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In a two-period tax competition model with provision of local public goods, we analyze efficiency properties of double taxation reliefs incorporating either the exemption method, the tax credit system or the full taxation after deduction system. Foreign direct investments are presumed to be one-way and characterized by long-term mergers and acquisitions. We find that in case of (i) tax revenue maximization the exemption method implies inefficiently low tax rates, whereas the full taxation after deduction system leads to inefficiently low / efficient / inefficiently high tax rates. In case of (ii) welfare maximization each of these tax rules can be efficient. The (limited) tax credit system, however, is shown to always result in inefficiently low / inefficiently high tax rates. A numerical example reveals that no tax regime per se entails efficiency. In case of (i), a ranking of tax systems subject to the Pareto criterion is shown to depend on the parameters of the production function. Regarding (ii) the exemption method is preferable as it is proven to be the least inefficient tax regime.

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1. Introduction

One main effect of globalization is the presence of foreign direct investments (FDI) as defined by the OECD (2008), which can roughly be separated into greenfield investments as well as mergers and acquisitions (M&A). In the former case investment abroad causes a reallocation of production factors whereas M&A cause a shift in ownership structures. In the pre-crisis era, the UNCTAD (2011) reports that in 2007 the worldwide FDI inflow culminated in 1.97 trillion US-Dollar and reached 2.17 trillion US-Dollar in outflow. Two years before, these capital flows accounted just for 0.98 as well as 0.88 trillion US-Dollar indicating the inherent dynamic of FDI.[1]

Bearing in mind the remarkable volume of FDI, fiscal implications thereof are captured by a large strand of public economics literature.[2] One of the associated fields of interest is the relief of double taxation of repatriated income generated abroad. At this, a disctintion is drawn between three different tax rules typically used in this kind of treaties and their implications regarding efficiency. These regimes are the exemption method (EM), the tax credit system (TCS) as well as the full taxation after deduction system (FTADS). The first system resembles pure source-based taxation. Following the residence principle, the TCS and the FTADS take as basis the world income of the tax debtor, where the fiscal treatment of repatriated income varies accordingly. In the TCS the government at home credits taxes on foreign income paid abroad against the overall tax debt. Depending on the tax ratio, the foreign tax load refunded by the government at home may exceed gains from taxing repatriated income if the foreign tax rate lies above that one at home. Even though this is technically possible, in practice double taxation treaties generally incorporate a "saving clause". That is, crediting is limited up to the point where the tax credit at home is nonnegative. In the FTADS, the tax base at home is comprised of gross world income minus taxes paid abroad.

Early contributions, such as e. g. Hamada (1966), build their analysis upon the assessment of national income for given tax rates. Considering two countries and a one-way capital flow, it is found to be globally advantageous to include the TCS in a double taxation treaty as long as the condition of the saving clause is fulfilled. Form the perspective of a capital exporting country, however, the FTADS is preferable as this regime ceteris paribus provides the largest tax base.[3] Endogenizing tax rates in a Nash equilibrium, Bond and Samuelson (1989) ascertain, that if discriminatory tax rate setting is feasible, the FTADS results in higher national income in both countries.[4]

More recent contributions, such as e.g. Janeba (1995) and Davies (2003) extend the above-mentioned approach by considering the recommendation of the OECD (2010) to base income taxation on non-discriminatory tax rates. Janeba finds, that without coordination governments are indifferent regarding the tax regimes in concern. It is pointed out, that in an international

[1] Since the global economic crisis represents a short term shock, statistic data for the time frame after 2007 are omitted.

[2] See Fuest et al. (2005) for a comprehensive survey of capital mobility and tax competition.

[3] See also Richman (1963) and Musgrave (1969).

[4] In their approach, the TCS turns out to cause international capital movement to disrupt due to prohibitvely high tax rates. See also Feldstein and Hartmann (1979), who find this result to be true in a Stackelberg equilibrium.

agreement on a double taxation treaty, the TCS is the preferred tax rule. Compared to the FTADS and the EM, neither a side payment (as in the FTADS) nor a harmonization of tax rates (as in the EM) is required for efficiency. In contrast, Davies' approach predicates on a model with two countries and two-way capital flows. He evaluates the OECD model tax treaty, where the FTADS is precluded, by considering either symmetric or asymmetric countries. It is concluded that if countries are symmetric, the TCS yields efficient allocation of capital even without coordination. This outcome relies on identical equilibrium tax rates in both countries, such that the effective tax rates on repatriated income are zero. In case of asymmetric countries, it is not clear whether a similar result can be achieved. In a harmonization process, however, the FTADS is recommended to be excluded.

Dickescheid (2004) investigates tax competition associated with tax financed provision of local public goods in a partial equilibrium model. Taking into account the model treaty of the OECD, Dickescheid focuses on two symmetric countries that mutually exchange foreign direct investment. In absence of discriminatory tax rate setting, it is scrutinized which tax rule a mutual double tax treaty should comprise.[5] He finds the EM to be unambiguously preferable over the TCS. The basic intuition behind this outcome is the following. Both tax rules generally imply a well known capital flight externality inducing inefficiently low tax rates. The TCS, though, features a second externality which he refers to as tax export externality. By virtue of this tax regime treasury income is linked to production and, thus, to the tax base abroad, such that the domestic tax rate is a cost factor of production in the foreign country. Taxation of repatriated income, then, leads to a decline in the foreign tax base and national tax yield is, hence, achieved at the expense of the foreign country's tax receipts. This induces inefficiently high tax rates. As Dickescheid assumes that both countries are sufficiently small, the influence of national tax policy on the world capital market is negligible, such that the interest-based capital flight externality is absent in his approach. In the TCS, however, the tax export externality prevails and source-based taxation turns out to be efficient. A mutual double tax treaty, then, should not contain the TCS because of the need to internalize the tax export externality in order to achieve efficiency.

It is worth noting that the aforementioned studies implicitly treat FDI as greenfield investment. Comparing this assumption with data provided by the UNCTAD (2011), a sole consideration of greenfield investment tends not to reflect real world investment behaviour. On the contrary, an incorporation of M&A in evaluating double tax treaties seems worthwhile, since global M&A is indicated to amount some one trillion US-Dollar in 2007.

Besides a growing strand of literature focussing on the interplay of taxation and ownership structures of multinational entities[6], Becker and Fuest (2011) analyse tax competition with local public good provision considering both endogenous greenfield investment as well as M&A. They set forth a model wherein a representative household initially owns a given set of national firms with exogenous production. Amongst other things, it is shown that if one country hosts a multinational enterprise after merging in absence of greenfield investments, source-based tax-

[5] Note, that Dickescheid finds a symmetrical application of the EM or the TCS to be superior.
[6] See e. g. Becker and Fuest (2010), Haufler and Schulte (2011) as well as Huizinga and Voget (2009).

ation of corporate income is efficient if taxes on dividends are precluded. This outcome arises as the representative household is supposed to choose between capital market investments and merging firms. If corporate taxation is, say, increased, the after-tax profit of firms decreases ceteris paribus rendering investments in additional firms less beneficial. Less mergers then are substituted by increased saving, which in turn lowers equilibrium global capital cost. Turning to the vendor of a firm, less revenue from selling firms leads to a reduction in capital market activities, which results in a downturn of the interest rate at the same amount. Efficiency, thus, comes by virtue of an undistorted capital market.

We set forth a tax competition model with local public good provision considering one-way mergers and acquisitions and at least two countries the world economy consists of. Net profit generated by an affiliate abroad is fully repatriated to the owner of a multinational enterprise. Efficiency properties of the three tax rules then are obtain by scrutinizing externalities caused by individually optimal profit taxation. We find that in case of tax revenue maximization, the EM involves inefficiently low tax rates. This outcome reflects typical implications found in tax competition literature. Source-based taxation is inefficient, since profit taxation distorts the capital market equilibrium. This is captured by a positive capital flight externality as well as a positive terms of trade externality.

In the TCS and the FTADS, another negative direct as well as a negative indirect tax export externality arise where the root of these effects can be found in the double taxation agreement itself. The direct tax export externality causes the government at home to take into account the tax load of the multinational enterprise abroad. The indirect tax export externality captures the fact that due to these tax rules, net profit of the foreign affiliate is dependent on both the foreign tax rate and the tax rate in the home country of the multinational's owner. The implication of these effects is that each national government has the incentive to derive national tax income at the expense of the respective other country. In case of the FTADS, it turns out that this tax regime might be able to reach efficiency, as those negative externalities could be exactly counteracted by the capital flight as well as the terms of trade externality. In the TCS, the same reasoning is true regarding profit taxation in the home country of the MNE. If, however, there is a tax levied on profit generated by an affiliate abroad, only the negative direct tax export effect is proven to emerge as long as the saving clause is fulfilled. It follows, that the TCS mandatorily requires cooperative tax rate setting to implement efficiency.

In case of welfare maximization, the above results with respect to the EM and the FTADS are accompanied by a negative income externality that represents a tax-induced variation in revenue from individual saving. As a consequence, both tax regimes result in either inefficiently low, efficient or inefficiently high intensity of taxation. The TCS is again shown to generally fail Pareto efficiency.

A numerical example elucidates that no tax system generally results in a Pareto efficient outcome. If governments maximize treasury income, the production structure of the multinational is crucial to the choice between tax regimes. Depending on the functional parameters, we find different rankings of tax regimes, such that any system might be preferable. Provided that the

fiscal objective is to maximize welfare, results obtained suggest source-based taxation, i.e. the EM, to be preferred over the TCS and FTADS.

The remainder of the paper is set up as follows. In section 2 we present the model utilized including basic assumptions as well as implications of merging firms. In the succeeding section 3 we elaborate the underlying three-stage Nash game by presenting comparative static results and efficiency properties of uncoordinated profit tax rate setting given the fiscal objective of tax revenue and welfare maximization. In doing so, we focus on either large or small countries. In section 4, we assess double tax treaties by relying on a numerical example. Eventually, section 5 concludes.

2. The Model

Basic assumptions. The world exist for two periods and the global economy consists of $n \geq 2$ countries. In each country there is a large number of internationally identical firms owned by a large number of internationally identical residents. Normalizing the amount of national actors to unity, we consider a national representative firm owned by a domestic representative resident in country $z \in \{1, \ldots, n\}$.[7] The firm produces a numériare consumption good according to the production function $F(k_z)$ which is identical in all countries. The consumer good is produced with capital input k_z. The function F is assumed to have a positive ($F_k > 0$) and decreasing ($F_{kk} < 0$) marginal productivity.[8] We furthermore implicitly presume that there is an exogenous second input factor, which can be conceived of as a patent, for example. In the following, this factor is needed in order to motivate an output-enhancing merger of firms. Each firm produces solely in period two and purchases capital on the world capital market at user cost of capital r. Denoting the profit tax rate in country z by $t_z \in [0, 1)$, the after-tax profit generated by each national firm in period two is given by

$$\pi_z = (1 - t_z)\left[F - \vartheta r k_z\right] - (1 - \vartheta) r k_z \tag{1}$$

where $\vartheta \in [0, 1)$ is the deduction rate of capital cost, which is the same for all countries.

Each resident spends her initial endowment e for consumption in period one (c_z^1) and for investment in the capital market at rate s_z, so that

$$c_z^1 = e - s_z. \tag{2}$$

In the second period, resident z's consumption is financed by her income from saving, $(1+r)s_z$, and by profit income from ownership of firm z. Since we abstract from any dividend taxation, the after-tax profit of firm z fully accrues to resident z, leading to

$$c_z^2 = (1 + r)s_z + \pi_z\,. \tag{3}$$

[7] The representative firm in country z is subsequently referred to as firm z. Likewise, the representative resident in country z is denoted as resident z.

[8] Throughout this essay partial derivatives are represented by corresponding subscripts.

