporate tax rate equilibrium is 30 percent. These three values are in line the evidence on OECD countries shown in the introduction.

[7] We defined the dividend paid in country i as the total declared profit minus the interest rate payment on existing capital.
$\Upsilon_t^i = [(1-\tau_t^i)(y_t^i - w_t^i - \delta k_t^i - s_t) - r_t k_t^i]$

Table 1: Calibration and steady state values in the benchmark case

Calibration			Steady State		
β	Discount factor	0.966	c/y	Consumption / output	0.587
δ	Depreciation rate (private capital)	0.08	I/y	Investment / output	0.16
δ_p	Depreciation rate (public capital)	0.05	$(g)/y$	Government consumption / output	0.225
α	Elasticity of output (private capital)	0.26	p/y	Public investment / output	0.0275
θ	Elasticity of output (public capital)	0.08	k/y	Private capital stock / output	2.00
$\bar{t}$	Lump sum tax	0.243	P/y	Public capital stock / output	0.55
$\frac{\gamma}{\xi}$	Relative preference for public capital	0.182	τ	Corporate tax rate	0.3
b	Cost of profit shifting	0.625	R/y	Corporate tax revenue / output	0.054

3.2 Steady State Effect of Competition

Starting from this baseline calibration, we now illustrate the consequences of tax competition on public capital stock and other key variables in the economy. Figure 5 illustrates how the tax rate equilibrium depends on the cost of profit shifting. We observe that when profit shifting becomes more affordable, a race to the bottom occurs. Not surprisingly in the extreme case of perfect profit mobility, tax rate is driven to zero.

The Figure 6 below shows how the steady state stocks of public capital and public investment over output respond to changes in the tax rate (driven by the decline in b). Under the benchmark scenario, a change of the statutory tax rate from 45% to 30% percent leads to a decline of public

Figure 5: Tax rate equilibrium and the cost of profit shifting

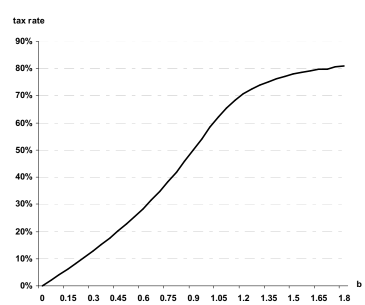
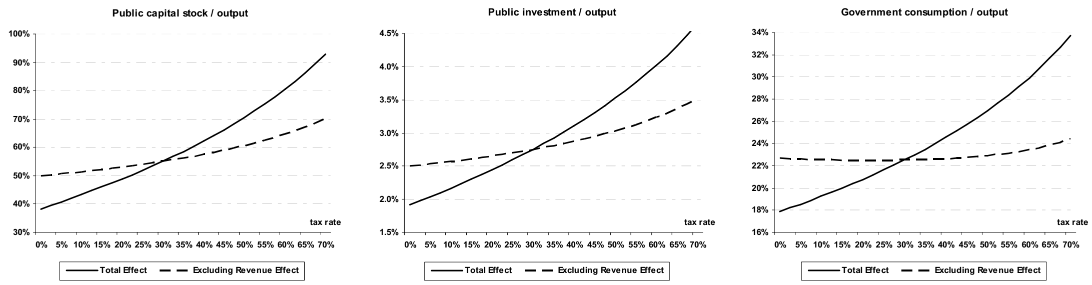


Figure 6: Corporate tax rate and the allocation of public spending



capital stock of 11% of output and a decline of public investment of 0.4% of output.

The overall effect of increasing competition can be decomposed in two: the revenue and substitution effects. On the one hand, a decline in the tax rate automatically reduces total tax receipts, thus reducing the level of public investment, as well as government consumption via the budget identity. On the other hand, reduction of the tax rate makes public investment less attractive in relation to government consumption, as discussed in the previous section. The overall decline might be, however, over-estimated because of the influence of the revenue effect. In reality, this effect is indeed likely to play a minor role since the total tax revenue derived from corporate taxation has remained relatively stable despite the fall of the statutory tax rate. In order to isolate the substitution effect in our analysis, we artificially control for the revenue effect by changing $\bar{t}$ such that total revenue is kept constant (see the dash lines in Figure 6). The decline of public capital and public investment would be slightly less than a half, 4% and 0.2% of output respectively.

Figure 7 illustrates the revenue and substitution effects. As tax rate decreases, corporate tax revenue goes down (left-hand side). In the case of extreme competition, corporate taxation disappears. The substitution effect is visible in the ratio between public investment and the general public good. As tax rates are driven to lower levels, we indeed observe a shift in the composition of public spending in favour of government consumption.

Figure 8 depicts the steady state response of some macroeconomic variables to changes in competition. The stock of private capital as well as private consumption go up with the increase in the tax competition. One might also expect that the race to the bottom of corporate tax rate always has a positive effect on total output. However, when tax rates reach very low levels, tax competition turns out to be counter-productive to the total output. The hump-shape curve displayed on the left-hand side is explained by the fact that public capital stock increases the marginal productivity of private capital. This productivity deteriorates when tax competition reduces the stock of public capital. When tax competition is strong, this negative effect cannot be compensated by the increase

Figure 7: Revenue and substitution effects

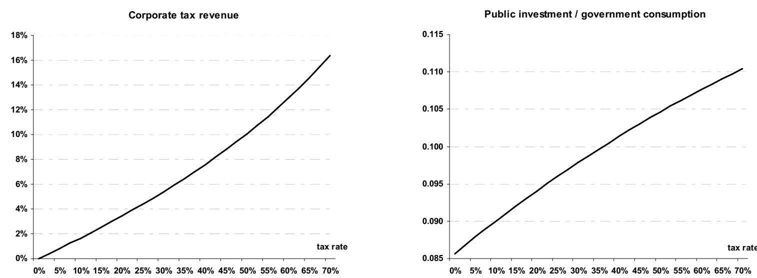
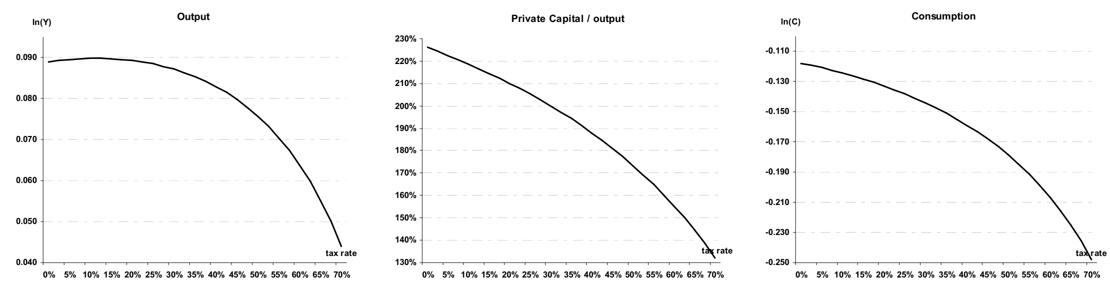


