Fiscal Autonomy under Formula Apportionment*

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Abstract: This paper investigates the choice of apportionment factors under a corporate tax system of Formula Apportionment. In a fully decentralized system jurisdictions choose apportionment weights non-cooperatively and in equilibrium the apportionment formula contains both mobile (capital) and immobile (labor) factors. As a result, tax rates and the quantities of local public goods are inefficient. A welfare gain can be realized by delegating the decision over apportionment factors to a central planner (centralization), while at the same time allowing jurisdictions fiscal autonomy in setting tax rates. In contrast to perceived wisdom, we show that a central planner also uses mobile factors as apportionment weights. The reason is fiscal externalities arising under FA that have previously not been identified in the tax competition literature.

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1 Introduction

Many federal countries such as Canada, Germany, Switzerland and the U.S. tax the corporate income of multijurisdictional enterprises by Formula Apportionment. Under such a system an enterprise consolidates the income of its affiliates into a single measure of (federal) taxable income, which is then allocated among jurisdictions according to a certain formula reflecting the corporate group's activity within each jurisdiction. As apportionment factors the formula usually employs the firm's payroll, capital and sales shares in the taxing jurisdictions.[1] The European Commission (Commission 2001a,b) has recommended that Formula Apportionment is implemented within the European Union. Among the reasons given for such a move is the desire to level the playing field for business competition, and the need to eliminate the problem of transfer pricing and competition among countries over shifty corporate income. A further attractive feature that has been emphasized is that, in contrast to tax harmonization, Formula Apportionment allows each country to retain its fiscal autonomy.

Fiscal autonomy is normally associated with a country's ability to independently choose its tax rate. The very nature of Formula Apportionment means that each country is allocated a share of profits that it can apply its own tax rate to without affecting the taxing ability of other countries. An open question, however, is whether the choice of apportionment factors in the formula should be centralized or decentralized. McLure (1980) demonstrates that Formula Apportionment transforms the corporate income tax into a tax on the apportionment factors and argues that it is therefore better to use immobile factors (low tax sensitivity) rather than mobile factors (high tax sensitivity) in the apportionment formula. This line of reasoning also follows from standard tax competition analysis (e.g. Gordon, 1986), where it is well known that a tax on a perfectly mobile factor (capital) would be fully passed on to immobile factors (labor). It is therefore better to levy a tax directly on the immobile tax base, since such a policy reduces the excess burden of the tax and is capable of implementing the first-best optimum. Our analysis shows that various fiscal externalities arise under

[1] To see how Formula Apportionment works consider a state which puts equal weight on all three apportionment factors. If a firm invests 30% of its total investment, sells 60% of its total production and incurs 30% of its total labor cost in that state, then the share of the firm's consolidated profit assigned to that state amounts to 40% ($= 30\% \times 0.33 + 60\% \times 0.33 + 30\% \times 0.33$).

formula apportionment that do not exist in standard tax competition analysis. These externalities invalidate the standard way of thinking about tax incidence and excess burden when jurisdictions compete over mobile tax bases.

A core result of our analysis is that if the choice of tax rates and apportionment factors is decentralized, each jurisdiction has an incentive to apportion corporate income by use of *both* mobile and immobile apportionment factors. The reason is that starting from a situation with labor as sole apportionment factor, a marginal reduction in a jurisdiction's weight on labor combined with a marginal increase (from zero) in the weight placed on capital, makes labor in country i cheaper relatively to labor in country j. This causes the MNE to demand more labor with rising wages and welfare in country i as an end result. The negative impact on capital formation in country i in equilibrium is of zero magnitude at the margin. Our finding is supported by evidence from the U.S. Formula Apportionment system where tax rates and the apportionment factors are chosen by the states. Martens-Weiner (2005a) documents that none of the 46 states with a corporate income tax uses only immobile factors in their apportionment formula. As a matter of fact, all but three states use mobile capital as well. The average weight placed on the capital factor is almost equal to that placed on the payroll and amounts to roughly 25%.

A second main result emerging from our analysis is when jurisdictions set tax rates and apportionment weights non-cooperatively, tax rates are set too low in the Nash equilibrium if the cost of capital is fully deductible. If on the other hand, the cost of capital cannot be fully deducted against taxable revenue, tax rates may be set either too high or too low. The reason for this inefficiency is that the jurisdictions' choice of tax rates causes several fiscal externalities and that with a decentralized choice of apportionment factors the sum of externalities turns out to be positive if the cost of capital is fully tax deductible, but may be negative under incomplete deductibility. Finally, we show that the inefficiency that arises under a fully decentralized system can be mitigated by allowing a central planner to choose the (common) apportionment factors while fiscal autonomy regarding tax rates remains with the jurisdictions. Surprisingly, under such a system (to be called a centralized system) the social planner also includes mobile factors in the apportionment formula, and the weight placed on the mobile factor may even exceed the weight on this factor chosen in the decentralized setting. The reason is that the social planner uses the formula weight as a corrective device in order to minimize the distortions. The solution to this minimization problem is not attained if the central planner puts the whole formula weight on immobile labor. Instead, due to the possible overtaxation under incomplete deductibility it may well be the case that the distortions are minimized by placing a higher weight on capital than what is the case in the decentralized setting.