Besides consumption in period one and two, resident z benefits from the provision of a local public good g_z in period two. Her utility is given by

$$U_z = u(c_z^1) + c_z^2 + V(g_z) \tag{4}$$

where the sub-function $u(c_z^1)$ is strictly concave and $V(g_z)$ is characterized by $V_g > 0 \geq V_{gg}$.[9]

In country z tax revenue is gained by taxing firm z's profit and is exclusively used to finance the provision of the local public good. It is assumed that the marginal rate of transformation between the local public and private good equals unity. The fiscal budget constraint of the government in country z (hereafter government z) is given by

$$g_z = t_z \left[F - \vartheta r k_z \right] . \tag{5}$$

The merger's benefit. Below we focus on a cross-border merger between two firms into one multinational enterprise (MNE). Owing to the symmetry of the initial situation, it is assumed that the world economy can equally be separated into two subsets. The first subset αn with $\alpha = 0.5$ may comprise those countries that are inhabited by investors. We refer to one of these countries as country j.[10] The second subset βn with $\beta = 1 - \alpha$ includes those countries a firm is sold from by the representative resident. One country being part of this subset is referred to as country m.[11] Resident j, thus, expands by investing in firm m leading to $n/2$ MNEs. Due to the production function and the associated decreasing returns of scale, a sole combination of production processes of both firms would generally be unprofitable since

$$F(k_j) + F(k_m) > F(k_j + k_m). \tag{6}$$

The driving force for merging, therefore, needs to incorporate sufficient economies of scope. Consider the case, that due to the implicitly assumed second input factor both firms are endowed with a certain set of patents. Sufficient economies of scope, then, are considered to be characterized by the compatibility of these two sets of patents, such that the union of both sets enables the MNE to apply more general patents positively influencing production output.

Since we do not want to employ in-firm structures in detail, we assume that this benefit is only attributable to the MNE's production as a whole and falls to the corporation's output $F(k_j + k_m)$ in terms of a multiplier. Provided that $\bar{\Delta}$ denotes the increase in productivity, merging is output-enhancing if

$$F(k_j) + F(k_m) \leq \bar{\Delta} F(k_j + k_m). \tag{7}$$

[9] Supposing intertemporal income effects to be sufficiently small, we are able to employ this type of utility function.

[10] Quantities associated with this country will be highlighted by the subscript j, such that, for example, the national tax rate reads t_j.

[11] Likewise, quantities connected with this country are labelled with the subscript m.

It follows from eqns. (6) and (7), that $\bar{\Delta} > 1$. Additionally, we assume that each of the former unrelated firms equally benefits from merging. Let the well-behaved function $F^z = F^z(k_z)$ with $z = j, m$ represent production of a MNE's affiliate in country z, post-merging production of the MNE, then, can be specified by

$$\bar{\Delta}F(k_j + k_m) = \bar{\Delta}\left(F^j(k_j) + F^m(k_m)\right)$$

As each production site equally benefits from merging and considering the identity of both former unrelated firms j and m, we set $F^j = F^m$.

Merging firms and its consequences. If resident j is supposed to be the owner of the MNE, we define country j as the home country and country m as the foreign country. Investment incentives are presumed to be exclusively driven by an increase in production, such that possible tax planning motives of resident j, as e.g. financing merging by debt to benefit from interest deduction, are excluded. At this, we simplify resident j's investment behaviour by assuming that merging firm j and m is equity-financed and represents a long-term decision.[12] Thereby we are allowed to state, that if the investment took place, any impact of taxation, which in turn is more of a short-term nature, does not harm the benefit of merging, see Haufler and Schulte (2011).

Consider the net profit generated in country m to be fully repatriated and taxes to be levied following the residence principle. The after-tax profit of the MNE, then, consists of net income from production at home and in the foreign country minus a possible extra tax burden μ due to cross-border corporate income taxation.

Depending on the tax regime incorporated in a double tax treaty, post-merging after-tax profit of the MNE varies in consequence of μ. Let $\tilde{\pi}_j$ denote resident j's post-tax income from owning the multinational, we get[13]

$$\tilde{\pi}_j = \underbrace{(1-t_j)\left[\bar{\Delta}F^j - \vartheta r k_j\right] - (1-\vartheta) r k_j}_{\text{net profit of production in } j} + \underbrace{(1-t_m)\left[\bar{\Delta}F^m - \vartheta r k_m\right] - (1-\vartheta) r k_m}_{\text{net profit of production in } m} - \mu \quad (8)$$

where the additional tax burden is given by

$$\mu = \begin{cases} 0 & \text{in the exemption method,} \\ \begin{cases} (t_j - t_m)\left[\bar{\Delta}F^m - \vartheta r k_m\right] & \text{if } t_j \geq t_m\,, \\ 0 & \text{else} \end{cases} & \text{in the tax credit system,} \\ t_j(1-t_m)\left[\bar{\Delta}F^m - \vartheta r k_m\right] & \text{in the full taxation after deduction system.} \end{cases}$$

[12] Merging both firms, thus, can be seen as a pure share deal. Abstracting from asset deals allows us to exclude any specific financial tax regulations from our approach. For details, see e.g. Becker and Fuest (2011).

[13] Hereafter a tilde emphasizes quantities after merging whenever a distinction is necessary.

and discriminatory tax rate setting is presumed to be outlawed. Without a tax treaty, government j taxes gross profit of both affiliates such that $\mu = t_j[\bar{\Delta}F^m - \vartheta r k_m]$. It follows that gross profit in m is taxed twice. In order to relief double taxation, the government at home implements a double tax treaty including either the EM, the TCS or the FTADS. With the EM employed, profit generated abroad is exempted from the global tax base. Each tax base, therefore, includes the national gross profit, exclusively, and is equivalent to the source principle leading to no cross-border corporate income taxation.

The TCS reduces double taxation of government j by crediting the taxes paid to government m against the global tax liability of the MNE in country j. From government j's point of view, it is assumed that this system is only favourable, if its profit tax rate is at least equal to that of country m, see e. g. Davies (2003). If tax rates are the same, government j's tax receipts based on repatriated income compensates the refund paid to the MNE. If t_j falls short of t_m, the MNE gains a full refund of the tax load paid in the foreign country plus a partial refund of its tax liability at home. We abstract from the latter in line with several mutual double taxation agreements containing a "saving clause" and assume a limited tax credit by government j. This arrangement is included, for example, in treaties between Germany and Denmark[14] as well as between the USA and Bulgaria[15]. If the double tax treaty includes the FTADS, the additional tax burden μ of the MNE comprises the net income generated in m. Consequently, the net profit of production in m and the gross profit of production in j represent the global tax base at home.

Since merging is not costless, we denote by P the price resident j has to pay for the firm abroad. Selling firm m obviously causes resident m to cease one out of two sources of income in period two. Assuming in line with e.g. Becker and Fuest (2011), that revenue from selling firm m is untaxed, resident m is only willing to participate in the market for merger if and only if

$$(1+r)P \geq \pi_m$$

is fulfilled in period two, where π_m is given by eqn. (1). That is, the present value of revenue from selling firm m meets at least the income generated by firm m without merging.

Turning to resident j, on the one hand merging firm j and m results in increasing income, i. e. $\tilde{\pi}_j > \pi_j$ where π_j is characterized by (1) and $\tilde{\pi}_j$ is determined in (8). On the other hand, the price P for firm m has to be paid, such that merging is at all possible. Consequently, resident j merges firm j and m if the profit generated by the MNE net of merging cost and taxes meets at least her outside option, such that[16]

$$\tilde{\pi}_j - (1+r)P \geq \pi_j \,. \tag{9}$$

Assuming perfect competition in the market for mergers, either participation condition is satisfied with equality, such that $(1+r)P = \pi_m$ and $\tilde{\pi}_j - (1+r)P = \pi_j$. It turns out, that corporate

[14] See art. 24, par. 2b therein.

[15] See art. 22, par. 4b therein.

[16] Note, that eqn. (9) might intensify the pressure on the merging benefit $\bar{\Delta}$. As the investment is supposed to be long-term beneficial, we assume $\bar{\Delta} \gg 1$.

taxation is capitalized by the equilibrium price for merging and each resident is ensured to earn her exogenous outside option. Formally, this can be seen by substituting the first equation into the second, i.e. $\tilde{\pi}_j = \pi_j + \pi_m$.[17] Total differentiation with respect to any national profit tax rate t_z gives $\mathrm{d}\tilde{\pi}_j/\mathrm{d}t_z = 0$. Hence, resident j's income generated by the MNE net of merging cost and taxes is unaffected by national profit taxation as the price P is adjusted accordingly in order to maintain indifference between merging both firms and her outside option. Turning to resident m, the equilibrium price P equals her discounted outside option, such that $P = \pi_m/(1+r)$. Totally differentiating with respect to any tax rate t_z gives $\mathrm{d}P/\mathrm{d}t_z = -P/(1+r)\frac{\mathrm{d}r}{\mathrm{d}t_z}$. Given that taxation distorts the capital market equilibrium, the price P changes correspondingly in order to maintain indifference of resident m between selling and keeping firm m.

To elucidate expenditures and gains from merging in total, we adapt the budget constraints (2), (3) and (5) presented above. With respect to the MNE's after-tax profit defined in eqn. (8) and equity-financed merging, for resident j we obtain

$$\tilde{c}_j^1 = e_j - s_j \tag{10}$$

$$\tilde{c}_j^2 = \tilde{\pi}_j + (1+r)(s_j - P) \tag{11}$$

for consumption in both periods. Considering cross-border income taxation, government j's budget constraint is given by

$$\tilde{g}_j = t_j \left[\bar{\Delta}F^j - \vartheta r k_j\right] + \mu\,. \tag{12}$$

Turning to country m, first and second period consumption of resident m is given by

$$\tilde{c}_m^1 = e_m - s_m \tag{13}$$

$$\tilde{c}_m^2 = (1+r)(s_m + P) \tag{14}$$

and the fiscal budget contsraint of government m reads

$$\tilde{g}_m = t_m \left[\bar{\Delta}F^m - \vartheta r k_m\right]. \tag{15}$$

3. Assessing tax regimes – a theoretical approach

In order to analyze efficiency properties of the three tax rules considered in a double tax treaty, we base our model on a three-stage game for a given benefit of merging.[18] At the first stage, government j chooses one out of three tax rules double taxation of the MNE owned by resident j is relieved by. These rules are the EM, the TCS or the FTADS. At the second stage, government j and m determine individually optimal corporate tax rates given the tax rule from stage one. Eventually, the representative resident as well as the MNE set optimal consumption and

[17] Note, that this expression implies eqn. (7) to be satisfied with equality.

[18] Endogenizing the benefit of merging results in an additional stage where resident j decides as to whether merge firm j and firm m. This, however, significantly complicates the following analysis without adding much insight.

production in the final stage. Endogenous quantities at this stage are saving, capital demand and global capital cost.

We solve this game by making use of backward induction commencing our analysis with stage three. At this, the MNE and each resident take as given the double tax relief and national profit tax rates. Maximizing the MNE's after-tax profit and utility, capital cost as well as factor demand turn out to be functions of national tax rates whereas individual saving is a function of capital cost.

At the second step of backward induction, each government maximizes its fiscal objective over the national profit tax rate subject to the budget constraints (10) to (15). In doing so, each government takes into account the effect of taxation on saving, capital demand as well as on global capital cost. Governments, however, take as given the tax rates of other countries. Put differently, we focus on a Nash tax competition game.

