# Multinational Capital Structure and Tax Competition

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## Abstract

This paper analyzes tax competition when welfare maximizing jurisdictions levy source-based corporate taxes and multinational enterprises choose tax-efficient capital-to-debt ratios. Under separate accounting, multinationals shift debt from low-tax to high-tax countries. The Nash equilibrium of the tax competition game is characterized by underprovision of publicly provided goods. Under formula apportionment, the country-specific capital-to-debt ratio of a multinational's affiliate is independent of the jurisdiction's tax rate. Public good provision is either too large or too small. If the debt externality is not negative, there is clearly underprovision under formula apportionment.


JEL-Code: F23, H25, H42, H73.

Keywords: multinational enterprises, financial policy, profit shifting, corporate taxation, tax competition.

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# 1 Introduction

Economic theory and empirical evidence suggest that multinationals shift profits from high-tax to low-tax countries, especially by means of debt financing and transfer pricing. There is convincing evidence from micro data that profit shifting is sizeable (see, e.g., Mintz and Smart, 2004; Devereux, 2006; Dischinger, 2007; Weichenrieder, 2009) and that it implies a significant loss in tax revenue for high-tax countries (see Huizinga and Laeven, 2008). In the past, literature on income shifting focussed on transfer pricing, but more recently Mintz and Smart (2004), Huizinga, Laeven, and Nicodeme (2008), Schindler and Schjelderup (2008) and Haufler and Runkel (2009) have developed theoretical models of the tax-efficient debt financial policies of multinationals. Desai, Foley, and Hines (2004) discovered that U.S. multinationals alter the overall level and composition of debt in response to tax incentives, internal finance being particularly sensitive to tax differences. Huizinga, Laeven, and Nicodeme (2008) observe for European multinational firms that the leverage ratio is more sensitive to taxation on account of international debt shifting than it is for stand-alone domestic firms. Egger, Eggert, Keuschnigg, and Winner (2009) find that foreign-owned European firms on average exhibit a significantly higher debt ratio than their domestically owned counterparts in the host country and that the gap in the debt ratio increases with the host country's statutory corporate tax rate.

Governments respond to income shifting behavior by changing the tax code and the tax rate. Haufler and Schjelderup (2000) argue that income shifting may induce governments to eliminate investment allowances in an effort to offset revenue losses, thus increasing the effective tax rates on capital. Mintz and Smart (2004) and Hong and Smart (2007) point out that international tax planning may reduce tax burdens on mobile capital and so facilitate investment that can offset the negative consequences of lost revenue. This conjecture is empirically confirmed by Overesch (2009) who, based on a panel of German inbound investments, finds a positive tax response of real investments with a decreasing tax rate in the foreign direct investor's home country. In response to sizeable profit shifting, the European Commission suggested a transition from separate accounting to a common tax base and formula apportionment (see European Commission, 2001). Although the idea seems like a good one at first glance, since its inception the proposed benefits, namely a reduction in compliance costs, tax planning, and tax competition, have been seriously challenged (see, for an overview, Fuest, 2008).

Ever since Zodrow and Mieszkowski (1986), it is well known that tax competition leads to underprovision of public goods when jurisdictions cannot use the full set of tax instruments. When firms can shift profits from high-tax to low-tax countries without relocating capital, tax rates may be too high (see Eichner and Runkel, 2008; Nielsen, Raimondos-Moeller, and Schjelderup, 2010). Harmonizing the tax base and employing formula apportionment does not solve the problem of inefficient public good supply. Scholars reach various conclusions as to whether there is under- or overprovision under formula apportionment. According to Nielsen, Raimondos-Moeller, and Schjelderup (2010), the positive fiscal externality of taxation and the negative aggregate investment externality are responsible for this ambiguity. Pethig and Wagener (2007) argue that equilibrium tax rates are too low for property-share apportionment but tend to be too high for other formulas. Eichner and Runkel (2008) unambiguously find underprovision. Kolmar and Wagener (2007) claim that tax competition leads to suboptimally low tax rates if and only if the investment elasticity of the tax base is lower than the investment elasticity of the apportionment factor. When jurisdictions can appropriately tax residents, tax competition does not distort the public good supply. This has been shown for the standard model of tax competition by Bucovetsky and Wilson (1991) and has been confirmed for formula apportionment by Eggert and Schjelderup (2003).

This paper aims at extending previous analyses of corporate tax competition under separate accounting and formula apportionment when firms are able to shift profits from high-tax to low-tax countries via debt financing. It sets up a many-region general equilibrium model of multinational firms that make decisions regarding employment, investment, and leverage ratios. The symmetric Nash equilibrium of welfare-maximizing countries engaged in corporate tax competition is analyzed. In the main part of the paper, only external debt is considered. By external borrowing, firms benefit from the tax shield of interest deduction. However, implicitly even external borrowing involves profit shifting, since an increase in one country's tax rate decreases the common interest rate and, therefore, the value of the tax shield in any other country. This leads the subsidiaries in in the other countries to reduce borrowing. As a consequence, ceteris paribus taxable profits in other countries increase relative to the profit in the country where the tax rate has been increased. However, as an extension of the basic model, internal debt is added to the set of the firm's instruments. However, since external and internal debt are close substitutes, internal debt does not affect the main results qualitatively.

The approach of this contribution differs from the extant literature on tax competition in several ways:

1. In contrast to most papers on this topic which assume revenue-maximizing governments (see, e.g., Pethig and Wagener, 2007; Kolmar and Wagener, 2007; Eichner and Runkel, 2008), this paper analyzes the strategies of welfare-maximizing governments. Private consumption effects, as well as revenue effects, are considered.

2. Previous papers on corporate tax competition considers decreasing returns to scale technology (see, e.g., Pethig and Wagener, 2007; Eichner and Runkel, 2008); however, this paper assumes linearly homogeneous production functions. Since corporate taxes are distorting as long as equity is not fully deductible, even with constant returns to scale economic profits are non-zero.