These insights have strong political implications for the debate on the possible introduction of Formula Apportionment in the European Union. Our analysis suggests that the Union itself should be responsible for setting the formula weights and that it should include mobile apportionment factors in the formula. Moreover, the results have implications for the existing Formula Apportionment systems. For example, the German local business tax of multiregional firms is apportioned to the German municipalities by a formula that is centrally chosen and contains labor as the sole apportionment factor. Centralization of the formula design is supported by our analysis, but the results suggest that efficiency gains can be attained if the German system takes into account capital as an apportionment factor. Last but not least, our analysis also provides important policy implications for the U.S. Formula Apportionment system. Based on Article IV of the Multistate Tax Compact from 1967 the U.S. states initially committed themselves to use the so-called Massachusetts formula that places equal weight on the property, payroll and sales factors in the apportionment formula. Such a setting is supported by our results. However, after the famous Moorman vs. Bair decision of the U.S. Supreme Court in 1978, many states deviated from the Massachusetts formula and the choice of apportionment factors is by now essentially decentralized. Our analysis suggests that this development was detrimental and that the states can realize welfare gains by returning to a compact on the use of a common apportionment formula.

The findings in our paper are brought forth using a two-country model with one (representative) multinational enterprise (henceforth MNE) that runs a subsidiary in each country. The MNE produces an output good in each of its affiliates using a mobile (capital) and an immobile input (labor). The production function exhibits decreasing returns to scale that gives rise to a positive pure profit which can be taxed. The consolidated tax base of the MNE is allocated to the two countries with the help of a formula that equals a convex combination of the MNE's capital and labor shares in the countries. Tax revenues are used to finance locally provided public goods. We first consider the cooperative (Pareto efficient) solution obtained by a social planner who sets both tax rates and the formula weights placed on the capital and labor factors in order to maximize joint welfare of the two countries. This solution is used as benchmark for the equilibrium of a (Nash) tax competition game in a fully decentralized economy where jurisdictions non-cooperatively determine all policy instruments. Finally, we consider the centralized economy where the central planner chooses the formula while the jurisdictions set the tax rates.

Our paper is part of a very small literature that considers the choice of apportionment factors under Formula Apportionment.[2] In contrast to our findings Wellisch (2004) shows that when apportionment factors are chosen at a decentralized level, countries use only immobile factors (as suggested by the first intuition). As a consequence he finds that the corporate tax effectively turns into a non-distortionary lump-sum tax, which is capable of implementing the first-best welfare optimum. Hence, contrary to our conclusion, Wellisch (2004) provides an argument in favor of the decentralized choice of apportionment factors. However, he models the corporate tax as a source-based wealth tax on capital, since profit income in his model is zero due to the assumption of constant returns to scale. This effectively turns his model into the canonical tax competition model where, as stated above, it is well known that it is optimal to tax immobile factors. Our analysis makes it clear that such a short-cut of corporate taxation may lead to completely different results compared to a model which views corporate taxation explicitly as a tax on corporate income.

Anand and Sansing (2000) also consider the choice of apportionment factors under Formula Apportionment. They theoretically and empirically find that in a decentralized setting importing countries have an incentive to place more weight on the sales factor than exporting countries. Hence, the decentralized economy misses the efficient solution which is characterized by an equal formula across countries. In contrast to our analysis, however, this inefficiency result rests on the assumption of asymmetric

[2]There is a rapidly growing literature on corporate income taxation under Formula Apportionment versus Separate Accounting. See Gordon and Wilson (1986), Eggert and Schjelderup (2003), Nielsen et al. (2003, 2004), Pethig and Wagener (2006), Sørensen (2004), Kind et al. (2005), Gérard (2005, 2006) and Riedel and Runkel (2006). But none of these studies discuss the relative merits of a centralized versus decentralized choice of apportionment factors under Formula Apportionment.

countries. We show that the decentralized choice of apportionment factors may render corporate income taxation inefficient even if we ignore country asymmetries. Moreover, Anand and Sansing (2000) take into account only one (immobile) production factor and, thus, cannot answer the question of how to distribute the tax burden on mobile and immobile factors. They also assume a fixed tax rate and therefore do not work out the implications of the formula design for the efficiency properties of tax rates.

The paper is organized as follows. The next section describes the behavior of the representative MNE. In Section 3, we investigate the cooperative (Pareto efficient) solution. Sections 4 and 5 then analyze the decentralized and centralized choice of apportionment factors, respectively. Section 6 concludes.

2 Firms

We consider a model with two countries (jurisdictions) labeled a and b. There is a large number of MNEs. All firms are identical so we restrict attention to a representative MNE which operates a subsidiary in both countries. In country $i \in \{a, b\}$, it employs k_i units of capital and ℓ_i units of labor in order to produce $F(k_i, \ell_i)$ units of an output good whose price is normalized to one. The production function F exhibits positive and decreasing returns to each input, i.e. $F_x > 0$ and $F_{xx} < 0$ for $x \in \{k_i, \ell_i\}$. Capital and labor are complements so that $F_{k\ell} > 0$. Moreover, we assume that F is homogenous of degree $\eta \in]0, 1[$ so that $F(\theta k_i, \theta \ell_i) = \theta^\eta F(k_i, \ell_i)$ for all $\theta > 0$. The condition $\eta \in]0, 1[$ implies that the production function shows decreasing returns to scale. This property implicitly assumes a fixed third production factor like, e.g., entrepreneurial services, which gives rise to positive pure profit. The case of constant returns to scale is obtained in the limiting case of $\eta \to 1$, where pure profit converges to zero.