In the last step of backward induction, government j chooses a tax system incorporated in a double tax treaty given optimal results obtained in the preceding stages. As we are interest in efficiency properties of the three tax rules, we do not need to fully analyse the underlying game. Instead, we can base the following analysis on externalities generated by uncoordinated profit taxation. These externalities obtained provide the insight whether or not tax rates are set Pareto efficiently considering the respective tax system.[19]

Tax competition in general. Focussing on the second step of backward induction, we consider two different fiscal objectives. That is, either national tax revenue or domestic welfare is maximized.[20] In order to implement these objectives in our model, we rewrite the utility function of resident $z \in \{1, \ldots, n\}$ from (4) as the fiscal objective function

$$Y_z = \eta \left[u(c_z^1) + c_z^2\right] + V(g_z) \tag{16}$$

where η is a binary parameter with

$$\eta = \begin{cases} 1 & \text{for welfare maximization} \\ 0 & \text{for tax revenue maximization} \end{cases}$$

For $\eta = 1$, eqn. (16) turns into the national welfare function, since the right hand side of (16) represents utility of resident z. For $\eta = 0$ the first-order condition with respect to the national tax rate t_z reads

$$\left.\frac{\mathrm{d}Y_z}{\mathrm{d}t_z}\right|_{\eta=0} = V_g \frac{\mathrm{d}g_z}{\mathrm{d}t_z} = 0\,.$$

[19] Pareto efficiency is characterized by externalities amounting to zero. Accordingly, a positive externality induces inefficiently low tax rates while a negative externality induces the opposite.

[20] In tax competition literature, the assumption of tax revenue maximization is made by e.g. Kanbur and Keen (1993). Edwards and Keen (1996) discuss implications of a combination of both objectives with respect to capital tax competition.

Because of the monotonic increasing function $V(g_z)$, maximizing the same is tantamount to maximizing national tax revenue. Summing up eqn. (16) over all n countries gives the joint objective function

$$\mathcal{Y} := \sum_{z=1}^{n} Y_z = n\left(\alpha Y_j + \beta Y_m\right) . \tag{17}$$

Totally differentiating (17) with respect to t_j gives the effect of domestic taxation in country j on all other countries' objective in a general equilibrium, i.e.

$$\frac{\mathrm{d}\mathcal{Y}}{\mathrm{d}t_j} = \alpha n \frac{\mathrm{d}Y_j}{\mathrm{d}t_j} + \beta n \frac{\mathrm{d}Y_m}{\mathrm{d}t_m}.$$

Due to our focus on one MNE and the two countries its affiliates are located in, we need to identify other countries in the respective subset. This is done by setting $(\alpha n - 1)Y_{-j}$ and $(\beta n - 1)Y_{-m}$, where the first expression captures all other countries in first subset while the second expression does so considering the second. The effect of uncoordinated tax rate setting in country j, thus, reads

$$\begin{aligned}\frac{\mathrm{d}\mathcal{Y}}{\mathrm{d}t_j} = \frac{\mathrm{d}Y_j}{\mathrm{d}t_j} + (\alpha n - 1)\frac{\mathrm{d}Y_{-j}}{\mathrm{d}t_j} \\ + \frac{\mathrm{d}Y_m}{\mathrm{d}t_j} + (\beta n - 1)\frac{\mathrm{d}Y_{-m}}{\mathrm{d}t_j}\end{aligned} \tag{18}$$

In an uncoordinated Nash equilibrium the first term in (18) becomes zero. With respect to government m, the externality of profit taxation inflicted by government j is given by the third term $\frac{\mathrm{d}Y_m}{\mathrm{d}t_j}$. The terms $(\alpha n - 1)\frac{\mathrm{d}Y_{-j}}{\mathrm{d}t_j}$ and $(\beta n - 1)\frac{\mathrm{d}Y_{-m}}{\mathrm{d}t_j}$ represent the impact of corporate taxation at home on fiscal objectives of other governments in each subset.

Likewise, totally differentiating (17) with respect to the corporate tax rate in country m leads to

$$\begin{aligned}\frac{\mathrm{d}\mathcal{Y}}{\mathrm{d}t_m} = \frac{\mathrm{d}Y_m}{\mathrm{d}t_m} + (\beta n - 1)\frac{\mathrm{d}Y_{-m}}{\mathrm{d}t_m} \\ + \frac{\mathrm{d}Y_j}{\mathrm{d}t_m} + (\alpha n - 1)\frac{\mathrm{d}Y_{-j}}{\mathrm{d}t_m}\end{aligned} \tag{19}$$

where the first term again is zero due to uncoordinated optimal tax rate setting in coutnry m. Following the above reasoning according to eqn. (18), the identification of the second to fourth term applies mutatis mutandis.

Since the following remarks build upon on the last three terms in (18) and (19), note that totally differentiating each national fiscal objective (16) with respect to another country's corporate tax rate leads to

$$\frac{\mathrm{d}Y_z}{\mathrm{d}t_x} = \eta\left[\frac{\mathrm{d}u(\tilde{c}_z^1)}{\mathrm{d}t_x} + \frac{\mathrm{d}\tilde{c}_z^2}{\mathrm{d}t_x}\right] + V_g\frac{\mathrm{d}\tilde{g}_z}{\mathrm{d}t_x} \quad z, x \in \{j, m\} \wedge z \neq x \tag{20}$$

It can be shown, that the term in squared brackets can be reduced to $s\frac{\mathrm{d}r}{\mathrm{d}t_x}$, such that (20) becomes[21]

$$\frac{\mathrm{d}Y_z}{\mathrm{d}t_x} = \underbrace{\eta s \frac{\mathrm{d}r}{\mathrm{d}t_x}}_{=:\mathrm{IE}} + V_g \underbrace{\frac{\mathrm{d}\tilde{g}_z}{\mathrm{d}t_x}}_{=:\mathrm{TE}} \quad z, x \in \{j, m\} \wedge z \neq x \tag{21}$$

where the acronyms IE and FE stand for *income externality* and *tax base externality*. The latter caputres the effect of taxation abroad on the national tax base.[22] Regarding the former externality, recall that the equilibrium price for merging capitalizes any tax-induced changes in the MNE's after-tax profit or in revenue from selling firm m. Second period income earned in these two ways, thus, turns out to be unaffected by taxation as P ensures each resident to receive her exogenous outside option. The residual effect on private consumption is depicted by a tax-induced variation in saving return in period two and amounts to zero in case of tax revenue maximization ($\eta = 0$).

3.1. Large countries

Tax competition in large countries. In sections 3.1.1 to 3.1.3 we set forth externalities in case of large countries, where the world economy is assumed to consist of $n = 2$ countries and one MNE, respectively. This approach allows us to focus on efficiency properties in the home country of the MNE and in its foreign country. In section 3.2 this assumption is relaxed by assuming that there are many small countries with half as many MNEs.

For $n = 2$ countries, the second and fourth terms in eqns. (18) and (19) disappear. Each third term therein remains, such that the general influence of taxation at home and in the foreign country on the respective other fiscal objective reads

$$\frac{\mathrm{d}Y_m}{\mathrm{d}t_j} = \eta \underbrace{s \frac{\mathrm{d}r}{\mathrm{d}t_j}}_{=:\mathrm{IE}} + V_g \underbrace{\frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_j}}_{=:\mathrm{TE}} \tag{22}$$

as well as

$$\frac{\mathrm{d}Y_j}{\mathrm{d}t_m} = \eta \underbrace{s \frac{\mathrm{d}r}{\mathrm{d}t_m}}_{=:\mathrm{IE}} + V_g \underbrace{\frac{\mathrm{d}\tilde{g}_j}{\mathrm{d}t_m}}_{=:\mathrm{TE}} . \tag{23}$$

[21] REFEREE: See the appendix for the derivation of the income externality.

[22] The first derivative of the subfunction $V(\cdot)$, i.e. $V_g > 0$, is omitted from analysing tax base externalities, since it represents a positive transformation of $\mathrm{d}g_z/\mathrm{d}t_x$ thereby not changing results.

3.1.1. Exemption method

Profit & utility maximization. Consider government j to exempt foreign profits from national taxation and $\mu = 0$ in (8). The first-order conditions for profit maximization of the MNE, then, are given by

$$\frac{\partial \tilde{\pi}_j}{\partial k_j} = (1 - t_j)\left[\bar{\Delta} F_k^j - \vartheta r\right] - (1 - \vartheta) r = 0 \tag{24}$$

$$\frac{\partial \tilde{\pi}_j}{\partial k_m} = (1 - t_m)\left[\bar{\Delta} F_k^m - \vartheta r\right] - (1 - \vartheta) r = 0 \tag{25}$$

They constitute, that the MNE equates marginal productivity and marginal cost of production in each country. Resident z's first-order condition for utility maximization with respect to saving is given by

$$u_{c_z^1}(\tilde{c}_z^1) = (1 + r) \quad z \in \{j, m\} \tag{26}$$

According to (26), marginal utility of consumption in period one equals the marginal cost of corresponding forgone consumption in period two. Moreover, eqn. (26) implicitly determines the saving function $s_z = S^z(r)$ with $S_r^z > 0$, i.e. capital supply is increasing in the user cost of capital. Since s_z is identical for all residents, we simplify notation by skipping subscripts, such that $s_z = s$ and $s = S(r)$. Equations (24) to (26) and the capital market clearing condition

$$\sum_{i=1}^{n} k_i = ns \tag{27}$$

determine the general market equilibrium, where capital demand and the interest rate are functions of n cooperate tax rates. Totally differentiating (24) to (27) with respect to the national profit tax rates t_j and t_m yields the comparative static results[23]

$$\frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \qquad \frac{\mathrm{d}r}{\mathrm{d}t_m} < 0 \tag{28}$$

$$\frac{\mathrm{d}s}{\mathrm{d}t_j} = S_r \frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \qquad \frac{\mathrm{d}s}{\mathrm{d}t_m} = S_r \frac{\mathrm{d}r}{\mathrm{d}t_m} < 0 \tag{29}$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} < 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_m} < 0 \tag{30}$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_m} > 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_j} > 0 \tag{31}$$

$$\frac{\mathrm{d}k_{-j}}{\mathrm{d}t_j} > 0 \qquad \frac{\mathrm{d}k_{-j}}{\mathrm{d}t_m} > 0 \tag{32}$$

$$\frac{\mathrm{d}k_{-m}}{\mathrm{d}t_j} > 0 \qquad \frac{\mathrm{d}k_{-m}}{\mathrm{d}t_m} > 0 \tag{33}$$

Consider an increase in the national profit tax rate t_z with $z \in \{j, m\}$. As a consequence, production cost in the respective country raise, so that capital demand of the MNE in z declines. This leads to an excess supply in the capital market. For the purpose of equilibrating the capital

[23] For a detailed outline see the appendix.

market, the world interest rate falls, see (28). A lower return on saving, however, induces each resident to save less, see (29). Additionally, a reduced interest rate implies a reduction in the MNE's capital cost and an increase in capital demand. It can be shown that the latter effect is smaller than the tax-induced increase in production cost causing overall capital demand in country z to decrease, see (30). Subsequently, (27) is rebalanced at a lower level.
Equation (31) reveals, that production abroad benefits from an increase in the national corporate tax rate. This is due to the fact, that t_z does not directly influence production in country $x \in \{j, m\}$ with $x \neq z$. Instead, production in x is affected indirectly via a global downturn in capital cost, cf. (28), which enhances production abroad. Put differently, eqns. (30) and (31) imply that if government z increases the national profit tax rate, the MNE shifts part of its production to country x in order to avoid increased production cost.

Eventually, eqns. (32) and (33) illustrate how production of MNEs owned by other investors is influenced by a tax rate change in country $z = j, m$. At this, k_{-j} depicts capital demand of another MNE in that country the respective investor, who is not resident j, resides in. Likewise, k_{-m} reflects capital demand of the foreign affiliate owned by resident $-j$. Since t_j and t_m do not directly influence production of other MNEs, their production is solely affected via a change in global capital cost. As a higher tax rate in country z decreases capital cost, cf. (28), the after-tax profit of other MNEs benefits by virtue of less production cost.