Figure 8: Effect of competition on key macroeconomic variables



in private capital. One can, therefore, observe that there exists a threshold tax rate under which corporate tax competition is harmful to production.[8]

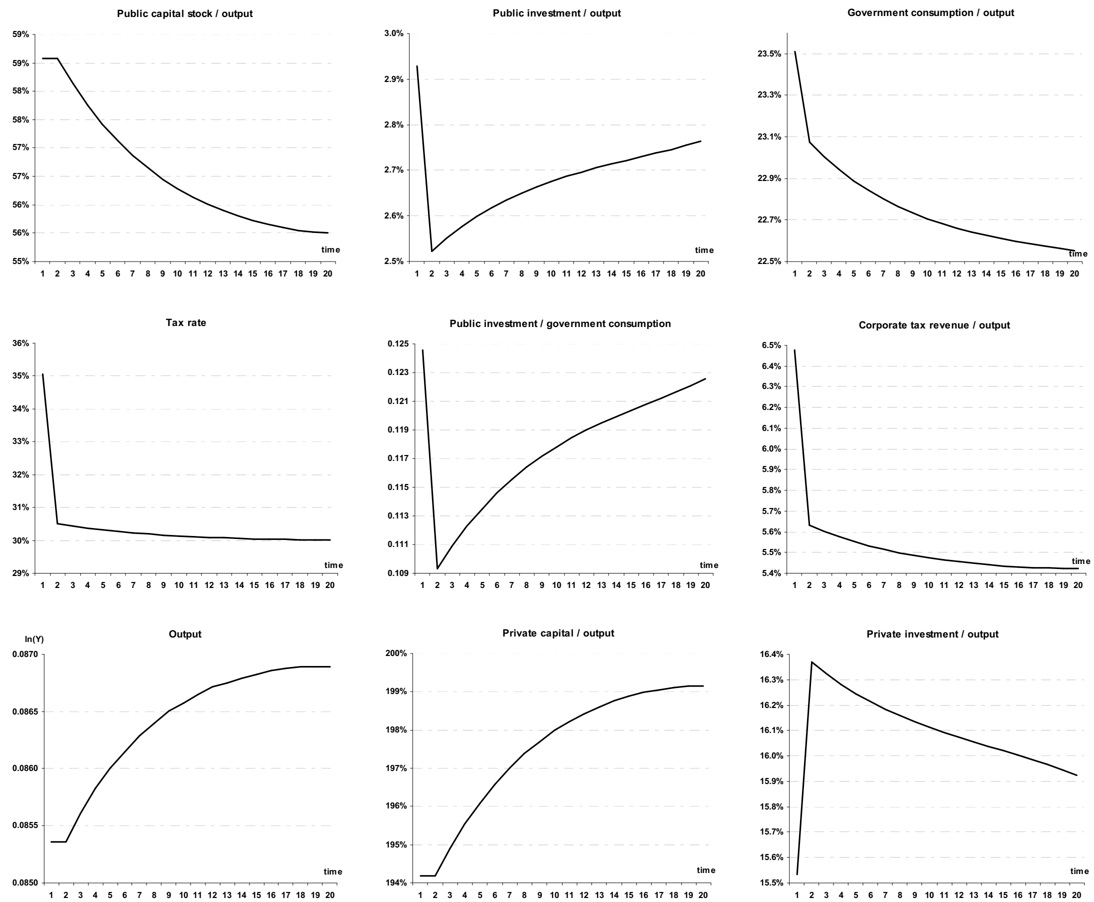
3.3 Dynamic effects of competition

Our model allows us to study the transition dynamics. We analyse how the main variables of the model respond to an increase in corporate tax rate competition from $b = 0.705$ (which implies a tax rate of 35%) to $b = 0.625$ (baseline scenario with 30% tax rate).

One can see from the Figure 9 that tax rate declines immediately close to its new steady state value once the shock occurs. Furthermore, public investment also drops sharply in response, then picks up and converges to the new steady state. Simulations show that the short run effect is roughly three times higher than the long run effect. In this particular case, a decline of the tax rate by 5% has an immediate impact on public investment of 0.41% while the long run effect is only

[8]Note that this threshold value is highly dependent on the value of the parameter θ. We do not explore this issue further as our model is not indicated for welfare analysis.

Figure 9: Response to an unanticipated permanent shock in b



0.14%. This outcome occurs because the government readjusts his optimal stock public capital in response to the decline of the tax rate. Not surprisingly, a greater degree of tax competition has a positive effect on the stock of private capital and on output.

3.4 Robustness analysis

3.4.1 Alternative calibration

Having described the main effects of corporate tax competition on our benchmark model, we now consider different realistic scenarios. For all of them, we analyze the evolution of the public capital stock, public investment and government consumption. We observe that the main conclusion of the first section is confirmed: corporate tax competition has a negative impact on the stock of

Table 2: Effects of competition under alternative parameterizations

	Public capital stock				**Public Investment**			
Parameters	$\tau = 45\%$	$\tau = 30\%$	TE	SE	$\tau = 45\%$	$\tau = 30\%$	TE	SE
1. $\theta = 0.12$	77.2%	62.6%	14.6%	5.2%	3.1%	2.5%	0.6%	0.3%
2. $\theta = 0.04$	56.5%	48.4%	8.1%	2.6%	2.3%	1.9%	0.3%	0.1%
3. $\alpha = 0.30$	65.0%	52.5%	12.4%	4.4%	2.6%	2.1%	0.5%	0.2%
4. $\alpha = 0.2$	67.2%	57.4%	9.8%	3.4%	2.7%	2.3%	0.4%	0.2%
5. $\gamma/\xi = 0.22$	76.1%	63.7%	12.4%	4.0%	3.0%	2.5%	0.5%	0.2%
6. $\gamma/\xi = 0.14$	55.7%	46.0%	9.7%	3.8%	2.2%	1.8%	0.4%	0.2%
7. $\bar{t} = 0.30$	75.1%	63.7%	11.4%	4.3%	3.0%	2.5%	0.5%	0.2%
8. $\bar{t} = 0.18$	57.1%	46.2%	10.8%	3.4%	2.3%	1.8%	0.4%	0.2%

public capital. The quantitative prediction is also quite robust. Public capital stock over GDP falls between 8% and 15% of output and public investment between 0.3% and 0.6% of output under the alternative scenarios. The substitution effect accounts for close to half of the total effect.