Capital is assumed to be perfectly mobile and is supplied to the MNE in the international capital market at a per unit cost equal to $r > 0$. Countries a and b are small compared to the rest of the world so r is exogenously given. Labor is totally immobile and there is a local labor market in each country. The MNE demands labor in country i's labor market at the wage rate $w_i > 0$. Assuming a fixed labor supply $\bar{\ell}$, the wage rate in country i is determined by the labor market equilibrium condition

$$\ell_i = \bar{\ell}. \tag{1}$$

The demand for labor depends on the wage rate according to the MNE's profit maximization conditions which we derive below.

The pre-tax profit of the MNE in country i is

$$\pi_i = F(k_i, \ell_i) - rk_i - w_i\ell_i. \tag{2}$$

The MNE's tax base in country i will differ from the pre-tax profit defined by (2) if the government allows the MNE to deduct only a fraction of its capital cost and/or grants partial depreciation allowances only. We denote $\rho \in [0, 1]$ as the share of interest expenses that are tax deductible. Then, the MNE's tax base in country i reads

$$\pi_{it} = F(k_i, \ell_i) - \rho rk_i - w_i\ell_i. \tag{3}$$

To help focusing on the choice of apportionment factors, the tax base parameter ρ is assumed to be fixed and equal across countries.[3]

The MNE is taxed according to the Formula Apportionment principle and we therefore ignore shifting of corporate income to low tax jurisdictions by the MNE, since it is well known that under this tax system the firm cannot reduce its tax payments by profit shifting (e.g., Nielsen et al. 2004).[4] Under Formula Apportionment the tax base of the MNE in the two countries is first consolidated and then apportioned according to a certain formula. The consolidated tax base equals $\pi_{at} + \pi_{bt}$. The MNE's relative capital (property) and labor shares serve as apportionment factors. The weights the government of country i places on the capital factor and the labor factor are $\gamma_i \in [0, 1]$ and

[3]These assumptions can be motivated by empirical observations. For example, in the Formula Apportionment system of Canada all provinces use the federal tax base definition for corporations. Furthermore, the Formula Apportionment system proposed by the European Union intends to use a common tax base definition. Finally, in calculating taxable income of corporations, every U.S. state starts with the federal tax base definition, even though some state-specific tax rules lead to slight differences in the tax base definition across states. These examples suggest that differences in the tax base definition are less relevant in Formula Apportionment tax systems. The assumption of a fixed ρ may be supported by the observation that at least in the U.S. system there have been substantial variations in the apportionment formulas over the last decades while changes in the tax base definition were moderate. For a detailed discussion see Martens-Weiner (2005b).

[4]If the MNE shifts an amount s of profit from country a to country b, then s will be subtracted from (1) and (2) for $i = a$ and added to (1) and (2) for $i = b$. Hence, total economic profit $\pi_a + \pi_b$ and the total tax base $\pi_{at} + \pi_{bt}$ are independent of s and the MNE has no benefit from setting $s \neq 0$.

$1-\gamma_i \in [0,1]$, respectively. Denoting the national tax rate of country i by $\tau_i \in [0,1]$, the effective tax rate of the MNE in country i reads

$$\tilde{\tau}_i = \tau_i \left[\gamma_i \frac{k_i}{k_a + k_b} + (1-\gamma_i) \frac{\ell_i}{\ell_a + \ell_b} \right]. \tag{4}$$

The expression in the squared bracket equals the share of the consolidated tax base that is allocated to country i. As mentioned in the introduction, many Formula Apportionment systems employ the MNE's sales share as a third apportionment factor. Since our purpose is to show how the tax burden is distribute to mobile and immobile factors, we only need one immobile factor (here labor) and one mobile factor (here capital). The sales factor can therefore be ignored, but all our basic insights would hold if we were to introduce sales as a third apportionment factor.

Using equations (2)–(4) the after-tax profit of the MNE can be written as

$$\pi = \pi_a + \pi_b - \bar{\tau}(\pi_{at} + \pi_{bt}), \tag{5}$$

where

$$\bar{\tau} = \tilde{\tau}_a + \tilde{\tau}_b \tag{6}$$

is the effective tax rate on the MNE's consolidated tax base. Taking equation (4) into account, we see that the effective tax rate equals the weighted average of the national tax rates τ_a and τ_b, the weights being equal to the shares of the MNE's consolidated tax base allocated to the two countries.

The MNE maximizes the after-tax profit (5) with respect to capital k_i and labor demand ℓ_i for $i \in \{a, b\}$. In doing so, it takes as given the factor prices and the policy instruments. The first-order conditions read

$$\frac{\partial \pi}{\partial k_i} = (1-\bar{\tau}) F_k(k_i, \ell_i) - (1-\rho\bar{\tau}) r - \frac{\partial \bar{\tau}}{\partial k_i}(\pi_{at} + \pi_{bt}) = 0, \tag{7}$$

$$\frac{\partial \pi}{\partial \ell_i} = (1-\bar{\tau}) [F_\ell(k_i, \ell_i) - w_i] - \frac{\partial \bar{\tau}}{\partial \ell_i}(\pi_{at} + \pi_{bt}) = 0, \tag{8}$$