Tax competition in the EM. Due to the EM resembling pure source-based taxation, profit taxation turns out to be symmetrical in our approach. Hence, it suffices to focus on externalities imposed on treasury income in m as the opposite case applies mutatis mutandis. In case of tax revenue maximization ($\eta = 0$), the tax base externality in eqn. (22) reads

$$\frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_j} = t_m \left[\bar{\Delta} F_k^m - \vartheta r\right] \frac{\mathrm{d}k_m}{\mathrm{d}t_j} - t_m \vartheta k_m \frac{\mathrm{d}r}{\mathrm{d}t_j} \quad > 0\,. \tag{34}$$

The first term represents the change in tax revenue owing to a change in capital demand. This effect is usually referred to as *capital flight externality*. Consider again an increase in t_j. As discussed above, a higher tax rate at home induces the MNE to shift part of its production to the foreign country, cf. (30) and (31). This increases the tax base in country m. Additionally, the world interest rate decreases, cf. (28), which leads to diminished capital cost deduction of the MNE in country m. This effect captured by the second term in (34) also enlarges the tax base in m and is referred to as *terms of trade externality*. Since both effects are positive, the tax base externality (34) itself is positive inducing inefficiently low profit taxation.

Changing the governmental objective into national welfare maximization ($\eta = 1$), eqn. (22) associated with (28) reveals that a tax-induced decrease in revenue from saving counteracts the positive tax base externality, such that we can state

Lemma 1 *Suppose that the world economy consists of $n = 2$ countries, then the EM induces inefficiently low tax rates in case of national tax revenue maximization. Regarding national welfare maximization, the sign of the sum of income and tax base externality is ambiguous.*

3.1.2. Tax credit system

Profit & utility maximization. Next, consider government j to set off payments of foreign taxes on profit generated in m against the overall tax liability of the MNE at home. That is, with

$$\mu = (t_j - t_m)\left[\bar{\Delta}F^m - \vartheta r k_m\right]$$

in (8), presuming that the saving clause is met ($t_j \geq t_m$), we obtain the MNE's first-order conditions for profit maximization

$$\frac{\partial \tilde{\pi}_j}{\partial k_j} = (1-t_j)\left[\bar{\Delta}F_k^j - \vartheta r\right] - (1-\vartheta)r = 0, \tag{35}$$

$$\frac{\partial \tilde{\pi}_j}{\partial k_m} = (1-t_j)\left[\bar{\Delta}F_k^m - \vartheta r\right] - (1-\vartheta)r = 0. \tag{36}$$

An implication of the TCS is that from the MNE´s point of view, global income is taxed solely by the home country. This is due to government j rebating the foreign tax load of the MNE. Like in case of the EM, eqns. (35) and (36), the first-order conditions for utility maximization with respect to saving (26) and the capital market clearing condition (27) determine the general market equilibrium. Totally differentiating (26), (27), (35) as well as (36) with respect to t_j and t_m gives the comparative static results[24]

$$\frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \tag{37}$$

$$\frac{\mathrm{d}s}{\mathrm{d}t_j} = S_r\frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \tag{38}$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} < 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_j} < 0 \tag{39}$$

$$\frac{\mathrm{d}k_{-j}}{\mathrm{d}t_j} > 0 \qquad \frac{\mathrm{d}k_{-m}}{\mathrm{d}t_j} > 0 \tag{40}$$

$$\frac{\mathrm{d}r}{\mathrm{d}t_m} = \frac{\mathrm{d}s}{\mathrm{d}t_m} = \frac{\mathrm{d}k_j}{\mathrm{d}t_m} = \frac{\mathrm{d}k_m}{\mathrm{d}t_m} = \frac{\mathrm{d}k_{-j}}{\mathrm{d}t_m} = \frac{\mathrm{d}k_{-m}}{\mathrm{d}t_m} = 0 \tag{41}$$

The interpretation of a tax-induced change in capital cost, eqns. (37), saving, (38), as well as the reaction of other MNE's factor demand, (40), is the same as regarding the EM, cf. eqns. (28), (29) and (32), and is not repeated here. Instead, we need to clarify comparative static results according to (39) and (41).

Consider again an increase in the profit tax rate in country j. Capital demand in country j consequently decreases whereas capital demand in country m decreases, too. The interpretation of the former effect follows that one discussed in the context of the EM. The latter effect, however, arises because of the fact, that t_j is the sole relevant tax rate according to total production, see (35) and (36). The tax rate in country m is irrelevant since taxes paid by the MNE to the treasury in m will be refunded by government j. In other words, from a fiscal point of view, the affiliates of the MNE reside solely in country j. If t_j is raised production cost increase, which

[24] For a detailed outline see the appendix.

tends to lower capital demand. Additionally, a higher tax rate leads to a decline in the world interest rate, cf. (37). Since it can be shown that the former negative effect again dominates the latter positive effect of less capital cost, capital demand in m falls because of an increase in t_j. Note that in contrast to the EM, the MNE is not able to avoid increased production cost by means of shifting factor demand from one country to another. This implies that relative to the EM capital cost as well as saving decline stronger under the TCS.

Equation (41) reveals that corporate taxation in country m has no effect on endogenous quantities in the first step of backward induction as government j de facto pays the tax bill of the MNE in country m.

Tax competition in the TCS. Prior to discussing externalities, we need to emphasize that the TCS induces government m to fully exploit the saving clause, see e.g. Wilson (1999). First, recall that the process of setting optimal tax rates typically requires a national government to weigh marginal benefits and marginal cost of taxation. If an internal solution to this maximization problem exists, the optimal intensity of taxation, then, is typically given if the former matches the latter. Second, be aware of the fact that in the limited TCS the MNE's tax load abroad is refunded at home. Based upon the assumption, that tax revenue is exclusively gained by taxing gross profit, see (15), marginal cost of taxation in country m end up to be absent under the TCS in a way that there is no tax-induced downturn in production, see comparative static results in (41). No matter what tax rate is set in the foreign country the tax base of the foreign affiliate remains the same as it only depends on the profit tax rate in country j. The capital market, thus, is unaffected by taxation in m as a tax-induced change in capital demand is absent. Consequently, individual saving also is unaltered as the equilibrium interest rate remains unswayed. It follows, that in country m there is only a marginal benefit of taxation in terms of a marginal increase in national tax yield. Given that the local government maximizes the latter or national welfare, the national profit tax rate, then, is set as high as possible, i.e. $t_j = t_m$.[25] This behaviour is captured by

Proposition 1 *Suppose that the TCS is implemented in a double tax treaty and that the saving clause is fulfilled ($t_j \geq t_m$), then government m always sets the same profit tax rate as government j.*

Proof. See the appendix.

Addressing efficiency properties of the TCS in case of tax revenue maximization, the externality imposed by government j on the tax base in country m is given by

$$\frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_j} = t_m \left[\bar{\Delta} F_k^m - \vartheta r\right] \frac{\mathrm{d}k_m}{\mathrm{d}t_j} - t_m \vartheta k_m \frac{\mathrm{d}r}{\mathrm{d}t_j} \quad \gtrless 0 \tag{42}$$

[25] Note, that the saving clause is crucial for the following proposition to hold. Provided that the corporate tax rate in m exceeds that one in country j, government j would not have opted for the TCS in order to relief double taxation. Moreover, the optimal tax rate in m would then be $t_m = 1$, which immediately follows from proposition 1, and tax revenue in m turns out to be entirely financed by government j.

As discussed above, profit taxation in j harms capital demand of the MNE in m, see (39). The first term in (42) captures this reaction and, thus, is negative. Setting tax rates non-cooperatively, government j does not anticipate that domestic tax revenue is gained at the expense of tax revenue in m due to less capital demand abroad. We refer to this mechanism as *indirect tax export externality*. Because of only one entrepreneurial relevant tax rate[26], a capital flight externality as in the EM is not existent.

The second term in (42) is positive, cf. eqn. (37). It represents the terms of trade externality, such that a higher tax rate in country j raises tax revenue in country m via a reduction of the MNE's local capital cost deduction. The overall property of non-cooperative profit taxation of government j regarding tax revenue in country m, thus, is ambiguous.

Considering the tax base externality inflicted by profit taxation of government m, tax revenue in country j reacts according to

$$\frac{\mathrm{d}\tilde{g}_j}{\mathrm{d}t_m} = -\left[\bar{\Delta}F^m - \vartheta r k_m\right] \; < 0 \tag{43}$$

That is, as long as there is production in country m, an increase in t_m reduces tax revenue in country j after crediting. In a Nash equilibrium, government m does not consider government j's tax relief which is carried out at the expense of tax revenue in j. The higher profit taxation is in country m, the more foreign tax load has to be credited by government j. We refer to this as *direct tax export externality*.

Turning to national welfare maximization, we apply $\eta = 1$ in (22) and (23). The comparative static effect in (37) implies that in case of corporate taxation in j the ambiguous tax base externality (42) is accompanied by a negative income externality, which is due to a tax-induced downturn in revenue from saving. The income externality regarding profit taxation in m is zero as the local corporate tax rate does not distort the capital market, see (41). This leads to

Lemma 2 *Suppose that the world economy consists of $n = 2$ countries and governments maximize national tax revenue, then the TCS leads to an ambiguous tax base externality in country m while it is negatively signed in country j. Results are the same in case of domestic welfare maximization.*

3.1.3. Full taxation after deduction system

Profit & utility maximization. Finally, supposing that government j fully taxes the repatriated net profit of the MNE generated in country m, we get

$$\mu = t_j(1 - t_m)\left[\bar{\Delta}F^m - \vartheta r k_m\right]$$

[26] Recall the first-order conditions for profit maximization (35) and (36)

in (8) leading to the first-order conditions for profit maximization in country j and m

$$\frac{\partial \tilde{\pi}_j}{\partial k_j} = (1-t_j)\left[\bar{\Delta} F_k^j - \vartheta r\right] - (1-\vartheta) r = 0 \tag{44}$$

$$\frac{\partial \tilde{\pi}_j}{\partial k_m} = (1-t_j)(1-t_m)\left[\bar{\Delta} F_k^m - \vartheta r\right] - (1-\vartheta) r = 0 \tag{45}$$

In contrast to the tax rules discussed above, capital demand in country m now depends both on t_j and t_m. Again, equations (44) and (45) together with resident z's first-order condition for utility maximization with respect to saving, cf. (26), and the capital market clearing condition (27) determine the general market equilibrium. Totally differentiating (26), (27), (44) and (45) with respect to t_j and t_m leads to the comparative static results[27]

$$\frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \qquad \frac{\mathrm{d}r}{\mathrm{d}t_m} < 0 \tag{46}$$

$$\frac{\mathrm{d}s}{\mathrm{d}t_j} = S_r \frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \qquad \frac{\mathrm{d}s}{\mathrm{d}t_m} = S_r \frac{\mathrm{d}r}{\mathrm{d}t_m} < 0 \tag{47}$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} \gtrless 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_j} < 0 \tag{48}$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_m} > 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_m} < 0 \tag{49}$$

$$\frac{\mathrm{d}k_{-j}}{\mathrm{d}t_j} > 0 \qquad \frac{\mathrm{d}k_{-j}}{\mathrm{d}t_m} > 0 \tag{50}$$

$$\frac{\mathrm{d}k_{-m}}{\mathrm{d}t_j} > 0 \qquad \frac{\mathrm{d}k_{-m}}{\mathrm{d}t_m} > 0 \tag{51}$$

The economic intuition behind the tax-induced change in capital cost, (46), saving, (47), and in other MNE's factor demand ,(50) and (51), is the same as in the EM. From equations (48) and (49), however, it can be seen that because of the actual tax rule capital demand in j and m reacts differently according to taxation in country j and m. $\frac{\mathrm{d}k_j}{\mathrm{d}t_m} > 0$ in combination with $\frac{\mathrm{d}k_m}{\mathrm{d}t_m} < 0$ indicates the typical reaction of a tax-induced shift in the MNE's capital demand, which has already been discussed in the context of the EM, cf. (31). This effect, however, is not generally true in the opposite case of increased taxation in country j. $\frac{\mathrm{d}k_m}{\mathrm{d}t_j} < 0$ from (48) builds upon the fact, that due to the FTADS the affiliate in the foreign country considers both corporate tax rates as cost factors. This implies that if t_j is increased capital demand in m is affected in two ways. First, there is a direct effect based on increased production cost, which lowers capital demand. This reaction entails a fall in user cost of capital, cf. (46), such that a second indirect effect emerges. Due to lower capital cost the latter tends to increase capital demand in the foreign county. It can be shown, that the indirect effect is outweighed by the former direct one, such that capital demand in country m falls given that the corporate tax rate at home is increased.