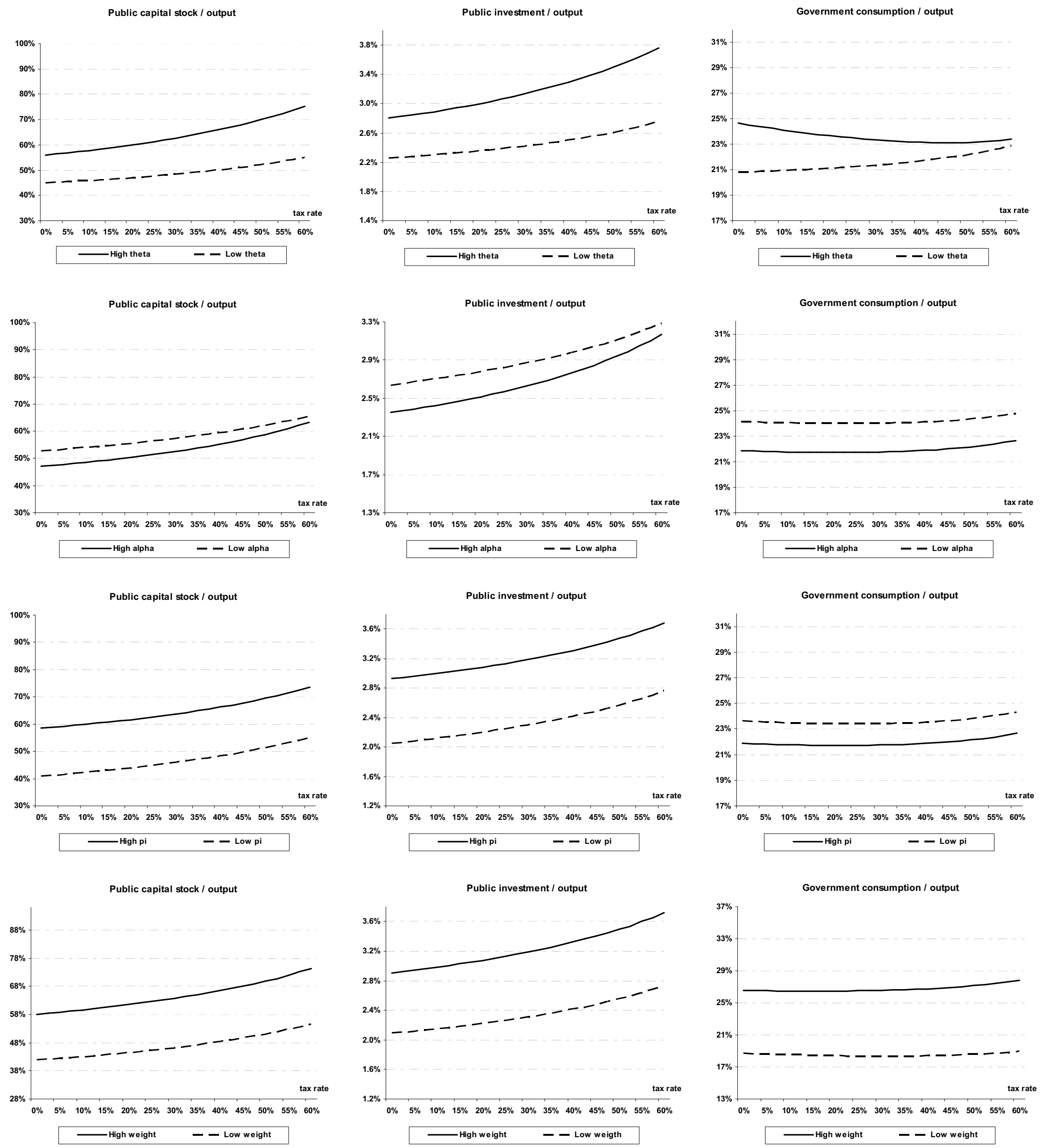
Since the value of the parameter θ has involved a lot of controversies, we test alternative values for the contribution of public capital stock on private output (scenarios 1 and 2). For this reason, and despite the fact that our calibration is in line with the recent estimations given in the literature, we simulate two extreme cases. When P^i has a minor effect on the output, the stock of public capital is lower at the steady state and exhibits a lower variability in the tax rates. By contrast, when θ is relatively high, we observe that tax competition entails a larger drop of public capital stock.

Allowing different values for α (scenarios 3 and 4) affects the substitutability between the private and the public capital. Not surprisingly, when the production process relies more on private capital, we observe a greater decline of public capital stock. Scenarios 5 and 6 describe the effect of a change of the relative preferences of the society for the two public policy dimensions. Without a doubt, the relative preferences for public capital γ/ξ has a relatively high impact on the level of public capital stock but less on its pattern. Different preferences do not affect the main mechanism of our model. Analyzing the impact of the variation of the exogenous tax rate leads to the same conclusions. The total stock of public capital increases with $\bar{t}$, whose real value is a major determinant of the scope of government. The relationship between the corporate tax rate and the stock of public capital is robust to changes in the value of the parameters.

3.4.2 Asymmetric countries

Our final exercise is to analyse the steady state values when asymmetries between the two countries are introduced. We consider two cases: asymmetries in θ and in α. The respective results are shown in Figures 11 and 12.