with

$$\frac{\partial \bar{\tau}}{\partial k_i} = \frac{k_j(\tau_i\gamma_i - \tau_j\gamma_j)}{(k_a + k_b)^2}, \qquad \frac{\partial \bar{\tau}}{\partial \ell_i} = \frac{\ell_j[\tau_i(1-\gamma_i) - \tau_j(1-\gamma_j)]}{(\ell_a + \ell_b)^2} \tag{9}$$

for $i, j \in \{a, b\}$ and $i \neq j$. If we ignore the terms containing the derivatives of the effective tax rate $\bar{\tau}$, the first-order conditions (7) and (8) equate the marginal return of the input factors to the factor cost. Since capital cost may be deductible, the marginal return of capital is computed after taxation, whereas for labor the before-tax marginal return is relevant. The terms containing the derivatives of $\bar{\tau}$ in (7) and (8) reflect the MNE's well-known formula manipulation incentive (e.g. Gordon and Wilson 1986). To understand this incentive, suppose that the 'effective' tax burden on capital in country i is larger than that in country j, i.e. $\tau_i \gamma_i > \tau_j \gamma_j$. From (9) we then have $\partial \bar{\tau}/\partial k_i > 0 > \partial \bar{\tau}/\partial k_j$, and (7) states that the MNE tends to invest more in country j than in country i since, ceteris paribus, this reduces the effective tax rate $\bar{\tau}$ by placing more weight in the apportionment formula on the tax burden of the low-tax country j. An analogous interpretation holds with respect to labor demand.

Equations (7) and (8) determine inter alia the MNE's demand for labor as a function of the wage rates. Inserting these labor demand functions into the labor market equilibrium condition (1) yields the equilibrium wage rates in the two countries. Formally, equations (1), (7) and (8) for $i \in \{a, b\}$ represent six equations in the six unknowns k_i, ℓ_i and w_i for $i \in \{a, b\}$. From equation (1) we know that in equilibrium labor demand ℓ_i always equals the fixed labor supply $\bar{\ell}$. Hence, in (7) and (8) labor demand ℓ_i may be replaced by labor supply $\bar{\ell}$ so that the number of equations and endogenous variables is reduced to four, i.e. equations (7) and (8) for $i \in \{a, b\}$ then determine investment k_i and the equilibrium wage rate w_i for $i \in \{a, b\}$.

For further use, it is helpful to conduct a comparative static analysis of the MNE's optimal investment choice and the equilibrium wage rates. To focus on the strategic incentives of the governments, we shall restrict our attention to a symmetric situation where both countries have the same tax rate and the same formula weight, i.e. $\tau_a = \tau_b =: \tau$ and $\gamma_a = \gamma_b =: \gamma$. Equations (1)–(9) then imply $k_a = k_b =: k$, $\ell_a = \ell_b = \bar{\ell}$, $w_a = w_b =: w$, $\pi_{at} = \pi_{bt} =: \pi_t$ and $\bar{\tau} = \tau$. For the comparative static analysis we have to differentiate (7) and (8) and then apply the symmetry property. With respect to the impact of country i's tax rate on the MNE's optimal investment levels, we obtain[5]

$$\frac{\partial k_i}{\partial \tau_i} = \frac{1}{(1-\tau)F_{kk}} \left(\sigma + \frac{\gamma \pi_t}{2k} \right), \tag{10}$$

$$\frac{\partial k_j}{\partial \tau_i} = \frac{1}{(1-\tau)F_{kk}} \left(\sigma - \frac{\gamma \pi_t}{2k} \right) \tag{11}$$

[5]All comparative static results are proven in the Appendix.

for $i, j \in \{a, b\}$ and $i \neq j$, with

$$\sigma = \frac{(1-\rho)r}{2(1-\tau)}. \tag{12}$$

The MNE's response to the tax change can be decomposed into a tax base effect and a formula effect. An increase in country i's tax rate means that the effective tax rate facing the MNE goes up. If capital cost is not fully deductible ($\rho < 1$ and $\sigma > 0$), the firm reduces its tax base by lowering capital investment in both countries. This is the tax base effect and it is represented by σ in (10) and (11). If the weight on capital in the apportionment formula is non-zero ($\gamma > 0$), the increase in country i's tax rate induces the MNE to reallocate capital from country i to country j in order to reduce its effective tax rate and thus the overall tax burden. This incentive to manipulate the formula is the formula effect which is reflected by the terms containing γ in (10) and (11). Taking both effects together it is seen from equation (10) that they affect investments in country i negatively. The sign of the total effect on investment in country j, however, is indeterminate as seen by examining equation (11).

The impact of a change in country i's tax rate on the equilibrium wage rates is

$$\frac{\partial w_i}{\partial \tau_i} = -\frac{1}{(1-\tau)F_{kk}}\left[F_{kk}\frac{(1-\gamma)\pi_t}{2\bar{\ell}} - F_{k\ell}\left(\sigma + \frac{\gamma\pi_t}{2k}\right)\right], \tag{13}$$

$$\frac{\partial w_j}{\partial \tau_i} = \frac{1}{(1-\tau)F_{kk}}\left[F_{kk}\frac{(1-\gamma)\pi_t}{2\bar{\ell}} + F_{k\ell}\left(\sigma - \frac{\gamma\pi_t}{2k}\right)\right]. \tag{14}$$

In contrast to the conditions for investment choice there is no (direct) tax base effect in equations (13) and (14) since labor cost is fully deductible. There is still, however, a formula effect if the weight on labor is positive ($\gamma < 1$). The reason is that an increase in τ_i induces the MNE to demand less labor in country i and more labor in country j in order to save tax payments. Consequently, the wage rate in country i falls and the wage rate in country j rises. This effect is given by the first term in the squared brackets of equations (13) and (14). There is a secondary effect on labor demand and wages from a rise in τ_i, since labor is connected to capital by the positive cross derivative of the production function. Due to this complementarity, a decrease (increase) in investment reduces (raises) labor demand and the wage rate. These effects are given by the second term in the squared brackets of equations (13) and (14). If the cost of capital is not fully deductible ($\rho < 1$ and $\sigma > 0$), and the apportionment formula uses both factors ($0 < \gamma < 1$), it is seen from equations (13) and (14) that in total a rise in τ_i causes w_i

to fall, while the effect on country j's wage rate is ambiguous.