3. Following Eichner and Runkel (2008), the total stock of capital is fixed, but the return to capital is endogenous. Most other papers consider the small-country case where the return to capital is exogenous (see, e.g., Wellisch, 2004; Pethig and Wagener, 2007; Pinto, 2007; Riedel and Runkel, 2007; Nielsen, Raimondos-Moeller, and Schjelderup, 2010).

4. Most papers treat profit shifting as an additive-separable component of profits (see, e.g., Riedel and Runkel, 2007; Eichner and Runkel, 2008). This paper takes a different approach by explicitly modeling the debt policy of multinationals where debt is an implicit profit shifting device leading to complex interactions with investment.

In short, this paper sets up a more general model than do previous papers. The main results can be summarized as the following:

1. Symmetric Nash equilibria of tax competition games are generically inefficient under separate accounting as well as under formula apportionment.

2. Tax competition under separate accounting always leads to underprovision of public goods; however, overprovision cannot be ruled out under formula apportionment. Nevertheless, under apportionment, underprovision will occur unambiguously when a unilateral tax rate increase reduces debt in neighboring countries, thereby increasing the neighbors' tax base.

3. If leverage ratios are exogenously given, underprovision is the unambiguous outcome of tax competition even under formula apportionment.

Pinto (2007) and Nielsen, Raimondos-Moeller, and Schjelderup (2010) analyze tax competition in a small, open federation framework where governments maximize the welfare of their citizens. Pinto (2007) focuses on formula apportionment only. Nielsen, Raimondos-Moeller, and Schjelderup (2010) compare separate accounting and formula apportionment using a rather simple profit-shifting mechanism and consider only capital-share-based formulas; they could not establish underprovision under separate accounting. Furthermore, Nielsen, Raimondos-Moeller, and Schjelderup (2010) do not consider locally captured income in their welfare analysis.

The paper is organized as follows. Section 2 develops the basic model and describes its general features. Sections 3 and 4 analyze market equilibria and equilibria of the tax competition game under separate accounting and formula apportionment, respectively. Section 5 discusses the results by comparing them briefly, on the one hand, with the benchmark without profit shifting and, on the other hand, with the policy outcome when internal debt is explicitly modeled. Section 6 concludes.

## 2 The model

I consider an economy having $n$ identical jurisdictions, with $n \geq 2$, where the population in each jurisdiction is normalized to 1. There are a great many identical multinational enterprises (MNEs) operating a plant in each jurisdiction. These firms produce a private good with a constant returns to scale technology. Since the production function is linearly homogenous, the number of firms and output per firm are indeterminate. Without loss of generality, I proceed as if the total output is produced by a single representative MNE that behaves competitively. It employs $K_i$ units of capital and $L_i$ units of labor in jurisdiction $i$ to produce $F(K_i, L_i)$ units of output whose price is normalized to 1. Marginal productivity of any input is positive and decreasing: $F_K > 0$, $F_L > 0$, $F_{KK} < 0$, and $F_{LL} < 0$.[1] Since the production function is linearly homogenous, $F = F_K K + F_L L$ and $F_{KL} = -F_{KK}K/L > 0$. By assuming that marginal products of capital become rather large when capital intensity approaches 0, it is ensured that the MNE will indeed produce in all jurisdictions. For example, the Inada conditions would guarantee this. The wage in jurisdiction $i$ is denoted by $w_i$; the common return to capital by $r$.

The MNE maximizes total profits net of corporate taxes, $\Pi$. Each jurisdiction levies a source-based tax on corporate income while exempting foreign-source income of domestic residents. The firm finances investment with equity $E_i$ and debt $D_i$: $K_i = E_i + D_i$, the debt-to-capital ratio in jurisdiction $i$ is denoted $\alpha_i = D_i/K_i$. Equity is not deductible, but debt is fully deductible from tax liabilities in every jurisdiction. In accordance with most of the literature, I assume that costs per unit of capital $C(\alpha_i)$ are associated with borrowing, with $C(0) = C'(0) = 0$, $C'(\alpha_i) \geq 0$, $C''(\alpha_i) > 0$, and $\lim_{\alpha \to 1} C'(\alpha) = \infty$. These costs reflect increasing bankruptcy risks and bankruptcy costs.[2] In my basic model, all debt is external debt; internal debt is discussed as an extension. However, regardless of whether debt is internal or external, the MNE will shift debt toward high-tax countries, as will be shown later. The economic profit in jurisdiction $i$ is output minus labor costs and capital costs including borrowing costs:

$$\pi_i = F(K_i, L_i) - w_i L_i - [r + C(\alpha_i)]K_i, \qquad i = 1, \ldots, n. \tag{1}$$

Taxable profits in jurisdiction $i$ differ from economic profits, since only borrowing costs are deductible:

$$\pi_i^t = F(K_i, L_i) - w_i L_i - r\alpha_i K_i, \qquad i = 1, \ldots, n. \tag{2}$$

In this model, I assume without loss of generality that borrowing costs are not tax deductible. Including borrowing costs in the tax base would not change the results qualita-

[1] Partial derivatives are indicated by a subscript.

[2] In my model, the optimum leverage ratio in a tax-free world would be 0. I could easily introduce a strictly positive benchmark leverage ratio without affecting qualitative results, see Schindler and Schjelderup (2008) and Haufler and Runkel (2009).

tively.