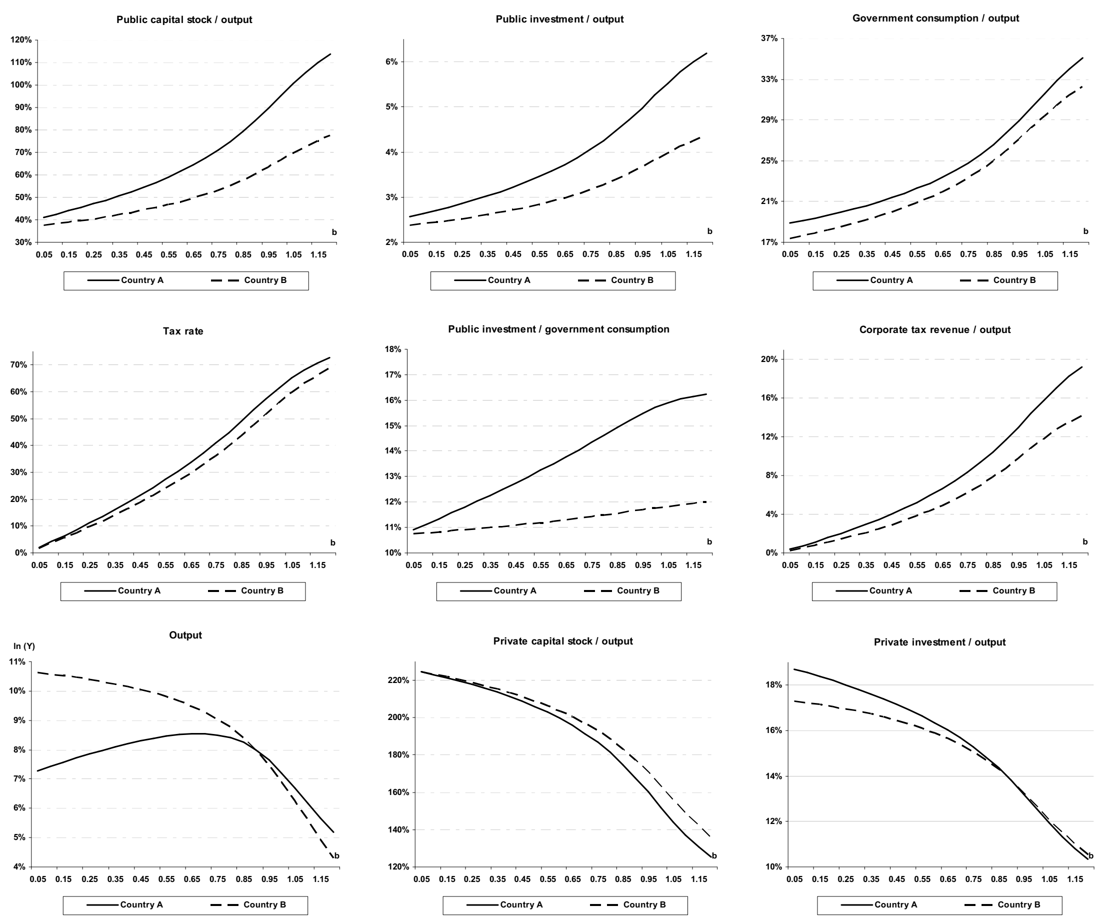
Figure 10: Robustness analysis - substitution effect



When the production of a country relies more on public capital (country A in this simulation), the government accumulates more public capital than country B. This generates higher rents for the firm in country A, so the government sets a higher tax rate. In this case, there is profit shifting from country A to county B. If the level of competition is low, then the country with high θ has a higher output than its partner, but as competition increases and tax rate declines, the negative effect in public capital is very strong and total output also declines. This suggests that for countries that depend more on public capital, corporate tax competition might induce significant welfare costs.

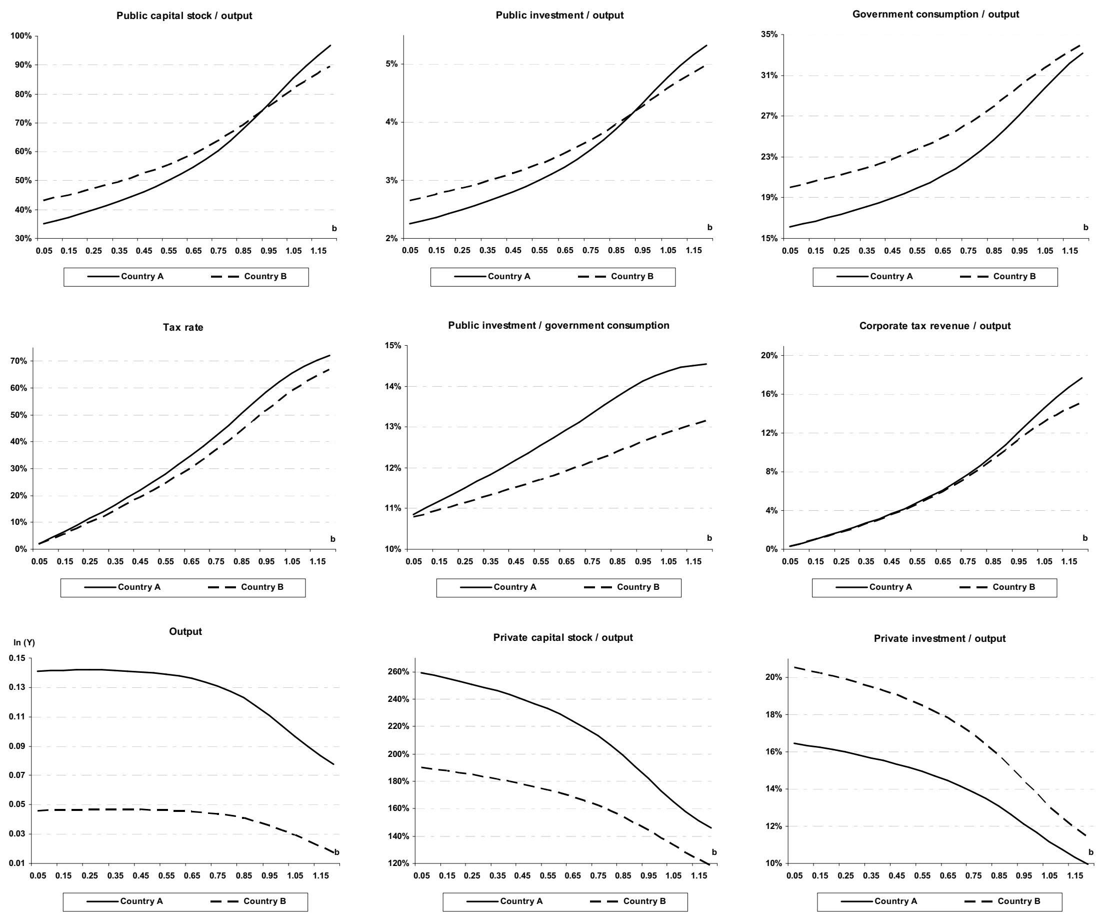
We now turn to the analysis of the case with different α's. Country A, where α is higher, has a higher capital stock and higher output than its partner. The government sets a higher tax rate for this country, so there is profit shifting to country B. It is also interesting to notice that the decline in public capital is much stronger for country A. In the absence of tax competition, it has a higher public capital stock, but when competition is more intense, its public capital stock as a share of output is lower than of the country B.