[27] For a detailed outline, see the appendix.

In contrast to other tax regimes, capital demand in country j reacts ambiguously because of a change in domestic taxation, see (48). Consider again an increase in t_j and note that

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} = \underbrace{\frac{\left[\bar{\Delta}F_k^j - \vartheta r\right]}{(1-t_j)\bar{\Delta}F_{kk}^j}}_{=\partial k_j/\partial t_j <0} + \underbrace{\frac{(1-t_j\vartheta)}{(1-t_j)\bar{\Delta}F_{kk}^j}\frac{\mathrm{d}r}{\mathrm{d}t_j}}_{=:\mathcal{A}>0}.$$

On the one hand, k_j decreases directly due to increased taxation (first term). On the other hand, capital demand increases indirectly due to less capital cost. This is captured by the second term $\mathcal{A}$ with (46). $\frac{\mathrm{d}k_j}{\mathrm{d}t_j} \gtrless 0$ then elucidates that exclusively in case of the FTADS and a change in country j's profit tax rate, the increase in production cost does not strictly dominate the gain from less capital cost as shown associated with other tax regimes.

Since the sign of $\mathrm{d}k_j/\mathrm{d}t_j$ depends on the deduction rate of capital cost, suppose ϑ to be raised. It follows, that the direct negative effect becomes weaker as ϑ increases, i.e. $\frac{\partial^2 k_j}{\partial t_j \partial \vartheta} > 0$. The more deduction of capital cost is permitted the less tax base ceteris paribus has to be declared by the MNE. Accordingly, an increase in taxation is less harmful to capital demand in $\partial k_j/\partial t_j$ if ϑ is raised.

As regards the indirect second effect, note that $\frac{\partial \mathcal{A}}{\partial \vartheta} < 0$. A higher depreciation rate renders the tax-induced reduction in capital cost less beneficial. The less tax base has to be declared by the MNE, the less beneficial is a decrease in production cost.

Eventually, it can be shown that if capital cost deduction is ruled out, the direct effect strictly dominates the indirect one, such that $\frac{\mathrm{d}k_j}{\mathrm{d}t_j}\big|_{\vartheta=0} < 0$. It immediately follows, that $0 < \left|\frac{\partial \mathcal{A}}{\partial \vartheta}\right| < \frac{\partial^2 k_j}{\partial t_j \partial \vartheta}$ must hold, i.e. the indirect effect falls slower in ϑ than the direct one increases therein. Under the FTADS, then, the overall sign of $\frac{\mathrm{d}k_j}{\mathrm{d}t_j}$ is given by[28]

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} \left\{ \begin{matrix} > \\ = \\ < \end{matrix} \right\} 0 \quad \text{if}$$

$$\vartheta \left\{ \begin{matrix} > \\ = \\ < \end{matrix} \right\} \frac{-nS_r(1-t_j)(1-t_m)\bar{\Delta}F_{kk}^j F_{kk}^m + (\alpha n - 1)(1-t_m)F_{kk}^m + (\beta n - 1)F_{kk}^j}{t_j(\alpha n - 1)(1-t_m)F_{kk}^m + t_j(\beta n - 1)F_{kk}^j + t_m \beta n (1-t_j)F_{kk}^j} > 0\,.$$

Tax competition in the FTADS. Focussing on tax revenue maximization ($\eta = 0$), first, totally differentiating the fiscal budget constraint (15) with respect to t_j determines the tax base externality imposed on government m. This is given by

$$\frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_j} = t_m\left[\bar{\Delta}F_k^m - \vartheta r\right]\frac{\mathrm{d}k_m}{\mathrm{d}t_j} - t_m \vartheta k_m \frac{\mathrm{d}r}{\mathrm{d}t_j} \quad \gtrless 0 \tag{52}$$

The first-order condition for profit maximization in country m (45) elucidates that, as under the TCS, t_j is a cost factor abroad. The indirect tax export externality (first term), then, is

[28] See the exact comparative static results presented in the appendix.

negative, cf. (48), whereas the terms of trade externality (second term) is positive, cf. (46). The intuition for these two effects can be found in the discussion linked to the TCS and the EM. Setting tax rates non-cooperatively, government j does not take into account, that corporate taxation at home reduces both capital demand and capital cost deduction in the foreign country. The sign of (52), thus, is indeterminate.

Totally differentiating the fiscal budget constraint of government j, (12), with respect to t_m yields the tax base externality inflicted by government m and reads

$$\begin{aligned}\frac{\mathrm{d}\tilde{g}_j}{\mathrm{d}t_m} = -t_j\left[\bar{\Delta}F^m - \vartheta r k_m\right] + t_j(1-t_m)\left[\bar{\Delta}F_k^m - \vartheta r\right]\frac{\mathrm{d}k_m}{\mathrm{d}t_m} \\ + t_j\left[\bar{\Delta}F_k^j - \vartheta r\right]\frac{\mathrm{d}k_j}{\mathrm{d}t_m} - t_j\vartheta\left(k_j + (1-t_m)k_m\right)\frac{\mathrm{d}r}{\mathrm{d}t_m} \gtrless 0\end{aligned} \tag{53}$$

Consider the tax rate in country m to be raised. According to (53) the indirect tax export externality (second term) is accompanied by a direct tax export externality (first term). The intuition for the latter is that an increase in t_m cetris paribus raises the tax load of the MNE abroad and the required tax relief of government j. The indirect effect stems from the tax-induced downturn in production in m. Accordingly, a higher t_m lowers capital demand abroad such that the repatriated profit and, thus, the tax base of the MNE at home declines, see (48). Moreover, capital demand in country j increases because of a tax-induced shift in production, cf. (49). This capital flight externality is captured by the third term in (53). Eventually, a higher tax rate in m ceteris paribus implicates a positive terms of trade externality, cf. (46). The tax load of the MNE in country j increases by the fourth term in (53) due to less capital cost deduction. Because of the negative direct and indirect tax export externality as well as the positive capital flight and terms of trade externality, the overall outcome of (53) is ambiguous.

Turning to welfare maximization ($\eta = 1$), the ambiguous tax base externalities (52) and (53) each are combined with a negative income externality. We can, thus, infer

Lemma 3 *Provided that the world economy consists of $n = 2$ countries, profit taxation under the FTADS leads to ambiguous externalities in* (22) *and* (23) *regardless of the fiscal objective.*

3.1.4. Implications for large countries

$(\eta = 0)$	$\mathrm{d}Y_m/\mathrm{d}t_j$	$\mathrm{d}Y_j/\mathrm{d}t_m$
EM	> 0	> 0
TCS	$\gtrless 0$	< 0
FTADS	$\gtrless 0$	$\gtrless 0$

Table 1: Tax revenue maximization with $n = 2$ countries

$(\eta = 1)$	$\mathrm{d}Y_m/\mathrm{d}t_j$	$\mathrm{d}Y_j/\mathrm{d}t_m$
EM	$\gtrless 0$	$\gtrless 0$
TCS	$\gtrless 0$	< 0
FTADS	$\gtrless 0$	$\gtrless 0$

Table 2: Welfare maximization with $n = 2$ countries

Based on eqns. (22) and (23), table 1 and 2 summarize lemma 1 to 3 and we conclude

Proposition 2 *Suppose that the world economy consists of $n = 2$ countries and governments uncooperatively maximize national tax revenue ($\eta = 0$), then*

i) the EM induces inefficiently low tax rates,

ii) the TCS requires cooperative tax rate setting to internalize externalities,

iii) the FTADS features ambiguous externalities.

Regarding the fiscal objective of welfare maximization, the above results can be aggregated to

Proposition 3 *Given that countries are large compared to the rest of the economy and governments maximize national welfare,*

i) the EM and the FTADS cause ambiguous externalities,

ii) the TCS leads to inefficiently high or inefficiently low tax rates.

Proposition 2 and 3 reveal, that in case of large countries, the EM is generally not superior. If the fiscal objective is to maximize treasury income, the tax base externalities obtained in our approach suggest that the EM unambiguously results in inefficiently low tax rate setting. The FTADS, however does not generally imply inefficiency. It could be possible, that those partial effects driven by a tax-induced distortion in the capital market are counterbalanced by the direct and/or indirect tax export externalities. If governments maximize national welfare, the EM and/or the FTADS might avoid tax competition. Hence, a general preclusion of the FTADS from double tax treaties, as suggested by the OECD (2010), might be detrimental. Nevertheless, the TCS always requires a process of cooperative tax rate setting to gain Pareto efficiency.

3.2. Small countries

In order to provide a comprehensive analysis and to link our approach to common assumptions in tax competition literature, we alter the influence of national tax policy on the world capital market. The assumption of large countries ($n = 2$) and one MNE is now relaxed, such that the global economy consists of $n \to \infty$ countries with $n/2$ MNEs. Owing to the large number of countries and half as many MNEs, capital demand of a single affiliate is now small compared to the rest of the economy. If national taxation, then, is increased the repercussion on the global capital market caused by a downturn in national capital demand also turns out to be small. As a consequence, local tax policy has a vanishingly small effect on the equilibrium interest rate, i.e. $\lim_{n\to\infty} \frac{\mathrm{d}r}{\mathrm{d}t_j} = \lim_{n\to\infty} \frac{\mathrm{d}r}{\mathrm{d}t_m} = 0$ irrespective of the tax system in use. In order to establish results in a general equilibrium encompassing all small countries in the global economy, recall that our analysis initially builds upon one MNE with affiliates in country j and m. We therefore commence this section by focussing on these two countries.

Suppose that governments maximize national tax receipts. Provided that national tax rate setting exhibits a vanishingly small influence on the global capital market, any interest-driven externalities imposed by taxation in either country j or m, such as the capital flight or the terms

of trade externality, also are vanishingly small. Since in the EM, the tax base externality solely comprises these two effects, the influence of national profit taxation on the other country's tax revenue given by (34) is absent. It follows, that the tax base externality is zero in case of the EM. Furthermore, note that under the TCS and under the FTADS both the direct as well as the indirect tax export externality arise because of the double tax treaty itself. Hence, these effects are present independent of relative country size. Considering the tax base externalities (42) and (43) with respect to the former tax system as well as (52) and (53) associated with the latter, interest-driven effects are lacking such that either tax base externality is unambiguously negative.[29] In case of welfare maximization, the income externality represented by the first term in (22) and (23) is absent, since national tax policy has a vanishingly small effect on the remuneration of capital market investment of resident j and m. We can, thus, state

Lemma 4 *Suppose, that governments maximize national tax revenue or national welfare and that the global economy consists of sufficiently many countries ($n \to \infty$), then eqns.* (22) *and* (23)

i) are zero in case of the EM.

ii) are negatively signed in case of the TCS as well as the FTADS. The direct and/or the indirect tax export externality prevail.

Proof. See the appendix.