Capital is perfectly mobile, labor is inelastically supplied and perfectly immobile. Each jurisdiction is endowed with $\bar{K}$ units of capital and $\bar{L}$ units of labor. The common return to capital $r$ is determined so as to clear the capital market in all jurisdictions; the wage $w_i$ clears the labor market in jurisdiction $i$. The capital market clearing condition is

$$\sum_{i=1}^{n} \left(K_i - \bar{K}\right) = 0, \tag{3}$$

the labor markets clear at

$$L_i - \bar{L} = 0, \qquad i = 1, \ldots, n. \tag{4}$$

The representative individual in jurisdiction $i$ derives utility from private consumption $X_i$ and a publicly provided good $G_i$. The utility function $U(X_i, G_i)$ exhibits positive and diminishing marginal utilities and is strictly quasi-concave. To exclude corner solutions, I assume that marginal utilities are sufficiently large when private and public consumption approaches 0. The representative individual in jurisdiction $i$ owns one share of the MNE, and earns capital and labor income. The budget constraint reads:

$$X_i = \frac{\Pi}{n} + r\bar{K} + w_i\bar{L}, \qquad i = 1, \ldots, n. \tag{5}$$

The government of jurisdiction $i$ pays for the provision of good $G_i$ with its tax revenue $T_i$. The marginal rate of transformation between the private and the publicly provided good is constant and normalized to 1: $G_i = T_i$. National governments set tax rates non-cooperatively to maximize the welfare of their citizens $U(X_i, G_i)$. The timing is as follows:

1. National governments simultaneously set tax rates $t_i$, $0 \leq t_i \leq 1$, $i = 1, \ldots, n$.

2. National wages and the common interest rate are determined such that the MNE maximizes its profits through choice of labor demand, capital demand, and debt, and markets clear.

Nash equilibria are determined by the government's first-order conditions:

$$\frac{\partial U(X_i, G_i)}{\partial X_i} \frac{dX_i}{dt_i} + \frac{\partial U(X_i, G_i)}{\partial G_i} \frac{dT_i}{dt_i} = 0, \qquad i = 1, \ldots, n. \tag{6}$$

The marginal rate of substitution between private and public consumption is equal to the perceived marginal rate of transformation:

$$\frac{\partial U(X_i, G_i)/\partial G_i}{\partial U(X_i, G_i)/\partial X_i} = -\frac{dX_i/dt_i}{dT_i/dt_i}, \qquad i = 1, \ldots, n. \tag{7}$$

I focus only on symmetric Nash equilibria of the tax-competition game where all jurisdictions set the same tax rate. A symmetric equilibrium is characterized by $K_i = K$, $L_i = L$, $w_i = w$, $D_i = D$, $\alpha_i = \alpha$, $t_i = t$, $X_i = X$, and $G_i = G$, for $i = 1, \ldots, n$.

Unilateral tax rate changes give rise to two types of externalities, a private consumption externality (PCE) and a public good externality (PGE):

$$\text{PCE} = (n-1)\frac{dX_j}{dt_i} \quad \text{and} \quad \text{PGE} = (n-1)\frac{dT_j}{dt_i}. \tag{8}$$

# 3 Separate accounting

**Market equilibrium** Under separate accounting, the tax base in jurisdiction $i$ is the taxable profit $\pi_i^t$. The MNE solves

$$\max_{K_i, L_i, D_i} \Pi^{SA} := \sum_{j=1}^{n} \left(\pi_j - t_j \pi_j^t\right) \quad \text{s.t. } E_i \geq 0, \quad i = 1, \ldots, n. \tag{9}$$

Since the marginal costs of borrowing approach infinity as the debt-to-capital ratio approaches 1, the non-negativity constraints will never be binding. The market equilibrium is characterized by the first-order conditions with respect to labor demand, debt, and investment for $i = 1, \ldots, n$

$$F_L(K_i, L_i) - w_i = 0, \tag{10}$$

$$t_i r - C'(\alpha_i) = 0, \tag{11}$$

$$(1 - t_i) F_K(K_i, L_i) - r - C(\alpha_i) + \alpha_i C'(\alpha_i) = 0, \tag{12}$$

and the market-clearing conditions of Equations (3) and (4). Since labor costs are fully deductible, the marginal product of labor is equal to the wage rate. The firm's affiliate increases debt until marginal costs of borrowing are equal to tax refunds. Rewriting Equation (12) and using Equation (11),

$$F_K^i = r\,\frac{1 - \alpha_i t_i}{1 - t_i} + \frac{C(\alpha_i)}{1 - t_i} > r, \tag{13}$$

it is obvious that the user cost of capital exceed the return to capital $r$; thus there are incentives to underinvest. Holding the return to capital fixed, and taking Equation (11) into account by setting $d\alpha_i/dt_i = r/C''(\alpha_i)$, it follows that $dF_K^i/dt_i > 0$. Underinvestment is more severe in high-tax countries than in low-tax countries.

Plugging first-order conditions into the definitions for profits and taking linear homogeneity into account yields

$$\pi_i = t_i \pi_i^t, \quad \text{and} \quad \pi_i^t = (F_K^i - \alpha_i r)K_i, \qquad i = 1, \ldots, n. \tag{14}$$

Economic profits and taxable profits are non-zero, since the rental rate of capital $r$ falls short of the user cost of capital $F_K^i$. However, as a consequence of constant returns to scale, profits net of corporate taxes are zero in every jurisdiction.

From the first-order conditions and the market clearing conditions, the impact of taxation on investment, borrowing, wages, and the interest rate can be calculated in a symmetric equilibrium for $i = 1, \ldots, n$ and $j \neq i$:

$$\begin{aligned}
&\frac{dK_j}{dt_i} = -\frac{F_K - \alpha r}{n(1-t)F_{KK}} > 0, \qquad \frac{dK_i}{dt_i} = -(n-1)\frac{dK_j}{dt_i} < 0, \\
&\frac{dw_j}{dt_i} = \frac{(F_K - \alpha r)K}{n(1-t)L} > 0, \qquad \frac{dw_i}{dt_i} = -(n-1)\frac{dw_j}{dt_i} < 0, \\
&\frac{dr}{dt_i} = -\frac{F_K - \alpha r}{n(1-\alpha t)} < 0, \qquad \frac{d\alpha_j}{dt_i} = \frac{t}{C''}\frac{dr}{dt_i} < 0, \qquad \frac{d\alpha_i}{dt_i} = \frac{1}{C''}\left(t\,\frac{dr}{dt_i} + r\right), \\
&\frac{d(nD)}{dt_i} = \frac{1}{C''}\left(nt\,\frac{dr}{dt_i} + r\right).
\end{aligned} \tag{15}$$

In response to an increase in one country's tax rate, firms shift capital abroad, which, due to labor-capital complementarity, reduces wages in the country that raised taxes and increases wages abroad. The increase in the tax rate also implies higher user cost of capital, which mitigates investment incentives and, eventually, reduces the return to capital. A lower return to capital reduces tax savings abroad and, thus, the debt-to-capital ratio. In the country that raised taxes, the MNE will raise the debt-to-capital ratio if direct tax savings exceed the dampening interest rate effect, an effect that becomes more likely as the number of countries involved increases. Total debt $nD$ will shrink in response to a unilateral increase in the tax rate if and only if the tax-rate elasticity of the interest rate, $\eta := -(dr/dt_i)(t/r)$ is larger than $1/n$ which is equivalent to $t > r/F_k$. Hence, if the tax rate is large relative to the ratio of the interest rate and the user cost of capital, for the economy as a whole interest-rate reduction dominates the direct tax rate effect. Note that this condition is independent of the number of countries $n$.