Figure 11: Asymmetric countries (elasticity of output with respect to public capital)



Country A: $\theta = 0.12$; *country B:* $\theta = 0.04$

Figure 12: Asymmetric countries (elasticity of output with respect to private capital)



Country A: $\alpha = 0.30$; country B: $\alpha = 0.22$

4 Empirical evidence

4.1 Estimation strategy

To access the validity of the main mechanism of our model, we estimate policy functions for the statutory corporate tax rate (tax_{it}) and for public investment (inv_{it}) in the spirit of Devereux, Lockwood, and Redoano (2008):

$$\begin{aligned} tax_{it} &= \alpha_1 inv_{it} + \alpha_2 tax_{it}^{rw} + \alpha_3 X_{it} + \varepsilon_i + \epsilon_{it} \\ inv_{it} &= \beta_1 tax_{it} + \beta_2 inv_{it}^{rw} + \beta_3 X_{it} + \upsilon_i + \mu_{it} \end{aligned} \tag{21}$$

We use statutory tax rate and not effective marginal tax rate. It is clear from the model that public investment depends on the statutory tax rate (the true rate of return of generating one extra unit of rents) and not on the effective marginal tax rate.[9]

Apart from the endogeneity between the two tools, we also consider the international competition element. The statutory tax rate also responds to the tax rate of the rest of the world (tax_{it}^{rw}).[10] Public investment depends on the statutory tax rate, but we also allow it to respond to the level of public investment of foreign countries (inv_{it}^{rw}). Although we do not model this element explicitly with our model, we include it to make the setting more realistic. Moreover, it allows us to identify the effect of public investment on the tax rate. In the absence of this element, it is hard to find another possible instrument for public investment. X_{it} is a vector of control variables. We estimate each equation separately using instrumental variables estimation. The system is exactly identified: each equation has one omitted variable that is used as an instrument for the endogenous variable in the other equation. For the instruments to be valid, it is crucial that the corporate tax rate does not respond to foreign public investment and public investment does not react to the foreign tax rate. Although we cannot a priori justify this assumption based on existing evidence, we can test the validity of the instruments after the estimation.

The estimation of these reaction functions, suffers from more problems of endogeneity. The tax rate and public investment of the rest of the world might react to domestic developments in the respective variables. Furthermore, some of the controls might also be endogenous to the tax rate or to public investment. To minimize these problems, we compute a 3 year non overlapping averages. Each time observation corresponds to 3 years averages. We, then, estimate these equations with all controls that might be endogenous, as well as the foreign variables entering in lags. Although we cut the sample size to one third, it still allows us to be much more confident that our estimator will be consistent.

The corporate tax and public investment of the rest of the world are weighted averages of the variables for all other countries in the sample.

$$tax_{it}^{rw} = \sum_{j=-i} w_{jt} tax_{jt}^{rw}$$

$$inv_{it}^{rw} = \sum_{j=-i} w_{jt} inv_{jt}^{rw}$$

In the reaction functions we include public investment instead of public capital. Firstly because

[9]It should be noted that the dependence of public investment on the statutory tax rate exists regardless of the level of the effective marginal tax rate. Also, this relation persists in a closed economy or in the absence of international competition.

[10]It is not our purpose to find out if the response to the foreign tax rate is due to competition for profits or for private investment

the decision variable of governments is public investment. Secondly, this way we avoid problems of non-stationarity, because both tax rate and public investment are bound between 0 and 1 and, therefore, cannot have unit roots. Similarly to Devereux, Lockwood, and Redoano (2008) we do not include lagged dependent variables.[11]

4.2 Data

We estimate the policy functions using a panel of 21 OECD countries. The variable corporate tax rate was taken from Michigan World Tax Database, and public investment was taken from Kamps (2006) and expanded with OECD data until 2005.

For robustness purposes, we use three different weights to calculate the variables for the rest of the world: uniform weights (W_1), the openness of the economy (W_2) and the population (W_3). The correlations between the three measures within a country range from 0.80 to 0.95 for both variables.

We use the following control variables: government consumption, the fiscal surplus, the degree of openness, GDP growth, the level of private capital, population growth, a dummy for election year, the % of left wing votes and a dummy if the country joined the EMU2 after 1999. Summary statistics and the source of each variable can be found in Table A1 in the data appendix.

4.3 Estimation

We estimate the policy functions using IV estimation. Given that we only have 21 countries, we model the country's specific error as fixed effect. In the estimations, we also include country specific time trends.

We consider government consumption, the fiscal surplus, the degree of openness, GDP growth, the level of private capital as potentially endogenous, so they enter the equation in lags (previous non-overlapping 3 year's average).

We estimate an unrestricted and a restricted model. The unrestricted model includes all controls. We, then, remove the non-significant variables and add them as additional controls. We test the under-identification of each equation and, in the case of the restricted models, we perform the Sargan over-identification test.

[11]In this way we can still have consistent estimates of the short run coefficients without introducing technical complications of estimating equations with lagged dependent variables in panel data. For instance, we would have to estimate the equations in differences (Arellano and Bond), which would be problematic because there would be many zeros on the left hand side. If we ignored the bias generated by the lagged dependent variable and estimated the system in levels, we would have multicollinearity problems between the (tax_{it-1}) and (tax^{rw}_{it-1}).

Table 3: Estimation results: corporate tax rate

	W1		W2		W3	
	(1)	(2)	(1)	(2)	(1)	(2)
Inv_t	2.999	2.478	15.224	2.055	4.532***	3.524***
	(0.78)	*(1.35)*	*(0.54)*	*(1.02)*	*(2.63)*	*(2.71)*
Tax_{t-1}^{rw}	0.385***	0.410***	0.342	0.454***	0.427***	0.461***
	(3.14)	*(3.74)*	*(1.05)*	*(4.18)*	*(3.45)*	*(4.29)*
$Govcons_{t-1}$	0.892*	0.858***	2.165	0.699**	0.951***	0.815***
	(1.92)	*(3.2)*	*(0.68)*	*(2.34)*	*(2.89)*	*(3.07)*
$Budget_{t-1}$	0.038		0.637		0.136	
	(0.17)		*(0.47)*		*(0.85)*	
$GDPg_{t-1}$	0.007		0.212		0.068	
	(0.03)		*(0.34)*		*(0.28)*	
$Open_{t-1}$	0.137**	0.128**	0.18	0.116*	0.115	0.105
	(2.05)	*(2.12)*	*(0.94)*	*(1.92)*	*(1.59)*	*(1.64)*
K_{t-1}	0.628		12.967		2.379	
	(0.13)		*(0.46)*		*(0.64)*	
$Popg_t$	-4.266***	-4.079***	-7.945	-3.718***	-4.514***	-4.002***
	(-2.83)	*(-4.11)*	*(-0.87)*	*(-3.65)*	*(-3.82)*	*(-4.02)*
$Election_t$	-0.255		-0.709		-0.464	
	(-0.17)		*(-0.22)*		*(-0.29)*	
$Left_t$	0.071		0.225		0.086	
	(0.82)		*(0.59)*		*(1.05)*	
Emu_t	-0.735		1.391		-0.36	
	(-0.38)		*(0.25)*		*(-0.19)*	
Country trends	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	245	245	245	245	245	245
Countries	21	21	21	21	21	21
R^2	0.67	0.69	-0.41	0.70	0.63	0.66
Underidentification test #	4.505 [0.034]	17.689 [0.014]	0.360 [0.548]	14.290 [0.046]	25.577 [0.000]	38.122 [0.000]
Sargan test &	-	1.160 [0.979]	-	2.015 [0.918]	-	1.803 [0.937]

Notes: Each observation corresponds to a 3 year average. The subscript t-1 denotes the observation of the previous 3 years. The estimation runs from 1966-1969 to 1999-2002. It includes the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. The equations are estimated using Instrumental Variables fixed effects estimation. In columns (1) the equation is exactly identify with inv_t^{rw} as instrument for inv_t. In columns (2) the non-significant variables are excluded from the equation but added as additional instruments. The t statistics are in parentheses. *, **, *** - statistically significant at the 10, 5, and 1 per cent.