The comparative static effects of a change in country i's formula weight on the MNE's optimal investment decision are given by

$$\frac{\partial k_i}{\partial \gamma_i} = -\frac{\partial k_j}{\partial \gamma_i} = \frac{\tau \pi_t}{2k(1-\tau)F_{kk}} \tag{15}$$

for $i, j \in \{a, b\}$ and $i \neq j$. If country i raises its formula weight on capital, equation (15) states that the MNE reallocates capital from country i to country j in order to reduce the effective tax rate and the overall tax burden. The impact of country i's formula weight on the equilibrium wage rates can be expressed as

$$\frac{\partial w_i}{\partial \gamma_i} = -\frac{\partial w_j}{\partial \gamma_i} = \frac{\tau \pi_t}{2(1-\tau)F_{kk}} \left(\frac{F_{kk}}{\bar{\ell}} + \frac{F_{k\ell}}{k} \right) = \frac{\tau \pi_t (\eta - 1) \bar{\ell}^{\eta-2} H'(k/\bar{\ell})}{2k(1-\tau)F_{kk}}, \tag{16}$$

where $H(k_i/\ell_i) := F(k_i/\ell_i, 1)$ and $H'(k_i/\ell_i) = F_k(k_i/\ell_i, 1) > 0$. Equation (16) states that an increase in country i's formula weight on capital increases the wage rate in country i and reduces the wage rate in country j as long as production is characterized by decreasing returns to scale, i.e. $\eta \in]0, 1[$. The reason is that when country i raises γ_i, labor in country i becomes cheaper relatively to labor in country j causing labor demand and the wage rate in country i to rise. The rise in the wage rate implies that the MNE allocates a larger part of its profit to workers in country i. The reversed effect holds with respect to labor demand and the wage rate in country j. Note that these effects only occur in the presence of pure profit in equilibrium. If production exhibits constant returns to scale ($\eta \to 1$), profit is zero and the effect on the formula weight on the wage rates disappears.

The impact of the policy parameters on the aggregate investment and the aggregate wage income can be found by using equations (10)–(16). The result is

$$\frac{\partial k_i}{\partial \tau_i} + \frac{\partial k_j}{\partial \tau_i} = \frac{2\sigma}{(1-\tau)F_{kk}}, \qquad \frac{\partial w_i}{\partial \tau_i} + \frac{\partial w_j}{\partial \tau_i} = \frac{2\sigma F_{k\ell}}{(1-\tau)F_{kk}}, \tag{17}$$

$$\frac{\partial k_i}{\partial \gamma_i} + \frac{\partial k_j}{\partial \gamma_i} = \frac{\partial w_i}{\partial \gamma_i} + \frac{\partial w_j}{\partial \gamma_i} = 0 \tag{18}$$

for $i, j \in \{a, b\}$ and $i \neq j$. Equations (17) and (18) reveal an important qualitative difference between a change in country i's tax rate and country i's formula weight. A change in τ_i affects aggregate investment and wage income (when $\rho < 1$ and $\sigma > 0$), while a change in γ_i – as shown by equation (18) – does not affect total investment and wage income. As we know from equations (15) and (16), the change in k_i and w_i following a rise in γ_i is matched by changes of equal size but opposite sign in k_j and w_j. A change in γ_i, therefore, is purely redistributive. Similarly, the formula effect stemming from a change in τ_i is also purely redistributive in that it redistributes production factors from one country to the other without changing the aggregate variables. But a change in τ_i additionally triggers a tax base effect. This effect makes the MNE reduce total investment and, by the cross derivative of the production function, it also changes labor demand and the sum of wage income (as shown by equation (17)).

3 Cooperative (Efficient) Policy

Having characterized the impact of corporate income taxation on the MNE's behavior, we can now turn to the choice of the policy parameters. In this section the focus is on the cooperative solution, i.e. a central (social) planner sets the tax rates and formula weights in order to maximize the joint welfare of the two countries. The cooperative solution serves as a normative benchmark for the (partially) decentralized decision structures considered in the next sections.

In order to determine the cooperative policy we have to specify the welfare in country $i \in \{a, b\}$. The country is populated by a representative household. Utility of the household is given by the quasi-concave utility function $U(c_i, g_i)$, where c_i represents the consumption of a private good and g_i the consumption of a local public good. The household is endowed with $\bar{k}$ units of capital and $\bar{\ell}$ units of labor, both supplied inelastically at the world interest rate r and the local wage rate w_i, respectively. Each household owns a share of the MNE denoted by $z_i \in [0, 1]$ for $i \in \{a, b\}$ with $z_a + z_b = 1$. To ensure that the two countries are perfectly identical we set $z_a = z_b = 1/2$ throughout, but it will often be convenient to work with the general notation z_a and z_b. The sum of these assumptions allows us to express the private budget constraint as

$$c_i = r\bar{k} + w_i\bar{\ell} + z_i\pi. \tag{19}$$

Equation (19) states that country i's household finances its private consumption by capital, labor and profit income.