**Tax competition** Since profits are zero, individual income effectively consists only of capital and labor income, $X_i = r\bar{K} + w_i\bar{L}$. Hence, the impact of a unilateral tax rate increase on private consumption is given by

$$\frac{dX_i}{dt_i} = \frac{dr}{dt_i}\bar{K} + \frac{dw_i}{dt_i}\bar{L} = \frac{K(F_K - \alpha r)[t(1-\alpha) - n(1-\alpha t)]}{n(1-t)(1-\alpha t)} < 0, \qquad i = 1, \ldots, n, \quad (16)$$

where symmetry is taken into account. Furthermore, tax revenue in jurisdiction $i$ is

$$T_i = t_i K_i [F_K(K_i, L_i) - \alpha_i r], \qquad i = 1, \ldots, n, \quad (17)$$

implying in a symmetric set-up

$$\frac{dT_i}{dt_i} = (F_K - \alpha r)\left(K + t\frac{dK_i}{dt_i}\right) + tK\left(F_{KK}\frac{dK_i}{dt_i} - \alpha\frac{dr}{dt_i} - r\frac{d\alpha_i}{dt_i}\right), \qquad i = 1, \ldots, n. \quad (18)$$

Inserting and rearranging leads to

$$\frac{dT_i}{dt_i} = \frac{\Psi}{C'' F_{KK} n(1-t)(1-\alpha t)}, \qquad i = 1, \ldots, n, \quad (19)$$

where

$$\begin{aligned}\Psi = {} & F_{KK}Kr(1-t)t[(F_K - \alpha r)t - nr(1-\alpha t)] \quad (20)\\ & + C''(F_K - \alpha r)\{(n-1)(F_K - \alpha r)t(1-\alpha t) + F_{KK}K[n(1-\alpha t) - (1-\alpha)t]\}.\end{aligned}$$

Since $dX_i, dt_i < 0$, the Nash equilibrium is at the left-hand side of the perceived Laffer curve where $\Psi$ must be negative. Equations (16) and (19), together with Equations (6), determine the Nash equilibrium of tax competition under separate accounting. To discover whether jurisdictions would benefit from cooperating on tax rates, I determine the impact of coordinated tax rate changes for $i = 1, \ldots, n$:

$$\frac{dX_i}{dt_i} + (n-1)\frac{dX_i}{dt_j} = n\frac{dr}{dt_i}\bar{K}, \quad (21)$$

$$\frac{dT_i}{dt_i} + (n-1)\frac{dT_i}{dt_j} = (F_K - \alpha r)K - tK\left[n\alpha\frac{dr}{dt_i} + r\left(\frac{d\alpha_i}{dt_i} + (n-1)\frac{d\alpha_i}{dt_j}\right)\right]. \quad (22)$$

This implies a marginal rate of transformation under symmetric changes of

$$-\frac{dX_i/dt_i + (n-1)dX_i/dt_j}{dT_i/dt_i + (n-1)dT_i/dt_j} = \frac{C''(F_K - \alpha r)}{C''(F_K - \alpha r) + rt(F_K t - r)}. \tag{23}$$

The real transformation curve under symmetry is independent of the number of countries. Furthermore, the marginal rate of transformation is larger than 1 if $r > F_K t \Leftrightarrow \eta < 1/n$, that is, when coordinated tax rate increases raise total debt. In this case, higher borrowing costs are associated with increasing tax rates and public good quantities. For tax rates close to 0, this inequality should always be fulfilled. When, on the other hand, an increase in all tax rates weakens borrowing incentives, extending the public sector saves borrowing costs. Marginal costs of publicly provided goods are below pure production costs.

Since the marginal rate of transformation under symmetric coordinated changes, Equation (23), and $(dX_i/dt_i)/(dT_i/dti)$ do not coincide, the outcome of tax competition is inefficient. The private consumption externality

$$\text{PCE}^{SA} = \frac{(1-\alpha)K(n-1)(F_K - \alpha r)t}{n(1-t)(1-\alpha t)} \tag{24}$$

is positive, but the public good externality $\text{PGE}^{SA}$ is ambiguous in sign. On the one hand, a unilateral tax rate increase raises the stock of capital abroad and reduces tax deductions in other countries by reducing the interest rate and the leverage ratio. On the other hand, an increase in country i's tax rate by shifting capital abroad reduces the marginal product of capital in all other countries, thereby reducing the tax base. The latter effect turns out be sufficiently small. Further calculations show that

$$\begin{aligned} &-\frac{dX_i/dt_i}{dT_i/dt_i} - \left[ -\frac{dX_i/dt_i + (n-1)dX_i/dt_j}{dT_i/dt_i + (n-1)dT_i/dt_j} \right] \\ &= -\frac{C''(n-1)(F_K - \alpha r)t(1-\alpha t)(C''(F_K - \alpha r)^2 + F_{KK}Kr(r - F_K)t))}{\Psi[C''(F_K - \alpha r) + rt(F_K t - r)]}. \end{aligned} \tag{25}$$

Taking into account that $\Psi$ is negative, the whole term is positive provided that the marginal rate of transformation under symmetric coordinated changes is positive. However, the Nash equilibrium must be on the left-hand side of the Laffer curve, since otherwise Equation (40) would be negative, implying that each jurisdiction taxes on the downward-sloping part of the perceived Laffer curve, which would contradict the assumption of welfare-maximizing behavior. Hence, the perceived marginal rate of transformation exceeds the true marginal rate of transformation. As a consequence, all jurisdictions would