The underidentification test is an LM test of whether the instruments are correlated with the endogenous regressors. The null hypothesis that the equation is underidentified. The test statistic is to be compared to a chi-square with degrees of freedom equal to the number of instruments. The p-value is in brackets.

& The null hypothesis of the Sargan overidentification test is that the instruments are uncorrelated with the error term and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as chi-squared in the number of overidentifying restrictions. The p-value is in brackets.

Table 4: Estimation results: public investment

	W1		W2		W3	
	(1)	(2)	(1)	(2)	(1)	(2)
Tax_t	0.062**	0.039*	0.066	0.069*	0.077*	0.075**
	(1.98)	*(1.73)*	*(1.57)*	*(1.9)*	*(1.92)*	*(2.00)*
Inv_{t-1}^{rw}	0.315*	0.356**	0.233	0.231	0.126	0.125
	(1.71)	*(2.13)*	*(1.38)*	*(1.48)*	*(0.44)*	*(0.44)*
$Govcons_{t-1}$	-0.164***	-0.142***	-0.173***	-0.172***	-0.166***	-0.161***
	(-4.11)	*(-4.11)*	*(-3.91)*	*(-4.06)*	*(-3.81)*	*(-3.82)*
$Budget_{t-1}$	-0.043**	-0.046***	-0.043**	-0.044**	-0.042**	-0.042**
	(-2.47)	*(-2.84)*	*(-2.44)*	*(-2.45)*	*(-2.25)*	*(-2.28)*
$GDPg_{t-1}$	-0.009		-0.01		-0.016	
	(-0.29)		*(-0.31)*		*(-0.51)*	
$Open_{t-1}$	-0.014		-0.017	-0.018*	-0.017	-0.018*
	(-1.27)		*(-1.38)*	*(-1.7)*	*(-1.57)*	*(-1.75)*
K_{t-1}	-0.711	-0.571	-0.757*	-0.712*	-0.944**	-0.865**
	(-1.63)	*(-1.53)*	*(-1.67)*	*(-1.72)*	*(-2.14)*	*(-2.11)*
$Popg_t$	0.552***	0.467***	0.581***	0.578***	0.590***	0.567***
	(3.16)	*(3.10)*	*(2.90)*	*(3.11)*	*(2.96)*	*(2.96)*
$Election_t$	0.015		0.012		0.038	
	(0.08)		*(0.06)*		*(0.18)*	
$Left_t$	-0.015	-0.013	-0.016	-0.015	-0.016	-0.015
	(-1.47)	*(-1.43)*	*(-1.52)*	*(-1.49)*	*(-1.53)*	*(-1.47)*
Emu_t	-0.068		-0.05		0.019	
	(-0.27)		*(-0.18)*		*(0.07)*	
Country trends	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	245	245	245	245	245	245
Countries	21	21	21	21	21	21
R^2	0.70	0.73	0.69	0.68	0.66	0.67
Underidentification test #	19.840 [0.000]	32.897 [0.000]	11.449 [0.001]	15.437 [0.004]	14.140 [0.000]	15.711 [0.003]
Sargan test &	-	2.865 [0.581]	-	0.151 [0.985]	-	0.304 [0.959]

Notes: Each observation corresponds to a 3 year average. The subscript t-1 denotes the observation of the previous 3 years. The estimation runs from 1966-1969 to 1999-2002. It includes the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. The equations are estimated using Instrumental Variables fixed effects estimation n columns (1) the equation is exactly identify with tax_t^{rw} as instrument for tax_t In columns (2) the non-significant variables are excluded from the equation but added as additional instruments. The t statistics are in parentheses. *, **, *** - statistically significant at the 10, 5, and 1 per cent.
The underidentification test is an LM test of whether the instruments are correlated with the endogenous regressors. The null hypothesis that the equation is underidentified. The test statistic is to be compared to a chi-square with degrees of freedom equal to the number of instruments. The p-value is in brackets.
& The null hypothesis of the Sargan overidentification test is that the instruments are uncorrelated with the error term and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as chi-squared in the number of overidentifying restrictions. The p-value is in brackets.

Table 3 and 4 shows the results. All specifications have considerable good fit with an R^2 above 0.65. Except for the unrestricted specification for the corporate tax rate using W2, all regressions pass the underindentification test, suggesting that in general, the rest of the world variables are valid instruments for the the corresponding domestic variables. Also, in all restricted specifications we conclude from the Sargan test that we do no reject the null hypothesis that the instruments are valid.

There are two important results. Firstly, there is evidence of the endogeneity between the the two variables, particularly from the corporate tax rate to the public investment. Corporate tax rate also responds positively to public investment but it is only statistically significant when we use W3 as weights. This result is consistent with our model, as the reaction function of tax rate was positive, but very flat in the stock of public capital. On the other hand, the result that public investment increases with the statutory tax rate is quite robust to different weighting procedures. The coefficient ranges from 0.04 to 0.07. For an exogenously driven reduction of 15% of the tax rate, public investment goes down between 0.6% to 1.1%.

The second result is that there is evidence for international competition particularly in the corporate tax rate. A country's tax rate responds close to 0.4% to an increase of 1% in the tax rate of the rest of the world. This is in line with values reported by Devereux, Lockwood, and Redoano (2008). For public investment, the coefficient of response to the foreign public investment is lower - between 0.2 and 0.3, but is only significant if we use uniform weights.

With respect to the control variables, government consumption, openness and population growth are, in general, significant in both equations. Private capital and fiscal surplus are only significant for public investment.

5 Concluding Remarks

The strong downward trend of the statutory corporate tax rates represents one of the most striking aspects of international competition between governments. The main objective of this paper is to point out that other consequences of corporate tax rate competition have been overlooked.