Without loss of generality, we normalize the cost of the public good to one so that the marginal rate of transformation between private and public consumption equals one, too. The sole source of governmental revenue is the corporate income tax. The public budget constraint in country i can therefore be written as

$$g_i = \tilde{\tau}_i(\pi_{at} + \pi_{bt}). \tag{20}$$

Inserting the private and public budget constraints (19) and (20) into the utility function, welfare in country i can be written as

$$V^i(\tau_i, \gamma_i, \tau_j, \gamma_j) := U[r\bar{k} + w_i\bar{\ell} + z_i\pi, \tilde{\tau}_i(\pi_{at} + \pi_{bt})] \tag{21}$$

for $i, j \in \{a, b\}$ and $i \neq j$. Note that w_i, π, $\tilde{\tau}_i$, π_{at} and π_{bt} depend on τ_i and γ_i for $i \in \{a, b\}$ due to the MNE's behavior described in the previous section. Each country's welfare function is assumed to be quasi-concave in order to ensure existence and uniqueness of the solution to the maximization problems considered below.

The cooperative solution is determined by the central planner who chooses τ_i and γ_i for $i \in \{a, b\}$ such that the countries' joint welfare

$$W(\tau_a, \gamma_a, \tau_b, \gamma_b) = V^a(\tau_a, \gamma_a, \tau_b, \gamma_b) + V^b(\tau_b, \gamma_b, \tau_a, \gamma_a) \tag{22}$$

is maximized. In doing so, the central planner takes into account the impact of the chosen policy on the MNE's behavior represented by the first-order conditions (7)–(9) or, equivalently, by the comparative static results (10)–(18). The solution to this welfare maximization problem is Pareto efficient in the sense that no Pareto improvement can be attained. The terms 'efficient' and 'cooperative' are therefore used interchangeably. Moreover, the cooperative solution can also be interpreted as the outcome of a fully centralized economy since all policy instruments are chosen at the central level.

As both countries are identical it is natural to assume that the central planner seeks a symmetric solution with $\tau_a = \tau_b =: \tau^*$ and $\gamma_a = \gamma_b =: \gamma^*$ where the star indicates the efficient policy. This symmetric solution is characterized by

Proposition 1 *In determining the symmetric cooperative policy, the central planner (i) is indifferent between all formula weights $\gamma_i \in [0, 1]$ for $i \in \{a, b\}$ and (ii) chooses the tax rates such that $U_g/U_c = 1$ if $\rho = 1$ and $U_g/U_c > 1$ if $\rho \in [0, 1[$.*

Proof: Differentiating equation (22) with respect to country i's formula weight, using equations (1), (7), (9) and (12) and finally applying the symmetry property yields

$$\frac{\partial W(\cdot)}{\partial \gamma_i} = U_c\left[\bar{\ell}\left(\frac{\partial w_i}{\partial \gamma_i} + \frac{\partial w_j}{\partial \gamma_i}\right) + \frac{d\pi}{d\gamma_i}\right] + U_g\left[2\tau^*\sigma\left(\frac{\partial k_i}{\partial \gamma_i} + \frac{\partial k_j}{\partial \gamma_i}\right) - \tau^*\bar{\ell}\left(\frac{\partial w_i}{\partial \gamma_i} + \frac{\partial w_j}{\partial \gamma_i}\right)\right].$$

The expression $d\pi/d\gamma_i$ represents the total derivative of the MNE's maximized after-tax profit with respect to the formula weight. Calculating this total derivative, we obtain $d\pi/d\gamma_i = 0$ due to equation (18) and the symmetry assumption. Equation (18) also implies that all parentheses in the above equation vanish so that we obtain $\partial W(\cdot)/\partial\gamma_i = 0$ for all $\gamma_i \in [0,1]$ for $i \in \{a,b\}$. This proves part (i) of the proposition as the joint welfare W does not depend on the formula weights.

In order to prove part (ii), we differentiate (22) with respect to country i's tax rate using the same steps as above. This yields the first-order condition

$$\begin{aligned}\frac{\partial W(\cdot)}{\partial \tau_i} &= U_c\left[\bar{\ell}\left(\frac{\partial w_i}{\partial \tau_i} + \frac{\partial w_j}{\partial \tau_i}\right) + \frac{d\pi}{d\tau_i}\right] \\ &\quad + U_g\left[\pi_t + 2\tau^*\sigma\left(\frac{\partial k_i}{\partial \tau_i} + \frac{\partial k_j}{\partial \tau_i}\right) - \tau^*\bar{\ell}\left(\frac{\partial w_i}{\partial \tau_i} + \frac{\partial w_j}{\partial \tau_i}\right)\right] = 0. \quad (23)\end{aligned}$$

The total derivative of the after-tax profit with respect to the tax rate is given by

$$\frac{d\pi}{d\tau_i} = -\pi_t - (1-\tau^*)\bar{\ell}\left(\frac{\partial w_i}{\partial \tau_i} + \frac{\partial w_j}{\partial \tau_i}\right). \quad (24)$$