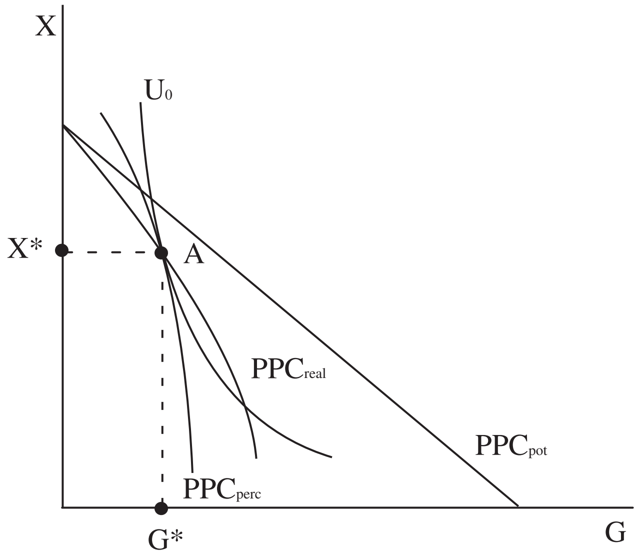


Figure 1: Underprovision of publicly provided goods

benefit from coordinated increases in tax rates and publicly provided good. The proposition summarizes this result:

**Proposition 1** *Under separate accounting, the symmetric Nash equilibrium of tax competition is characterized by underprovision of publicly provided goods. All jurisdictions would benefit from small increases in tax rates and public good quantities.*

The findings are illustrated by Figure 1. The figure shows private and public good quantities in a representative jurisdiction in the full symmetric setting. The potential production possibility curve is depicted as $\text{PPC}_{pot}$ with slope $-1$ and would be attainable under a hypothetical fully efficient tax system. However, since costs of equity are not deductible under corporate taxation, even with full coordination, the production possibility curve lies below the potential curve. The transformation curve under coordination is labeled $\text{PPC}_{real}$. In the tax competition game, non-cooperatively taxing governments perceive higher marginal costs of tax rate increases, since they expect capital flight and other financial reactions in response to unilateral tax changes. The perceived transformation curve is indicated by $\text{PPC}_{perc}$. Equation (40) shows that the perceived transformation curve is steeper than the real transformation curve, as shown in Figure 1. The symmetric

Nash equilibrium $(X^*, G^*)$, where the perceived transformation curve and an indifference curve have the same slope, clearly lies on the real production possibility curve. Starting at this equilibrium, jurisdictions would benefit from moving along the real production possibility curve toward a larger quantity of publicly provided goods. In Figure 1 it is assumed that the real production possibility curve is always steeper than the potential production possibility curve, but this would only hold when coordinated tax rate changes increase total borrowing. However, allowing for convex parts of the production possibility curve would not have any qualitative effect on the underprovision result.

# 4 Formula apportionment

**Market equilibrium** Under formula apportionment, the MNE faces a uniform tax rate $\tau$ independent of investment location. Hence, it solves

$$\max_{K_i, L_i, D_i} \Pi^{FA} := \sum_{j=1}^{n} \left(\pi_j - \tau \pi_j^t\right) \quad \text{s.t. } E_i \geq 0, \quad i = 1, \ldots, n. \tag{26}$$

Tax bases are consolidated and distributed to jurisdictions according to a formula based on the capital share $K_i / \sum_j K_j$, the sales share $F(K_i, L_i) / \sum_j F(K_j, L_j)$, and the payroll share $w_i \bar{L} / \sum_j w_j \bar{L}$. Jurisdiction i's share in the total tax base is

$$S^i = \gamma \frac{K_i}{\sum_j K_j} + \sigma \frac{F(K_i, L_i)}{\sum_j F(K_j, L_j)} + \phi \frac{w_i \bar{L}}{\sum_j w_j \bar{L}}, \quad i = 1, \ldots, n. \tag{27}$$

The weights of the capital share, the sales share and the payroll share sum up to 1: $\gamma + \sigma + \phi = 1$. Hence, the jurisdictions' shares also sum up to 1: $\sum_j S^j = 1$. The MNE's effective tax rate is

$$\tau = \sum_{j=1}^{n} t_j S^j = t_i + \sum_{j \neq i} (t_j - t_i) S^j. \tag{28}$$

The first-order conditions of the MNE's optimization problem are for $i = 1, \ldots, n$

$$(1 - \tau) \left[F_L(K_i, L_i) - w_i\right] + \sum_{j \neq i} (t_i - t_j) S^j_{L_i} \sum_{k=1}^{n} \pi_k^t = 0, \tag{29}$$

$$\tau r - C'(\alpha_i) = 0, \tag{30}$$

$$(1 - \tau) F_K(K_i, L_i) - r - C(\alpha_i) + \alpha_i C'(\alpha_i) + \sum_{j \neq i} (t_i - t_j) S^j_{K_i} \sum_{k=1}^{n} \pi_k^t = 0. \tag{31}$$

Since the effective tax rate is independent of the jurisdiction, the optimum debt-to-capital ratio $\alpha$ is the same in all jurisdictions. In its decision regarding labor and capital, the MNE takes into consideration that changes in employment and capital stock affect tax base shares and, therefore, the effective tax rate. High tax rates reduce marginal benefits of employment and investment.