Keen and Marchand (1997) argued that tax competition might lead to *"too many business centers and airports but not enough parks or libraries"*. In fact, this statement might be inconsistent with the general decline of public capital stock that has taken place over the last two decades among many OECD countries.

By contrast, we find a negative relationship between tax competition and public capital stock. The key difference between these two results is the following. In their setting, the relation between tax rate and public capital comes from international competition. In the presence of competition, there will be a bias in favour of public investment. In our model, this relation exists even in the absence of competition. Public capital stock increases tax revenue. Because of this positive externality there is always a bias in favour of public capital. As competition drives tax rate down, this reduces the externality of public capital and governments have an incentive to reduce their supply. The robustness analysis we performed provides a strong evidence that the central mechanism of our paper remains valid. Besides, this link appears to be significant for most countries where the share of public capital stock has, indeed, decreased.

The general equilibrium analysis appears to be extremely helpful since it allows us to assess quantitatively the effects of competition. We show that tax competition leads to a reduction of both tax rate and public investment. If tax rate goes down by 15%, public investment in steady state goes down between 0.2% and 0.4% of GDP. The short run impact is three times stronger. Our empirical estimates point to slightly higher values: between 0.6% and 1.1% of GDP. Further empirical evidence indicates that there is international competition in both corporate tax rate and public investment.

Although tax competition is likely to have a negative effect on the overall supply of public goods, the traditional view considers that tax competition favours the private sector. This is indeed what we found in the baseline scenario and it is explained by the fact that a race to the bottom reduces the net cost of capital. Nevertheless, we found that it exists a threshold tax rate under which tax competition has a negative effect on total output. This threshold depends crucially on the elasticity of output with respect to public capital.

We believe that our analysis is particularly relevant for the European Union countries where enlargement is likely to put more pressure on tax rates and therefore could reinforce the downward trend of public capital stock in western European countries.

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Appendix 1 - The General Equilibrium Model

For $i = A, B$, the following equations completely describe the model:

Euler equation

$c_{t+1}^{i} = c_{t}^{i}(1 + r_{t+1})\beta$

Law of motion of capital own by households

$B_{t+1}^{i} = (1 - \delta^{p})B_{t}^{i} + I_{t}^{i}$

Production function

$y_{t}^{i} = k_{t}^{i\alpha} P_{t}^{i\theta} n_{t}^{i(1-\alpha-\theta)}$

Firm's optimal choice of capital

$\alpha k_{t}^{i\alpha-1} P_{t}^{i\theta} n_{t}^{i(1-\alpha-\theta)} = \frac{r_t}{(1-\tau_t^i)} + \delta^{p}$

Firm's optimal choice of labour

$w_{t}^{i} = (1 - \alpha - \theta)\frac{y_t^i}{n_t^i}$

Firm's optimal choice of profit shifting

$s_t = \frac{\tau_t^A - \tau_t^B}{2b}$

Government's budget constraint

$g_t^i + p_t^i = \bar{t} + \tau_t^i[y_t^i - \delta k_t^i - w_t^i \pm s_t]$

Law of motion of public capital

$P_{t+1}^{i} = (1 - \delta^{g})P_{t}^{i} + p_{t}^{i}$

Government's choice of public investment

$\frac{1}{g_t^i} = \beta\{\frac{\gamma}{\xi P_{t+1}^i} + \frac{1-\delta^g}{g_{t+1}^i} + \frac{1}{g_{t+1}^i}\tau_t^i {P_t^i}^{\frac{\theta+\alpha-1}{1-\alpha}} {n_t^i}^{\frac{1-\alpha-\theta}{1-\alpha}} \frac{\theta}{1-\alpha}[(\alpha+\theta)(\frac{\alpha(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)})^{\frac{\alpha}{1-\alpha}} - \delta^p(\frac{\alpha(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)})^{\frac{1}{1-\alpha}}]\}$

Government's optimal choice of tax rate

$\frac{\tau_t^i}{b} = \frac{\tau_t^{-i}}{2b} + {P_t^i}^{\frac{\theta}{1-\alpha}} {n_t^i}^{\frac{1-\alpha-\theta}{1-\alpha}}\{(\alpha+\theta)(\frac{\alpha(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)})^{\frac{\alpha}{1-\alpha}} - \delta^p(\frac{\alpha(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)})^{\frac{1}{1-\alpha}} + \frac{\tau_t^i}{(1-\alpha)(1-\tau_t^i)}[\frac{\alpha\delta^p(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)} -$
$\alpha)((\alpha+\theta)(\frac{\alpha(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)})^{\frac{\alpha}{1-\alpha}} - \frac{\delta^p}{\alpha}(\frac{\alpha(1-\tau_t^i)}{r_t+\delta^p(1-\tau_t^i)})^{\frac{1}{1-\alpha}}]\}$

Market clearing condition in capital market

$B_t^A + B_t^B = k_t^A + k_t^B$

Market clearing condition in goods markets

$y_t^A + y_t^B = c_t^A + c_t^B + g_t^A + g_t^B + p_t^A + p_t^B + I_t^S + I_t^B + bs_t^2$

Equation that pins out consumption in each country

$c_t^A = w_t^A + r_t B_t^A - \bar{t} + (1 - \tau_t^A)[y_t^A - \delta k_t^A - w_t^A - s_t] - r_t k_t^A - \frac{bs_t^2}{2}$

Appendix 2 - Static model with labour and profit taxation and optimal policy

In our model we simplify the government's problem by maximizing the lifetime utility of public consumption and considering only profit taxation. The purpose of this appendix is to show in that the main properties of our model hold in a broader setting. The notation is similar to the main model.

We consider here that the government maximizes the utility function of the household as described by:

$$U = \ln(c) - \delta_n \ln(n) + \delta_g \ln(g) + \delta_p \ln(p)$$

For simplicity, we ignore the durable nature of public and private capital in order to focus on the intratemporal problem. Therefore, productive spending are described by the variable p. The parameters δ_g and δ_p describe the preferences of the representative household and δ_n describes the disutility of labour. Private consumption, denoted c, depends on distortionary taxes on labour, τ^n, and corporate profit, Υ.

$$c = wn(1 - \tau^n) + \Upsilon$$

The consumer chooses the hours of work and consumption according to the following first order condition:

$$wn(1 - \tau^n) = \delta_n c$$

The corporate sector borrows capital from the outside and it has to repay it after production. The production takes place according to the following production function:

$$y = F(k, n, p) = k^\alpha p^\theta n^{1-\alpha-\theta}$$

The declared profits of the representative firm are described below. As in the main model, s represents the profit shifted to an outside country and profit shifting operations have the cost bs^2

$$\Pi = [y - wn - s]$$

The corporate section maximizes after tax profits where the amount of profit shifted will pay $\breve{\tau}^\pi$, the corporate tax of the outside country. The objective function and the first order conditions describing the behaviour of the corporate section are as follows:

$$Max\ \{\Pi_t(1 - \tau^\pi) - rk + s(1 - \breve{\tau}^\pi) - bs^2\}$$

$$\begin{cases} F_k = \frac{r}{(1-\tau^\pi)} \\ F_n = w \\ s = \frac{\tau^\pi - \breve{\tau}^\pi}{b} \end{cases}$$