Consider first the case $\rho = 1$. Then $\sigma = 0$ and equation (17) implies that all parentheses in equations (23) and (24) vanish. We obtain $\partial W(\cdot)/\partial\tau_i = \pi_t(U_g - U_c) = 0$ and, thus, $U_g/U_c = 1$ as claimed. For $\rho \in [0,1[$ the parentheses in equations (23) and (24) are different from zero. Inserting equation (17) and rearranging equation (23) then yields

$$\frac{U_g}{U_c} = 1 - \frac{U_g}{U_c}\frac{4\tau^*\sigma^2}{(1-\tau^*)\pi_t F_{kk} - 2\tau^*\bar{\ell}\sigma F_{k\ell}} > 1. \quad (25)$$

The inequality follows from $\sigma > 0$, $F_{kk} < 0$ and $F_{k\ell} > 0$. ■

Part (i) of Proposition 1 is plausible in light of Coasean economics. Different apportionment formulas can be viewed as different allocation institutions. Since we abstract from institution-specific cost, it is clear that every institution yields the same efficient allocation. In our framework this means that the efficient policy is always the same regardless of the apportionment formula used. The rationale of Proposition 1 (ii) is also straightforward. If capital cost is fully deductible ($\rho = 1$), the corporate tax does not distort the MNE's total investment and labor demand as proven in (17). As a consequence, the cooperative policy coincides with the first-best outcome characterized by the Samuelson rule, i.e. the local public good is provided up to the point where the marginal rate of substitution matches the marginal rate of transformation. For no or partial deductibility of capital cost ($\rho \in [0,1[$), in contrast, equation (17) shows that the corporate income tax distorts the MNE's investment decision and, by the cross derivative of the production function, also labor demand and wage rates. In determining the efficient solution, the social planner is then restricted to the second-best optimum. She chooses the tax rates such that a modified Samuelson rule with the marginal rate of substitution larger than the marginal rate of transformation is satisfied.

4 Decentralized Choice of Formula Weights

The next step is to consider the other extreme of possible decision structures, i.e. a fully decentralized economy where the governments of the jurisdictions independently choose both the corporate tax rates and the formula weights. Such a decision structure prevails, for example, in the U.S. Formula Apportionment system.

Formally, under full decentralization country i's government chooses τ_i and γ_i in order to maximize welfare as given by equation (21). In doing so, it takes into account the MNE's profit maximizing behavior represented by the first order conditions (7)–(9) or, equivalently, by the comparative static results (10)–(18). Moreover, country i takes as given the corporate tax rate and formula weight chosen by country j. Hence, the countries play a non-cooperative Nash tax competition game with two instruments, the tax rate and the weight in the apportionment formula. We follow the previous literature on Formula Apportionment and focus on a symmetric equilibrium of this game with countries choosing the same tax rate $\tau_a = \tau_b =: \tau^d$ and the same formula weight $\gamma_a = \gamma_b =: \gamma^d$ where the superscript d indicates the fully decentralized case. The marginal effects of country i's tax rate and formula weight on country i's welfare are obtained by differentiating equation (21) and employing (1), (7), (9), (12), the symmetry property and $d\pi/d\gamma_i = 0$. This yields

$$\frac{\partial V^i(\cdot)}{\partial \tau_i} = U_c\left[\bar{\ell}\,\frac{\partial w_i}{\partial \tau_i} + z_i\frac{d\pi}{d\tau_i}\right] + U_g\left[\pi_t + \tau^d\sigma\left(\frac{\partial k_i}{\partial \tau_i} + \frac{\partial k_j}{\partial \tau_i}\right) - \frac{\tau^d\bar{\ell}}{2}\left(\frac{\partial w_i}{\partial \tau_i} + \frac{\partial w_j}{\partial \tau_i}\right)\right.$$
$$\left. + \frac{\tau^d\gamma^d\pi_t}{2k}\left(\frac{\partial k_i}{\partial \tau_i} - \frac{\partial k_j}{\partial \tau_i}\right)\right], \tag{26}$$

$$\frac{\partial V^i(\cdot)}{\partial \gamma_i} = U_c\,\bar{\ell}\,\frac{\partial w_i}{\partial \gamma_i} + U_g\frac{\tau^d\gamma^d\pi_t}{2k}\left(\frac{\partial k_i}{\partial \gamma_i} - \frac{\partial k_j}{\partial \gamma_i}\right), \tag{27}$$

for $i, j \in \{a, b\}$ and $i \neq j$. The first bracketed term in (26) equals the change in country i's labor and profit income due to a tax rate change in country i. The second squared bracket represents the impact of τ_i on country i's tax revenue that is influenced by a direct effect (π_t), a change in the MNE's consolidated tax base (second and third term in the bracket) and a change in the share of this tax base caused by the MNE's formula manipulation incentive (last term in the bracket). A similar interpretation holds for the marginal welfare effect of the formula weight in equation (27) except for the fact that γ_i does not have a direct effect on tax revenue in country i and that it influences neither the private profit income nor the consolidated tax base.