In a symmetric equilibrium $\tau = t_i = t$, $S^i = 1/n$, $S^i_{L_j} = -(\phi/L + \sigma F_L/F)/n^2 < 0$, $S^i_{K_j} = -(\gamma/K + \sigma F_K/F)/n^2 < 0$, $S^i_{L_i} = -(n-1)S^i_{L_j}$, and $S^i_{K_i} = -(n-1)S^i_{K_j}$. Using symmetry, the first-order conditions and the market-clearing conditions imply that unilateral tax rate changes affect the interest rate and national wages just as they do under separate accounting. Hence, $dr/dti$, $dw_i/dt_i$, and $dw_i/dt_j$ are determined by Equation (15).[3] The remaining comparative statics in a symmetric set-up are for $i = 1, \ldots, n$ and $j \neq i$

$$\frac{dK_j}{dt_i} = -\frac{F_K - \alpha r}{n(1-t)KF_{KK}} \left(\gamma + \sigma \frac{F_K K}{F}\right) > 0, \qquad \frac{dK_i}{dt_i} = -(n-1)\frac{dK_j}{dt_i} < 0, \quad (32)$$

$$\frac{d\alpha}{dt_i} = \frac{r - F_K t}{n(1-\alpha t)C''}.$$

If and only if $r > F_K t \Leftrightarrow \eta < 1/n$, a unilateral tax rate increase increases the uniform debt-to-capital ratio and therefore total debt. A negative debt externality would be associated with an increase in one jurisdiction's tax rate. The MNE would lower debt and, therefore, tax liabilities in other jurisdictions provided that interest rate changes do not overcompensate.

Plugging first-order conditions into the definitions for profits and taking linear homogeneity into account, yields

$$\pi_i = \tau(F^i_K - \alpha r)K_i + \sum_{j\neq i}(t_j - t_i)\left(\frac{S^j_{L_i} L_i}{1-\tau} + S^j_{K_i} K_i\right)\sum_{k=1}^{n} \pi^t_k, \quad i = 1, \ldots, n, \quad (33)$$

$$\pi^t_i = (F^i_K - \alpha r)K_i + \sum_{j\neq i}(t_j - t_i)\frac{S^j_{L_i} L_i}{1-\tau}\sum_{k=1}^{n} \pi^t_k, \quad i = 1, \ldots, n.$$

Economic and taxable profits are non-zero; outside a symmetric equilibrium, even net profits per country are not zero. However, it can be shown that total net profits $\Pi^{FA}$ are zero. Profits and losses cancel out. Hence, even under formula apportionment, individual income consists only of capital and labor income.

[3] Wages react differently in the model of Eichner and Runkel (2008) because their production function is subject to decreasing returns to scale.

**Tax competition** Since unilateral tax rate changes affect the common interest rate and national wages under formula apportionment exactly as they do under separate accounting, the impact of a single country's tax rate change on its private consumption, i.e., $dX_i/dt_i$, is the same under both tax systems. Hence, if there is a difference between the two tax competition game equilibria it must be related to tax revenue effects, $dT_i/dt_i$. Tax revenue at the symmetric equilibrium is

$$T_i = t_i S^i \sum_{j=1}^{n} K_j [F_K(K_j, L_j) - \alpha r], \qquad i = 1, \dots, n, \tag{34}$$

implying

$$\frac{dT_i}{dt_i} = (F_K - \alpha r) K \left(1 + tnS^i_{t_i}\right) - tK \left(\alpha \frac{dr}{dt_i} + r \frac{d\alpha}{dt_i}\right), \quad i = 1, \dots, n, \tag{35}$$

where

$$S^i_{t_i} = \frac{1}{nK} \left(\gamma + \sigma \frac{F_K K}{F}\right) \frac{dK_i}{dt_i} + \frac{1}{nw} \phi \frac{dw_i}{dt_i} < 0, \tag{36}$$

gives the impact of a country's tax rate on its share in the tax base. Any unilateral increase in the tax rate reduces the jurisdiction's share in the global tax base no matter what the weights in the formula are. Ceteris paribus, $S^i_{t_i}$ depends positively on each weight. Clearly, the capital-share weight affects $S^i_{t_i}$ more strongly than the sales share. If the tax rate elasticity of the jurisdiction's capital stock, $(t_i/K)(dK_i/dt_i)$, exceeds half the tax rate elasticity of the payroll, $(t_i/w_i\bar{L})(d(w_i\bar{L})/dt_i)/2$, the capital share's weight is also greater than the payroll share's weight.

A unilateral increase in the tax rate reduces the tax base if it increases $\alpha r$, that is, if

$$\alpha C''(F_K - \alpha r) + r(F_K t - r) < 0, \tag{37}$$

which requires a positive relationship between the a single tax rate and total debt, i.e., $r > F_K t$.

Although there are substantial differences in individual tax rate effects, the impact of coordinated tax rate increases is the same under the formula approach as it is under separate accounting. This is because separate accounting and formula apportionment are indistinguishable when tax rates are uniform. As a consequence, the true production possibility curve is always given by Equation (23).

Since interest rate and wage effects of taxation are the same under both approaches, the private consumption externality is also positive: $\text{PCE}^{FA} = \text{PCE}^{SA} > 0$. The public good externality

$$\text{PGE}^{FA} = (n-1)\left[(F_K - \alpha r)KtnS_{t_i}^j - tK\left(\alpha\frac{dr}{dt_i} + r\frac{d\alpha}{dt_i}\right)\right], \quad i = 1, \ldots, n, \tag{38}$$

where

$$S_{t_i}^j = \frac{1}{nK}\left(\gamma + \sigma\frac{F_K K}{F}\right)\frac{dK_j}{dt_i} + \frac{1}{nw}\phi\frac{dw_j}{dt_i} > 0, \tag{39}$$

is positive if a unilateral tax increase either reduces the debt-to-capital ratio or increases it only moderately, i.e., if $d\alpha/dt_i$ sufficiently low.

Due to these externalities, the symmetric Nash equilibrium of tax competition is generically inefficient. However, in contrast to separate accounting, overprovision could not be excluded analytically. The difference between perceived and real production possibility curve can be written as

$$\begin{aligned} &-\frac{dX_i/dt_i}{dT_i/dt_i} - \left[-\frac{dX_i/dt_i + (n-1)dX_i/dt_j}{dT_i/dt_i + (n-1)dT_i/dt_j}\right] \\ &= \frac{(n-1)t(1-\alpha t)\left[\frac{K\phi}{F - F_K K} - \frac{[F\gamma - F_K K(1-\gamma-\phi)]^2}{F^2 F_{KK} K}\right](F_K - \alpha r)^2 + F_K - \alpha r + \frac{r(F_K t - r)}{C''}}{[n(1-\alpha t) - t(1-\alpha)](F_K - \alpha r)}. \end{aligned} \tag{40}$$

If $F_K t > r \Leftrightarrow \eta > 1/n$, jurisdictions will clearly undersupply public goods. The underlying force is the positive public debt externality which reinforces positive externalities via the formula. A unilateral tax rate increase reduces the debt-to-capital ratio and thus increases the tax base.