In this appendix, we examine the case where the government follows an optimal policy, but has only labour and profit taxation to raise revenue. The objective function is therefore to maximize consumers utility subject to the following constraints:

$$
\begin{aligned}
g+p &= (1-\alpha-\theta)y\tau^n + (\alpha+\theta)y\tau^\pi - \frac{\tau^\pi - \breve{\tau}^\pi}{b}\tau^\pi \\
\delta_n c &= (1-\alpha-\theta)y(1-\tau^n) \\
r &= F_K(1-\tau^\pi) \\
y &= c+i+g+p-\frac{\tau^\pi-\breve{\tau}^\pi}{b}-\frac{(\tau^\pi-\breve{\tau}^\pi)^2}{b}
\end{aligned}
$$

The first constraint is the government budget constraint. The second is the consumers first order condition. The third is the firms optimality condition on capital and the final equation is the aggregate resource constraints. There are two sources of waste. One is that profits are shift to the foreign country, and the second is the cost the firm pays to shift them. The lagrangean for the government's problem is given by:

$$
L = [\ln(c) - \delta_n \ln(n) + \delta_g \ln(g) + \delta_g \ln(P)] + \Lambda^1[g_t + p_t - (1-\alpha-\theta)y\tau^n - (\alpha+\theta)y\tau^\pi + \tfrac{\tau^\pi-\breve{\tau}^\pi}{b}\tau^\pi] + \\
\Lambda^2[(1-\alpha-\theta)y(1-\tau^n) - \delta_n c] + \Lambda^3[F_K(1-\tau^\pi) - r] + \Lambda^4[c+k+g+p-\tfrac{\tau^\pi-\breve{\tau}^\pi}{b} - \tfrac{(\tau^\pi-\breve{\tau}^\pi)^2}{b} - y]
$$

The government is choosing the variables $c, n, g, p, k, \tau^n, \tau^\pi$ according to the following first order conditions:

$$
\begin{aligned}
c &: \quad \frac{1}{c} = \Lambda^2\delta_n - \Lambda^4 \\
n &: \quad -\tfrac{\delta_n}{n} - \Lambda^1[(1-\alpha-\theta)\tau^n F_N + (\alpha+\theta)F_N\tau^\pi] + \Lambda^2(1-\alpha-\theta)(1-\tau^n)F_N \\
&\qquad + \Lambda^3 F_{KN}(1-\tau^\pi) - \Lambda^4 F_N = 0 \\
g &: \quad \frac{\delta_g}{g} = -\Lambda^1 - \Lambda^4 \\
p &: \quad \tfrac{\delta_p}{p} = -\Lambda^1[1-(1-\alpha-\theta)\tau^n F_P - (\alpha+\theta)\tau^\pi F_P] - \Lambda^2[(1-\alpha-\theta)(1-\tau^n)F_P] \\
&\qquad + \Lambda^3[F_{KP}(1-\tau^\pi)] + \Lambda^4(1-F_P) = 0 \\
k &: \quad -\Lambda^1[(1-\alpha-\theta)F_K\tau^n + (\alpha+\theta)F_K\tau^\pi] + \Lambda^2[(1-\alpha-\theta)(1-\tau^n)F_K - \delta_n c] \\
&\qquad + \Lambda^3[F_{KK}(1-\tau^\pi)] + \Lambda^4[1-F_K] = 0 \\
\tau^n &: \quad \Lambda^1[(1-\alpha-\theta)y] - \Lambda^2[(1-\alpha-\theta)y] = 0 \\
\tau^\pi &: \quad \Lambda^1[-(\alpha+\theta)y + \frac{2\tau^\pi - \breve{\tau}^\pi}{b}] - \Lambda^3 F_K - \Lambda^4[\frac{2(\tau^\pi-\breve{\tau}^\pi)+1}{b}] = 0
\end{aligned}
$$

When choosing the unproductive public good, the government looks at the marginal benefit to the consumer and the marginal cost. The marginal cost consists on two elements: the resources used (Λ^4) as well as the cost in terms of distorting taxation that needs to be raised (Λ^1). When choosing the productive good, the government will consider two additional elements. As in the model presented in the main text, the government considers that the increase in productive good, increases the marginal productivity of factors, as well as profits, so it enlarges the tax base, both for corporate as well as labour income taxation. Additionally, the government considers the marginal effect on private capital (Λ^3) and that, by affecting the output it will raise total resources (Λ^4).

The tax rates are set to equate marginal cost of the distortion and the benefit of raising revenue. In the case of corporate taxation there will be two additional elements when we include the possibility of profit shifting. Governments know that when they increase corporate tax rate, part of the revenue will be lost to the other country $\Lambda^1[\frac{2\tau^\pi - \breve{\tau}^\pi}{b}]$, but besides this they know that the resources that are transfer abroad reduce the resources available to consume at home. Notice that as b or $\breve{\tau}^\pi$ declines, the optimal tax rate will go down, which will also reduce the public investment.

Appendix 3

Table A1

Variable	Description	Mean	Sd	Max	Min	Source
Inv	Public investment (% GDP)	3.499	1.504	10.09	0.770	Kamps (2006)
Tax	Top bracket corporate tax	38.21	8.730	56.41	7.148	Michigan World Tax Database
$Govcons$	Gov. consumption (% GDP)	17.66	4.511	30.14	7.325	OECD-Main Economic Indicators
$Budget$	Budget surplus (% GDP)	-2.212	3.851	18.00	-15.71	IMF- IFS
$GDPg$	GDP growth	2.778	2.639	12.48	-7.283	IMF- IFS
$Popg$	Population growth	0.660	0.569	3.799	-4.526	WB - WDI
$Open$	Openness (% GDP)	54.77	29.29	184.2	7.416	WB - WDI
$Capital$	Private capital (% GDP)	2.512	0.541	3.818	1.255	Kamps (2006)
$Left$	Left party votes (% total)	37.96	14.15	67.6	0	Comparative parties dataset
$Election$	Dummy for election year	0.316	0.465	1	0	Comparative parties dataset

Note: the comparative party dataset was created by Duane Swank and is available on http://www.mu.edu/polisci/Swank.htm.

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