In order to assess tax regimes in a general equilibrium considering small countries, we now turn to all other countries in the respective subset. Recalling (18) and (19), the effect of uncoordinated profit taxation in country j and m on the fiscal objective of other countries is given by $(\alpha n-1)\frac{\mathrm{d}Y_{-j}}{\mathrm{d}t_j}+(\beta n-1)\frac{\mathrm{d}Y_{-m}}{\mathrm{d}t_j}$ as well as by $(\alpha n-1)\frac{\mathrm{d}Y_{-j}}{\mathrm{d}t_m}+(\beta n-1)\frac{\mathrm{d}Y_{-m}}{\mathrm{d}t_m}$, respectively.[30] At this, we also need to take into account the effect of taxation in j and m on other MNEs. Comparative static results discussed previously reveal that capital demand of other affiliates generally increases due to intensified taxation in j and m concerning the EM and the FTADS, see (32), (33), (50), (51). In case of the TCS, this is only true considering profit taxation in country j, see (40) and (41). This outcome is driven by a global tax-induced downturn in capital cost, which enhances other MNEs' production and their respective tax base. Since each country and each affiliate now is presumed to be small compared to rest of the economy, the benefit of less capital cost caused by taxation in j and m accruing to another single MNE's capital demand is vanishingly small as the tax-induced interest reaction itself is negligible. However, summing up over all $(n/2-1)$ MNEs in $(\alpha n-1)+(\beta n-1)$ countries with $n \to \infty$, this benefit turns out to be unambiguously positive in (18) and (19). The intuition for this outcome is the following. Suppose government j to increase its profit tax rate given that e.g. the EM is incorporated in a double tax treaty.[31] This leads to an increase in production cost of the MNE's affiliate in

[29] Note, that due to comparative static results (37) to (41), eqn. (43) is negative anyway.

[30] It should be borne in mind that the effect of taxation in country j and m on other countries' fiscal objectives can only consist of interest-driven effetcs, i.e. the income externality, the capital flight externality and/or the terms of trade externality.

[31] Note that in the FTADS as well as in the TCS, capital demand of the foreign affiliate in country m is affected, too. The following intuition, though, applies mutatis mutandis in case of these two tax systems without changing the basic intuition. Furthermore, considering an increase in profit taxation in country m yields the same intuition in case of the EM and the FTADS. Regarding the TCS, it has already been stated that taxation in m is irrelevant with respect to other countries' fiscal objective.

country j and a drop in optimal capital demand. Since the affiliate is small compared to rest of the economy, the capital market equilibrium is hardly distorted. To equilibrate the latter, the interest rate yet needs to adjust to a very small extent nearly imperceptible to another MNE's affiliate. Its factor demand, however, increases by a minute amount. As there is a large number of entities, the aggregate over all vanishingly small reactions of all other MNEs' affiliates, then, ends up to be significantly different from zero. Simply put, the aforementioned capital flight externality capturing capital movement within a MNE in case of $n = 2$ is now replaced by an inter-MNE capital flight effect.

Besides the capital flight externality, other countries' tax base in each subset are generally affected by the terms of trade externality. As countries are small, the influence of national tax policy in country j and m on the interest rate and, hence, on capital cost deduction of another MNE is negligible. Given that tax revenue of another single government hardly benefits from a very small tax-induced reduction in national capital cost deduction, the sum of these vanishingly small effects over all other $(\alpha n - 1) + (\beta n - 1)$ countries in each subset becomes positive in (18) and (19). This result applies to the EM and the FTADS. Regarding the TCS, comparative statics in (37) reveal that this is only true with respect to taxation in country j. It is zero in the opposite case of intensified corporate taxation in country m, see (41).

Eventually, we turn to the income externality imposed on $(\alpha n - 1) + (\beta n - 1)$ representative residents. This effect depends on the tax-induced variation in the interest rate, see the first term in (20). As stated above, the income externality with respect to the resident of a single country is negligible since her revenue from saving is hardly affected given that countries are small. The sum of those negligible income effects accruing to each of the $(\alpha n - 1) + (\beta n - 1)$ representative residents, however, is negative. Each of these residents loses a very small amount in second-period income generated by capital market investment if taxation in country j or m is increased. This, again, is true in case of the EM, the FTADS and profit taxation in country j given the TCS, see again (41). We therefore reason

Lemma 5 *Suppose that the world economy consists of sufficiently many countries ($n \to \infty$), then an uncoordinated increase in corporate taxation in country j or m given the EM or the FTADS*

i) generally increases tax revenue in other countries.

ii) has an ambiguous effect on other countries' welfare.

Provided that the TCS is implemented in a double tax treaty, profit taxation in country m has no effect on other governments' fiscal objectives. Externalities caused by corporate taxation in country j feature the same results as those in presence of the EM or the FTADS.

Having scrutinized the second and fourth terms in (18) and (19), table 3 and 4 summarize lemma 4 and 5.

Compared to the efficiency properties in case of large countries, cf. propositions 2 and 3, there is no difference in quality. The EM involves inefficiently low tax rates in case of tax revenue maximization as local governments do not consider the capital flight and the terms of trade

$(\eta = 0)$	$\mathrm{d}\mathcal{Y}/\mathrm{d}t_j$	$\mathrm{d}\mathcal{Y}/\mathrm{d}t_m$
EM	> 0	> 0
TCS	$\gtrless 0$	< 0
FTADS	$\gtrless 0$	$\gtrless 0$

Table 3: Tax revenue maximization with $n \to \infty$ countries

$(\eta = 1)$	$\mathrm{d}\mathcal{Y}/\mathrm{d}t_j$	$\mathrm{d}\mathcal{Y}/\mathrm{d}t_m$
EM	$\gtrless 0$	$\gtrless 0$
TCS	$\gtrless 0$	< 0
FTADS	$\gtrless 0$	$\gtrless 0$

Table 4: Welfare maximization with $n \to \infty$ countries

externality. Regarding welfare maximization the two positive effects come along with a negative income externality, such that in the latter case source based taxation might be too low, efficient or too intense.

As the direct and indirect tax export externality emerge independently of country size and fiscal objective, the FTADS could be efficient. At this, the positive impact of the terms of trade externality and the capital flight externality on other countries might be offset by negative tax export effects (tax revenue maximization) or by negative income and tax export effects (welfare maximization).

Eventually, the TCS requires tax coordination irrespective of the fiscal objective. The driving force for this outcome still is the fact that government m can freely set the national profit tax rate bearing in mind the saving clause. Corporate taxation in m harms the fiscal objective of government j via a negative direct tax export externality and causes no international capital movement. The aforementioned positive capital flight and terms of trade externalities caused by tax-induced capital cost variations, then, are not able to arise under the TCS in order to counteract the tax export effect inflicted by government m.

Since we aim at evaluating the three tax systems considered, the results obtained are unrewarding as it is still unclear which tax regime is preferable. In order to answer this question, in the following we turn to a numerical example and fully analyze the underlying Nash tax competition game.

4. Assessing tax regimes – a numerical approach

To gain further insights into the present model, we focus on large countries and make use of the production function $F^z(k_z) = (a - bk_z)k_z$ with $z \in \{j, m\}$ and $a = 0.08$ as well as $b = 0.5$. The benefit of merging is given by $\bar{\Delta} = 2.5$. The deduction rate of capital cost and residents' endowment are assumed to be $\vartheta = 0.5$ and, respectively, $e = 1$. The fiscal objective function (16) is presumed to be of the type

$$Y_z = \eta \left[\ln(e - s_z) + c_z^2\right] + \lambda g_z$$

where λ can be interpreted as marginal cost of public funds. Because of distortive corporate taxation, these marginal cost contain opportunity cost as well as welfare cost of taxation leading to $\lambda > 1$, see e.g. Browning (1976). A common finding of empirical contributions is an estimated

range of marginal cost of public funds from 1.3 to 2.0, see e.g. Kleven and Kreiner (2006). Results are presented for $\lambda = 1.5$.

Table 5 summarizes equilibrium values after merging if governments maximize domestic tax receipts ($\eta = 0$) and set tax rates non-cooperatively. Note, that in the three columns on the right, we focus on tax revenue given by eqns. (12) as well as (15) and the sum thereof. As λ is identical across both countries, it suffices to determine $\tilde{g}_z$ with $z \in \{j, m\}$. Table 6 illustrates equilibrium values considering the cooperative solution in the same setting.

In order to contrast the three tax regimes, we have two equivalent approaches at hand. Since the cooperative solution is the same in each tax system, we can either focus on the level of tax revenue in Nash equilibria or on the deviation thereof from the efficient outcome. By choosing the latter, we evaluate tax regimes in view of global efficiency. Note, that the difference between global tax revenue in Nash equilibria and the efficient outcome captures the sum of tax base externalities inflicted by government j and m considering each tax system, viz. eqns. (34), (42), (43), (52) and (53).

Given the parameters above, table 5 and 6 elucidate that joint tax revenue with respect to individually optimal tax rates falls short of the cooperative solution by 3.44% in the TCS, 5.74% in the EM as well as 6.61% in the FTADS. Consequently, if cooperative tax rate setting is missing or impossible, the TCS should be opted for by government j from a global perspective. Regarding tax revenue in country j, however, the local government has a strong incentive to implement the FTADS in a double tax treaty, as domestic treasury income is some 70% and 67% larger than in the EM or the TCS. At the same time, government m forfeits averagely 72% of national tax revenue.

Recalling proposition 2 and the ambiguous outcome therein, a variation in the parameter b reveals, that the implication of table 5 is significantly dependent on parameters of the production function.[32] It can be shown that the ranking of tax regimes is related to the parameter b in such a way that three threshold values can be identified. That is

$$\begin{aligned}
b \geq 0.78 &\Rightarrow \text{EM} \geq \text{TCS} > \text{FTADS} \quad (-2.96\% > -7.48\%) \\
0.78 > b \geq 0.461 &\Rightarrow \text{TCS} > \text{EM} \geq \text{FTADS} \quad (-3.53\% > -6.43\%) \\
0.461 > b \geq 0.195 &\Rightarrow \text{TCS} \geq \text{FTADS} > \text{EM} \quad (-4.23\% > 18.7\%) \\
b < 0.195 &\Rightarrow \text{FTADS} > \text{TCS} > \text{EM}
\end{aligned}$$

where the percentage value in parenthesis denotes the respective deviation of Nash equilibria from the efficient solution if the previous expression is satisfied with equality.

We find that results presented in table 5 are only true in case of $b \in (0.461, 0.78)$. If b is set above the upper threshold, the ranking regarding the TCS and the EM is reversed, such

[32] Other parameters similarly affect the result of our numerical approach. However, attempting to reproduce the following results for $b = 0.5$ via a variation in other parameters fails on feasible equilibrium values or on plausible parameter values.

that for $b > 0.78$ the latter ends up to be the least inefficient tax rule. Additionally, a higher b renders the FTADS more inefficient. Regarding a decrease in b with $b \in (0.195, 0.461)$ the ranking derived via table 5 is changed with respect to the second and third position. The lower b is the more inefficient is the EM. The FTADS, however benefits from less b up to the point where, compared to the EM and the TCS, joint tax revenue is closest to the efficient solution ($b < 0.195$). Moreover, if the parameter considered is sufficiently small, it turns out that the FTADS results in an efficient outcome at $b \approx 5 \cdot 10^{-5}$, whereas the TCS and the EM fall short of the cooperative solution by 5.05% and 99.9%, respectively. By and large, a variation in b shows up to affect Nash equilibria to a varying extent. The EM reacts strongest compared to the FTADS and the TCS. The latter system, on the contrary, reacts weakest as inefficiency raises from 2.96% ($b = 0.78$) to 5.05% ($b \approx 5 \cdot 10^{-5}$).