The following proposition summarizes the results:

**Proposition 2** *Under formula apportionment, the symmetric Nash equilibrium of tax competition is generically characterized by an inefficient provision of publicly provided goods. If $\eta \geq 1/n$, jurisdictions unambiguously undersupply public goods.*

It should be stressed that even for $\eta < 1/n$ many rounds of numerical simulations for various parameters unambiguously found underprovision of public goods. Presumably, even the negative public debt externality could not change the results.

A direct comparison of the supply of public goods under separate accounting and formula apportionment in terms of exogenous parameters is generally not possible. A system change may or may not aggravate the underprovision problem.

# 5 Discussion

In this section, I discuss the results by comparing them to the benchmark case of tax competition without profit shifting and by subsequently analyzing internal debt.

## 5.1 Fixed debt-to-capital ratio

When the debt-to-capital ratio is fixed at a uniform level in all jurisdictions, the MNE cannot use financial policy to reduce its tax burden in response to tax rate differentials. Hence, $d\alpha_j/d_{t_i} \equiv 0$ for all $i, j$. As a consequence, there is no excess burden of taxation when all jurisdictions always levy the same tax rate. The true production possibility curve $\text{PPC}_{real}$ has slope $-1$. However, the perceived production possibility curve under separate accounting $\text{PPC}_{perc}$ in the symmetric Nash equilibrium of the tax competition game continues to be steeper since

$$-\frac{dX_i/dt_i}{dT_i/dt_i} = \frac{F_{KK}K[t(1-\alpha) - n(1-\alpha t)]}{F_{KK}K[t(1-\alpha) - n(1-\alpha t)] - (n-1)(F_K - \alpha r)t(1-\alpha t)} > 1. \quad (41)$$

Non-cooperatively taxing jurisdictions will undersupply public goods. Coordinated tax increases would increase welfare in all jurisdictions.

Underprovision of publicly provided goods is also the outcome of tax competition under formula apportionment when the debt-to-capital ratio is fixed. Not only is the private consumption externality positive, but also the public good externality

$$\text{PGE}^{FA\bar{\alpha}} := (n-1)\frac{dT_j}{dt_i} = (n-1)\left[(F_K - \alpha r)KtnS^j_{t_i} - tK\alpha\frac{dr}{dt_i}\right] > 0, \quad i = 1, \ldots, n. \quad (42)$$

Hence, autonomous jurisdictions will unambiguously undersupply public goods.

Furthermore, a purely capital-share based formula leads to particularly severe underprovision. Analytically it could be shown that an increase in the parameter $\gamma$ accompanied by a decrease in $\sigma$ leads to lower taxes and lower tax revenue at the equilibrium (see Appendix). Relocating capital reduces one to one the capital share, but has a smaller impact on the sales share. The more the formula relies on the mobile input, the fiercer competition is.

Whether underprovision will be more severe under separate accounting or under formula apportionment depends on the weights of capital, sales, and payroll in the formula. For a fully capital-share-based formula, i.e., for $\gamma = 1$, where tax competition is fiercest, it can be shown that

$$\left.\frac{dT_i}{dt_i}\right|_{SA\bar{\alpha}} - \left.\frac{dT_i}{dt_i}\right|_{FA\bar{\alpha}} = \frac{(n-1)(F_K - \alpha r)Kt}{n(1-t)} > 0. \tag{43}$$

Under separate accounting, there is a stronger incentive to raise taxes than under formula apportionment. Hence, introducing formula apportionment at the symmetric Nash equilibrium of the tax competition game under separate accounting would result in lower tax rates. Formula apportionment aggravates the underprovision problem. I conclude:

**Proposition 3** *If the leverage ratio is fixed at a uniform level, the symmetric Nash equilibrium of tax competition is characterized by underprovision of publicly provided goods regardless of whether separate accounting or formula apportionment is applied. A capital share base formula induces more severe underprovision than a sales share base formula. If the formula is purely capital share based, underprovision is even more severe under formula apportionment than under separate accounting.*

## 5.2 Internal debt

Following Mintz and Smart (2004) and Schindler and Schjelderup (2008), I now consider internal debt as an explicit device for profit shifting.[4] I add tax deductions for internal debt and also its costs to the analysis. The internal-debt-to-capital ratio in jurisdiction $i$ is $\beta_i = B_i/K_i$. Costs of internal borrowing are $Q(\beta_i)K_i$, with $Q(0) = Q'(0) = 0$, and $\lim_{\beta\to 1} Q'(\beta) = \infty$. Costs of internal lending are 0, $Q(\beta) = 0$ for $\beta < 0$, costs of internal borrowing positive and increasing, $Q'(\beta) \geq 0$ and $Q''(\beta) \geq 0$ if $\beta > 0$. Thin-capitalization rules are not explicitly modeled, but could be seen as part of costs of internal borrowing. Since lending is only internal, the total sum of internal debt is 0: $\sum_{j=1}^{n} \beta_j K_j = 0$. Economic profits and taxable profits become[5]

$$\pi_i = F(K_i, L_i) - w_i L_i - [r + C(\alpha_i) + Q(\beta_i)]K_i, \qquad i = 1, \ldots, n. \tag{44}$$

$$\pi_i^t = F(K_i, L_i) - w_i L_i - r(\alpha_i + \beta_i)K_i, \qquad i = 1, \ldots, n. \tag{45}$$

[4] See also Haufler and Runkel (2009).

[5] I assume that the interest rate for internal debt is the same as for external debt, there is no transfer-pricing issue involved. Chowdhry and Nanda (1994) have considered the external interest rate as anchor for the internal interest rate..

Under separate accounting, the MNE solves

$$\max_{K_i,L_i,D_i,B_i} \Pi^{ID} := \sum_{j=1}^{n} \left(\pi_j - t_j \pi_j^t\right) \quad \text{s.t.} \ \sum_{j=1}^{n} \beta_j K_j = 0 \text{ and } E_i \geq 0, \ i = 1, \ldots, n. \tag{46}$$

First-order conditions with respect to investment and internal borrowing in jurisdiction $i$, $i = 1, \ldots, n$, are

$$(1 - t_i)F_K(K_i, L_i) - r - C(\alpha_i) - Q(\beta_i) + \alpha_i C'(\alpha_i) + \beta_i Q'(\beta_i) = 0 \tag{47}$$

$$t_i r - Q'(\beta_i) - \lambda = 0, \tag{48}$$

where $\lambda$ is the Lagrangian of the internal debt constraint. Denoting the lowest tax rate by $t_m$, the internal debt condition can be written as

$$(t_i - t_m)r = Q'(\beta_i), \qquad i = 1, \ldots, n. \tag{49}$$

The firm's affiliate in the jurisdiction with the lowest tax rate will lend to all other affiliates. The size of internal debt is mainly determined by the tax rate differential. Internal assets in the minimum tax jurisdiction are determined by the borrowing constraint: $B_m = -\sum_{j \neq m} B_j$. However, in a symmetric equilibrium, there will be no internal borrowing.

Although the calculations are slightly more complex, it can be shown that with internal borrowing, the symmetric Nash equilibrium under separate accounting is characterized by underprovision of publicly provided goods. This should not be a surprise. External debt is a substitute for internal borrowing as means of profit shifting.

Finally, since under formula apportionment, the benefits of internal debt are always zero, the MNE will not issue internal debt, regardless of the tax rates. The tax game under formula apportionment is not affected by internal debt.

# 6 Concluding remarks

This paper analyzed tax competition when welfare-maximizing jurisdictions levy source-based corporate taxes and multinational enterprises choose leverage ratios in a tax-efficient way. First, separate accounting, under which multinationals shift debt from low-tax to high-tax countries, was considered. It was shown that in this situation the Nash equilibrium of the tax competition game is characterized by underprovision of publicly provided goods. Next analyzed was formula apportionment, under which the country-specific leverage ratio of a multinational's affiliate is independent of the jurisdiction's tax rate. The paper shows that public good provision is still inefficient and characterized the inefficient outcome. Finally, it was shown that underprovision is the unambiguous outcome of tax competition if leverage ratios are fixed at a uniform level.

The model could be extended in several ways. For example, asymmetry could be introduced. Asymmetric tax competition when profit shifting is feasible has been neglected in the literature to date. Stoewhase (2005) is an exception, but he considers capital taxation instead of profit taxation. Asymmetry is studied in the literature on tax havens (see, e.g., Hong and Smart, 2007; Slemrod and Wilson, 2006). Another extension could involve considering the deductible share as a policy variable, as Pinto (2007) has done.

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# Appendix

Setting $\sigma = 1 - \gamma - \phi$, the impact of an increase in $\gamma$ on $G_i = T_i/L$ could be written as

$$\frac{dG_i}{d\gamma} = \left(S^i + t_i S^i_{t_i}\right) \frac{\sum_{j=1}^{n} K_j F_K^j}{L} \frac{dt_i}{d\gamma}, \tag{50}$$

when $\partial S^i/\partial\gamma = 0$ is taken into account.

Since $S^i + t_i S^i_{t_i} > 0$, $\text{sign}(dG_i/d\gamma) = \text{sign}(dt_i/d\gamma)$. Denoting country $i's$ welfare by $V_i(t_i, t_j)$, from the first-order conditions of the Nash equilibrium, the impact on tax rates of changes in $\gamma$ could be calculated:

$$\frac{dt_i}{d\gamma} = -\frac{\frac{\partial^2 V_i}{\partial t_i \partial \gamma}\frac{d^2 V_j}{dt_j^2} - \frac{\partial^2 V_i}{\partial t_i \partial t_j}\frac{\partial^2 V_j}{\partial t_j \partial \gamma}}{\Delta}, \qquad i = 1, 2,\ j \neq i, \tag{51}$$

where

$$\Delta = \frac{\partial^2 V_i}{\partial t_i^2}\frac{\partial^2 V_j}{\partial t_j^2} - \frac{\partial^2 V_i}{\partial t_i \partial t_j}\frac{\partial^2 V_j}{\partial t_j \partial t_i}. \tag{52}$$

Using symmetry, this can be written as

$$\frac{dt_i}{d\gamma} = -\frac{\frac{\partial^2 V_i}{\partial t_i \partial \gamma}}{\frac{\partial^2 V_i}{\partial t_i^2} + \frac{\partial^2 V_i}{\partial t_i \partial t_j}}, \qquad i = 1, 2,\ j \neq i. \tag{53}$$

Stability of the Nash equilibrium implies

$$\frac{dt_i}{d\gamma} < 0 \quad \text{if and only if} \quad \frac{\partial^2 V_i}{\partial t_i \partial \gamma} < 0, \qquad i = 1, 2. \tag{54}$$

Furthermore, for $i = 1, 2$,

$$\frac{\partial^2 V_i}{\partial t_i \partial \gamma} = \frac{\sum_{j=1}^{n} K_j F_K^j}{L}\left[\frac{\partial S^i}{\partial \gamma}\left(U_{XG} t_i \frac{dX_i}{dt_i} + \frac{U_{GG} t_i}{L}\frac{dT_i}{dt_i} + U_G\right) + U_G t_i \frac{\partial^2 S^i}{\partial \partial t_i \gamma}\right]. \tag{55}$$

Together with

$$\frac{\partial S^i}{\partial \gamma} = 0 \quad \text{and} \quad \frac{\partial^2 S^i}{\partial t_i \partial \gamma} = \frac{1}{2}\frac{dK_i}{dt_i}\left(\frac{F - F_K K}{KF}\right) < 0, \tag{56}$$

this implies that $dt_i/d\gamma$ and $dT_i/d\gamma$ are negative.

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