A sensitivity analysis reveals that a 30%-variation in a, $\bar{\Delta}$ and ϑ is linked to reasonable adjustments in b to maintain the above differentiation. At this, b has to be raised or lowered by 40% at the utmost with $\bar{\Delta}$ having the greatest and a having the smallest influence. The endowment e, however, can be shown to be crucial for present results. An increase or decrease therein by 30% turns out to provide infeasible equilibria. To guarantee validity, only a 2%-variation in e is viable also requiring appropriate adjustments in b by a maximum shift of some 58%.

Turning to welfare maximization, table 7 and 8 depict quantities set in a Nash equilibrium as well as with regard to cooperative tax rate setting. Utility of each representative resident and global welfare in the former case can be found in the three columns on the right of table 7, whereas the last column in table 8 indicates global welfare if tax rates are set cooperatively.[33] A first insight is, that government j again has a strong incentive to relief double taxation using the FTADS. At this, domestic welfare is some 50% and 55% larger than with respect to the EM or the TCS. Welfare in country m, on the contrary, is averagely 60% larger if government j desists from the FTADS.

Following the above reasoning, we find that considering uncoordinated tax rate setting, the EM provides the highest global welfare deviating from efficiency by 1.29%. The sum of income and tax base externality in the TCS and the FTADS amounts to 4.72% and, respectively, 7.33% of the cooperative outcome. In contrast to the case of tax revenue maximization, a threshold value with respect to the parameter b is absent.

Conducting a sensitivity analysis via a 30%-variation in a, $\bar{\Delta}$ and ϑ as well as $\lambda \in [1.3, 2]$ proves the outcome to remain robust. Again, endowment e is crucial as only a maximum increase of 5% or a decrease of not more than 0.3% ensures feasible equilibrium values. Nevertheless, the ranking of tax regimes persists.

The findings associated with our numerical simulation, then, can be subsumed to

[33] In calculating welfare, we took into account, that the equilibrium price for merging P reduces second period income of resident j and m to the symmetric exogenous outside options π_j and π_m given by eqn. (1) and revenue from first-period saving. This can be seen by substituting $(1 + r)P = \tilde{\pi}_j - \pi_j$ into (11) and $(1 + r)P = \pi_m$ into (14). Because of the quasi-linear utility function (4), utility of second period consumption financed by (1) is excluded from the last columns in table 7 and 8. An inclusion would commonly increase respective values by the same amount.

Proposition 4 *Provided that the production function of the MNE's affiliate in country $z \in \{j, m\}$ is of the type $F^z(k_z) = (a - bk_z)k_z$,*

i) no tax regime generally provides Pareto efficiency.

ii) any tax system can be preferable according to the Pareto criterion in case of uncoordinated national tax revenue maximization. The choice between the EM, the FTADS and the TCS substantially depends on the parameters of the production function.

iii) the EM is the least inefficient tax rule if governments non-cooperatively maximize domestic welfare.

iv) government j has a strong interest in relieving double taxation by means of the FTADS.

5. Conclusion

In the present paper, we analyze tax competition with local public good provision in a general equilibrium model. In contrast to Dickescheid (2004), investment behaviour is presumed to base on cross-border acquisitions of firms. For the purpose of facilitating results and to ease notation, the analysis is restrained to one-way investments and multinationals consisting of two representative affiliates. The investor is supposed to own one of these former independent representative firms in the first place. Followed by an acquisition of a foreign firm, net profit generated by the affiliate abroad, then, is fully repatriated to the home country of the investor. Moreover, the benefit of merging firms is presumed to have a direct effect on production output as in e.g. Haufler and Schulte (2011). This reflects a deeper integration of merging advantages as in Becker and Fuest (2011), as they model this benefit in terms of an additively separable profit boost.

Our main findings are the following. In case of large countries and one multinational enterprise, treasury income maximization results in inefficiently low tax rates vis-a-vis the EM. Uncoordinated national tax rate setting imposes a well known positive capital flight externality as well as a positive terms of trade externality. The total tax base externality, thus, turns out to be positive. Under the TCS as well as under the FTADS, however, another externality emerges, which in line with Dickescheid is referred to as tax export externality. In our approach, though, a distinction has to be drawn between a negative direct as well as a negative indirect tax export effect. The intuition for the former one is as follows. By raising a foreign tax on profit generated abroad, the government at home forfeits part of the national tax base by less repatriated net income. Furthermore, if the government abroad intensifies taxation, the double tax relief at home increases. This occurs at the cost of national tax receipts at home. The second indirect effect bases on the influence of taxation on factor demand. In the FTADS the foreign affiliate treats both tax rates - at home and abroad - as cost factors, such that levying taxes in any country is detrimental to tax revenue in the opposite jurisdiction. To gain a better understanding of this finding, suppose an increase in either tax rate. Thereby the home government loses some tax base by means of less repatriated income which in turn is based on a decrease in factor demand

Tax regime	r	t_j	t_m	k_j	k_m	$\tilde{g}_j$	$\tilde{g}_m$	$\tilde{g}_j + \tilde{g}_m$
EM	.064276	.652075	.652075	.060394	.060394	.005124	.005124	.010248
TCS	.043454	.827863	.827863	.041644	.041644	.005249	.005249	.010498
FTADS	.047835	.751131	.322875	.063982	.027321	.00875	.001403	.010153

Table 5: Tax revenue maximization (Nash equilibria)

Tax regime	r	t_j	t_m	k_j	k_m	$\tilde{g}_j + \tilde{g}_m$
EM	.052812	.761875	.761875	.050163	.050163	.010872
TCS	.052812	.761875	.761875	.050163	.050163	.010872
FTADS	.052812	.761875	0	.050163	.050163	.010872

Table 6: Tax revenue maximization (Pareto efficiency)

Tax regime	r	s	t_j	t_m	k_j	k_m	$\tilde{U}_j$	$\tilde{U}_m$	$\tilde{U}_j + \tilde{U}_m$
EM	.066757	.062579	.622405	.622405	.062579	.062579	.009583	.009583	.019167
TCS	.048736	.046471	.792688	.792688	.046471	.046471	.00925	.00925	.0185
FTADS	.051919	.049357	.712686	.327418	.06695	.031763	.014286	.003708	.017994

Table 7: Welfare maximization (Nash equilibria)

Tax regime	r	s	t_j	t_m	k_j	k_m	$\tilde{U}_j + \tilde{U}_m$
EM	.060847	.057357	.689178	.689178	.057357	.057357	.019417
TCS	.060847	.057357	.689178	.689178	.057357	.057357	.019417
FTADS	.060847	.057357	.689178	0	.057357	.057357	.019417

Table 8: Welfare maximization (Pareto efficiency)

abroad caused by intensified foreign taxation. Likewise, foreign tax receipts suffer from increased taxation at home as higher production cost lead to diminished production of the affiliate located in the foreign country and less domestic tax base. Put differently, either tax export externality represents the incentive of governments to gain tax revenue at the expense of the respective other country. Considering efficiency properties of taxation in the home country, the indirect tax export externality is in opposition to the terms of trade externality. Capital movement as described by the capital flight externality is absent since both affiliates are directly affected by the respective tax rate. Taxation in the foreign country comes along with all four effects such that profit taxation can either be too low, efficient or too intense.

Results associated with the TCS differ slightly. First of all recall that we focus on the limited TCS, see also Davies (2003). At this, the home government is only willing to relief double taxation if the foreign tax rate is not larger than the domestic counterpart. Given this saving clause is met, taxes paid by the foreign affiliate to the foreign treasury are entirely refunded by the home government. The multinational anticipates this rebate and production abroad ends up to be solely dependent on profit taxation at home. Irrespective of the intensity of taxation, the foreign tax base will ceteris paribus remain the same. Since our model features only profit taxation, the foreign government consequently does not need to account for marginal cost of taxation given by a tax-induced change in production. It sets the national tax rate at the upper boundary subject to the saving clause as there is only a marginal benefit of taxation, i.e. higher tax revenue. As a result, tax rates are equal, see Wilson (1999). Turning to the efficiency properties of the TCS, the negative direct tax export externality inflicted by foreign taxation remains. Profit taxation at home is shown to feature the same properties as in the FTADS.

Changing the fiscal objective into welfare maximization, the above findings are complemented by a negative income externality incorporating a tax-induced change in saving return. This effect accrues to each national resident under the EM and under the FTADS, such that in each case the overall exsternality is ambiguously signed implying that tax rates are set inefficiently low, efficient or inefficiently high. Under the TCS, though, it is shown that cooperative tax rate setting is mandatory to reach an efficient outcome. This finding bases upon the above argumentation according to taxation in the foreign country. A negative income externality is not able to arise at home, since the world capital market is not distorted by profit taxation in the foreign country.

Having interpreted the scenario of two large countries, we next turn to the case of many small countries the world economy consists of. An implication of this assumption for our model is that instead of one there are many identical multinational enterprises with overall as many affiliates as there are countries. We find that in a general equilibrium, the quality of externalities obtained corresponds with the case of large countries. The main difference, however, is that capital movement characterized by the capital flight externality occurs between multinationals rather than within a single enterprise. This is in contrast to the case of large countries, where factors are shifted between affiliates.

Because of the lack of clearness, we also establish numerical results regarding each fiscal objective. The simulation shows that no tax system achieves a Pareto efficient allocation in a broad scope

of parameter constellations. Instead, it is shown that in case of tax revenue maximization and with respect to global efficiency a clear-cut decision in favour of one system is impossible to make. Depending on the parameters of the production function employed, we are able to point out three according thresholds that each are connected with a different ranking of tax systems. Considering welfare maximization source-based taxation, i.e. the EM, is found to be preferable to the TCS, which in turn dominates the FTADS. In each setting, though, the government of the country net profit is repatriated to is proven to have a strong incentive to reduce double taxation via the FTADS. At this, national tax yield and national welfare are significantly larger than under the EM or the TCS.

Eventually, it has to be pointed out, that our results are highly driven by the assumption of one-way foreign direct investments as well as the absence of greenfield investment. Scrutinizing efficiency properties of double tax treaties incorporating these extensions is postponed to future studies.

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A. Appendix

A.1. Comparative static results

Exemption method

$$\frac{\mathrm{d}r}{\mathrm{d}t_j} = \frac{\left[\bar{\Delta}F_k^j - \vartheta r\right](1-t_m)F_{kk}^m}{\mathcal{A}} < 0 \qquad \frac{\mathrm{d}r}{\mathrm{d}t_m} = \frac{\left[\bar{\Delta}F_k^m - \vartheta r\right](1-t_j)F_{kk}^j}{\mathcal{A}} < 0$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} = \frac{[\bar{\Delta}F_k^j - \vartheta r]}{(1-t_j)\bar{\Delta}F_{kk}^j} + \frac{\mathrm{d}r}{\mathrm{d}t_j}\frac{(1-t_j\vartheta)}{(1-t_j)\bar{\Delta}F_{kk}^j} < 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_m} = \frac{[\bar{\Delta}F_k^m - \vartheta r]}{(1-t_m)\bar{\Delta}F_{kk}^m} + \frac{\mathrm{d}r}{\mathrm{d}t_m}\frac{(1-t_m\vartheta)}{(1-t_m)\bar{\Delta}F_{kk}^m} < 0$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_m} = \frac{\mathrm{d}r}{\mathrm{d}t_m}\frac{(1-t_j\vartheta)}{(1-t_j)\bar{\Delta}F_{kk}^j} > 0 \qquad \frac{\mathrm{d}k_m}{\mathrm{d}t_j} = \frac{\mathrm{d}r}{\mathrm{d}t_j}\frac{(1-t_m\vartheta)}{(1-t_m)\bar{\Delta}F_{kk}^m} > 0$$

$$\frac{\mathrm{d}k_{-j}}{\mathrm{d}t_j} = \frac{\mathrm{d}r}{\mathrm{d}t_j}\frac{(1-t_{-j}\vartheta)}{(1-t_{-j})\bar{\Delta}F_{kk}^{-j}} > 0 \qquad \frac{\mathrm{d}k_{-j}}{\mathrm{d}t_m} = \frac{\mathrm{d}r}{\mathrm{d}t_m}\frac{(1-t_{-j}\vartheta)}{(1-t_{-j})\bar{\Delta}F_{kk}^{-j}} > 0$$

$$\frac{\mathrm{d}k_{-m}}{\mathrm{d}t_j} = \frac{\mathrm{d}r}{\mathrm{d}t_j}\frac{(1-t_{-m}\vartheta)}{(1-t_{-m})\bar{\Delta}F_{kk}^{-m}} > 0 \qquad \frac{\mathrm{d}k_{-m}}{\mathrm{d}t_m} = \frac{\mathrm{d}r}{\mathrm{d}t_m}\frac{(1-t_{-m}\vartheta)}{(1-t_{-m})\bar{\Delta}F_{kk}^{-m}} > 0$$

$$\frac{\mathrm{d}s_i}{\mathrm{d}t_z} = S_r^i\frac{\mathrm{d}r}{\mathrm{d}t_z} < 0 \quad i \in \{1,\ldots,n\},\ z \in \{j,m\}$$

where $\mathcal{A} = nS_r\bar{\Delta}(1-t_j)(1-t_m)F_{kk}^jF_{kk}^m - \alpha n(1-t_j\vartheta)(1-t_m)F_{kk}^m - \beta n(1-t_m\vartheta)(1-t_j)F_{kk}^j > 0$

Tax credit system

$$\frac{\mathrm{d}r}{\mathrm{d}t_j} = \frac{\left[\bar{\Delta}F_k^j - \vartheta r\right]F_{kk}^m + \left[\bar{\Delta}F_k^m - \vartheta r\right]F_{kk}^j}{\mathcal{B}} < 0$$

$$\frac{\mathrm{d}k_j}{\mathrm{d}t_j} = \frac{1}{(1-t_j)\bar{\Delta}F_{kk}^j\mathcal{B}} \cdot [\bar{\Delta}F_k^j - \vartheta r]\left(nS_r(1-t_j)\bar{\Delta}F_{kk}^jF_{kk}^m - (1-t_j\vartheta)\left((\alpha n-1)F_{kk}^m - (\beta n-1)F_{kk}^j\right)\right) < 0$$

$$\frac{\mathrm{d}k_m}{\mathrm{d}t_j} = \frac{1}{(1-t_j)\bar{\Delta}F_{kk}^m\mathcal{B}} \cdot [\bar{\Delta}F_k^m - \vartheta r]\left(nS_r(1-t_j)\bar{\Delta}F_{kk}^jF_{kk}^m - (1-t_j\vartheta)\left((\alpha n-1)F_{kk}^m - (\beta n-1)F_{kk}^j\right)\right) > 0$$

$$\frac{\mathrm{d}k_{-j}}{\mathrm{d}t_j} = \frac{\mathrm{d}r}{\mathrm{d}t_j}\frac{(1-t_j\vartheta)}{(1-t_{-j})\bar{\Delta}F_{kk}^{-j}} > 0$$

$$\frac{\mathrm{d}k_{-m}}{\mathrm{d}t_j} = \frac{\mathrm{d}r}{\mathrm{d}t_j}\frac{(1-t_j\vartheta)}{(1-t_{-j})\bar{\Delta}F_{kk}^{-m}} > 0$$

$$\frac{\mathrm{d}s_i}{\mathrm{d}t_j} = S_r^i\frac{\mathrm{d}r}{\mathrm{d}t_j} < 0 \quad i \in \{1,\ldots,n\}$$

where $\mathcal{B} = nS_r(1-t_j)\bar{\Delta}F_{kk}^jF_{kk}^m - (1-t_j\vartheta)\left(\alpha nF_{kk}^m + \beta nF_{kk}^j\right) > 0.$

Full taxation after deduction system

$$
\begin{aligned}
\frac{\mathrm{d}r}{\mathrm{d}t_j} &= \frac{(1-t_m)\left([\bar{\Delta}F_k^j-\vartheta r]F_{kk}^m+[\bar{\Delta}F_k^m-\vartheta r]F_{kk}^j\right)}{\mathcal{C}} \;<0\\
\frac{\mathrm{d}r}{\mathrm{d}t_m} &= \frac{(1-t_j)[\bar{\Delta}F_k^m-\vartheta r]F_{kk}^j}{\mathcal{C}} \;<0\\
\frac{\mathrm{d}k_j}{\mathrm{d}t_j} &= \frac{1}{(1-t_j)\bar{\Delta}F_{kk}^j\mathcal{C}}\\
&\quad\cdot[\bar{\Delta}F_k^j-\vartheta r]\Big(nS_r(1-t_j)(1-t_m)\bar{\Delta}F_{kk}^jF_{kk}^m-(\alpha n-1)(1-t_j\vartheta)(1-t_m)F_{kk}^m\\
&\quad-(\beta n-1)(1-t_j\vartheta)F_{kk}^j+t_m\vartheta\beta n(1-t_j)F_{kk}^j\Big)\;\gtrless 0\\
\frac{\mathrm{d}k_m}{\mathrm{d}t_m} &= \frac{1}{(1-t_m)\bar{\Delta}F_{kk}^m\mathcal{C}}\\
&\quad\cdot[\bar{\Delta}F_k^m-\vartheta r]\Big(nS_r(1-t_j)(1-t_m)\bar{\Delta}F_{kk}^jF_{kk}^m-\alpha n(1-t_j\vartheta)(1-t_m)F_{kk}^m\\
&\quad-(\beta n-1)(1-\vartheta(t_j+t_m-t_jt_m))F_{kk}^j\Big)\;<0\\
\frac{\mathrm{d}k_m}{\mathrm{d}t_j} &= \frac{1}{(1-t_j)\bar{\Delta}F_{kk}^m\mathcal{C}}\\
&\quad\cdot[\bar{\Delta}F_{kk}^m-\vartheta r]\Big(nS_r(1-t_j)(1-t_m)\bar{\Delta}F_{kk}^jF_{kk}^m-(\alpha n-1)(1-t_j\vartheta)(1-t_m)F_{kk}^m\\
&\quad-t_m\vartheta(1-t_j)(1-t_m)F_{kk}^m-(\beta n-1)(1-\vartheta(t_j+t_m-t_jt_m))F_{kk}^j\Big)\;<0\\
\frac{\mathrm{d}k_j}{\mathrm{d}t_m} &= \frac{\mathrm{d}r}{\mathrm{d}t_m}\frac{(1-t_j\vartheta)}{(1-t_j)\bar{\Delta}F_{kk}^j}\;>0\\
\frac{\mathrm{d}k_{-j}}{\mathrm{d}t_z} &= \frac{\mathrm{d}r}{\mathrm{d}t_z}\frac{(1-t_{-j}\vartheta)}{(1-t_{-j})\bar{\Delta}F_{kk}^{-j}}\;>0\quad z\in\{j,m\}\\
\frac{\mathrm{d}k_{-m}}{\mathrm{d}t_z} &= \frac{\mathrm{d}r}{\mathrm{d}t_z}\frac{(1-\vartheta(t_{-j}+t_{-m}-t_{-j}t_{-m}))}{(1-t_{-j})(1-t_{-m})\bar{\Delta}F_{kk}^{-m}}\;>0\quad z\in\{j,m\}\\
\frac{\mathrm{d}s_i}{\mathrm{d}t_z} &= S_r^i\frac{\mathrm{d}r}{\mathrm{d}t_z}\;<0\quad i\in\{1,\ldots,n\},\ z\in\{j,m\}
\end{aligned}
$$

where $\mathcal{C}=nS_r(1-t_j)(1-t_m)\bar{\Delta}F_{kk}^jF_{kk}^m-\alpha n(1-t_j\vartheta)(1-t_m)F_{kk}^m-\beta n(1-\vartheta(t_j+t_m-t_jt_m))F_{kk}^j>0$.

Proof of proposition 1

Proof. The general first-order condition for maximizing government m's fiscal objective (16), taking into account (10) to (15), is given by

$$
\frac{\mathrm{d}Y_m}{\mathrm{d}t_m}=\eta\left[\frac{\mathrm{d}u(\tilde{c}_m^1)}{\mathrm{d}t_m}+\frac{\mathrm{d}\tilde{c}_m^2}{\mathrm{d}t_m}\right]+V_g\frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_m}=0 \tag{54}
$$

where

$$
\frac{\mathrm{d}u(\tilde{c}_m^1)}{\mathrm{d}t_m}+\frac{\mathrm{d}\tilde{c}_m^2}{\mathrm{d}t_m}=s_m\frac{\mathrm{d}r}{\mathrm{d}t_m}\,,
$$

$$\frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_m} = \left[\bar{\Delta}F^m - \vartheta r k_m\right] + t_m[\bar{\Delta}F_k^m - \vartheta r]\frac{\mathrm{d}k_m}{\mathrm{d}t_m} - t_m \vartheta k_m \frac{\mathrm{d}r}{\mathrm{d}t_m}$$

If the TCS is implemented in the double taxation treaty and if $t_j \geq t_m$ there is only one relevant tax rate for the MNE, cf. (35) and (36). Recalling comparative static results (37) to (41), capital demand of the MNE is not affected by profit taxation in country m. It follows that $\frac{\mathrm{d}k_m}{\mathrm{d}t_m} = \frac{\mathrm{d}r}{\mathrm{d}t_m} = 0$ applies in (54). Hence, as long as there is production in country m, equation (54) reads

$$\frac{\mathrm{d}Y_m}{\mathrm{d}t_m} = \left[\bar{\Delta}F^m - \vartheta r k_m\right] > 0$$

and induces a tax rate in country m that is set at its upper boundary, i. e. $t_j = t_m$. ■

A.2. Proof of lemma 4

Proof. Substitute $\lim_{n\to\infty} \frac{\mathrm{d}r}{\mathrm{d}t_j} = \lim_{n\to\infty} \frac{\mathrm{d}r}{\mathrm{d}t_m} = 0$ in eqns. (34), (42), (52) and (53). Considering the EM, we obtain

$$\lim_{n\to\infty} \frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_j}\bigg|_{EM} = 0. \tag{A1}$$

which is symmetrical. The tax base externality caused by setting t_j under the TCS and the FTADS is generally given by

$$\lim_{n\to\infty} \frac{\mathrm{d}\tilde{g}_m}{\mathrm{d}t_j} = t_m \left[\bar{\Delta}F_k^m - \vartheta r\right] \frac{\mathrm{d}k_m}{\mathrm{d}t_j} \; < 0 \tag{A2}$$

with

$$\lim_{n\to\infty} \frac{\mathrm{d}k_m}{\mathrm{d}t_j} = \frac{\bar{\Delta}F_k^m - \vartheta r}{(1-t_j)\bar{\Delta}F_{kk}^m} < 0$$

Under the FTADS, the tax base externality of setting t_m reads

$$\lim_{n\to\infty} \frac{\mathrm{d}\tilde{g}_j}{\mathrm{d}t_m} = -t_j \left[\bar{\Delta}F^m - \vartheta r k_m\right] + t_j(1-t_m) \left[\bar{\Delta}F_k^m - \vartheta r\right] \frac{\mathrm{d}k_m}{\mathrm{d}t_m} < 0 \tag{A3}$$

with

$$\lim_{n\to\infty} \frac{\mathrm{d}k_m}{\mathrm{d}t_m} = \frac{\bar{\Delta}F_k^m - \vartheta r}{(1-t_m)\bar{\Delta}F_{kk}^m} < 0$$

Under the TCS the direct tax export externality of setting t_m remains unchanged, cf. eqn. (43). Equations (A2), (A3) as well as (43) are unambiguously negative due to comparative static results from eqns. (39) and (48) for $n \to \infty$. ■