With the help of equations (26) and (27) we are able to characterize the policy chosen in the fully decentralized economy. Let us start with the formula weight chosen by the countries. It is straightforward to show that $\gamma_i = 0$ is not an optimal policy for country i. To see this, we evaluate (27) at the point $\gamma_a = \gamma_b = \gamma^d = 0$ and obtain

$$\left.\frac{\partial V(\cdot)}{\partial \gamma_i}\right|_{\gamma^d=0} = U_c\,\bar{\ell}\,\frac{\partial w_i}{\partial \gamma_i}. \tag{28}$$

From equation (16) we know that $\partial w_i / \partial \gamma_i$ is positive. Equation (28) then shows that a situation where each country places the whole formula weight on the immobile factor labor ($\gamma^d = 0$) cannot be a Nash equilibrium. Both countries have an incentive to deviate from such a policy, since the marginal welfare gain from reducing the weight on labor and increasing the weight on capital is positive. Hence, we may state

Proposition 2 *In a symmetric tax competition game of the fully decentralized economy the Nash equilibrium is characterized by both countries setting a positive weight on the mobile factor capital; that is* $\gamma_a = \gamma_b = \gamma^d > 0$.

As shown in (27), a marginal increase in the weight γ_i has two effects on welfare in country i. The first effect relates to the fact that an increase in γ_i makes labor in country i cheaper relatively to labor in country j causing the MNE to demand more labor with rising wages and welfare in country i as an end result. The second effect pertains to the fact that an increase in γ_i induces the MNE to reallocate capital from country i to country j so that tax revenue and welfare in country i decline. At the margin at $\gamma_i = 0$, the second (negative) welfare effect disappears and only the first (positive) welfare effect remains. Thus, starting from a situation where the formula uses labor as sole apportionment factor it is beneficial from a single country's perspective to reduce the weight placed on labor and increase the weight placed on capital.

It is important to emphasize that the countries place some tax burden on a mobile factor (capital) even though an immobile factor (labor) that can be fully taxed is available. This is in contrast to the first intuition presented in the introduction which, based on the standard tax competition framework, tells us that in the Nash equilibrium of a fully decentralized economy the whole formula weight is placed on immobile factors. The reason for this difference lies in the assumption regarding the existence of pure economic rents. The standard tax competition framework assumes constant returns to scale in production so that no economic rents arise. In contrast, the driving force behind our result is the assumption of decreasing returns to scale, i.e. there exists a fixed third production factor that gives rise to pure corporate income. Under this assumption, each country has an incentive to redistribute a part of this income to its own workers by putting a positive formula weight on mobile capital. We would obtain a result in accordance with the first intuition if the limiting case of constant returns to scale is considered ($\eta \to 1$). Then the formula weight in country i would not influence the wage rate in country i according to (16) and each country would place the whole weight on immobile labor as implied by (15) and (23). However, we think that it is more suitable to investigate corporate income taxation within a model that accounts for decreasing returns to scale since we then have positive pure rents that can be taxed.[6]

From Proposition 1 we know that any apportionment formula is efficient. Hence, it cannot be stated that the formula weights determined non-cooperatively in the fully decentralized economy are inefficient. An open question is, however, whether the countries choose the right corporate tax rates. To answer this question, we have to investigate the fiscal externalities caused by the tax rates, i.e. the effect country i's tax rate exerts on welfare in country j. If the fiscal externality is positive (negative) a coordinated tax rate increase (decrease) improves welfare in both countries and, thus, leads to a Pareto improvement. The equilibrium tax rate τ^d is then inefficiently low (high).

With the help of the comparative static result in equations (10)–(14) and (17), the

[6]Most of the previous studies on corporate income taxation under Formula Apportionment referred to in the Introduction assume decreasing returns to scale.

fiscal externalities in the tax competition equilibrium can be calculated from (21) as

$$\frac{\partial V^j(\cdot)}{\partial \tau_i} = \text{WE} + \text{ZE} + \text{TE} + \text{FE} \tag{29}$$

with

$$\text{WE} = U_c\,\bar{\ell}\,\frac{\partial w_j}{\partial \tau_i} = U_c\,\frac{\bar{\ell}\pi_t}{2(1-\tau^d)F_{kk}}\left[(1-\gamma^d)\frac{F_{kk}}{\bar{\ell}} - \gamma^d\frac{F_{k\ell}}{k}\right] + U_c\,\frac{\sigma\bar{\ell}F_{k\ell}}{(1-\tau^d)F_{kk}}, \tag{30}$$

$$\text{ZE} = U_c z_j\frac{d\pi}{d\tau_i} = -U_c z_j \pi_t - U_c z_j\frac{2\sigma\bar{\ell}F_{k\ell}}{F_{kk}}, \tag{31}$$

$$\text{TE} = U_g\left[\tau^d\sigma\left(\frac{\partial k_i}{\partial \tau_i} + \frac{\partial k_j}{\partial \tau_i}\right) - \frac{\tau^d\bar{\ell}}{2}\left(\frac{\partial w_i}{\partial \tau_i} + \frac{\partial w_j}{\partial \tau_i}\right)\right] = U_g\frac{\tau^d\sigma(2\sigma - \bar{\ell}F_{k\ell})}{(1-\tau^d)F_{kk}}, \tag{32}$$

$$\text{FE} = -U_g\frac{\tau^d\gamma^d\pi_t}{2k}\left(\frac{\partial k_i}{\partial \tau_i} - \frac{\partial k_j}{\partial \tau_i}\right) = -U_g\frac{\tau^d\gamma^{d2}\pi_t^2}{2k^2(1-\tau^d)F_{kk}}. \tag{33}$$

The total cross country effect of the corporate tax rate can be decomposed into four fiscal externalities. First, if country i changes its tax rate, the MNE changes its labor demand in both countries so that the wage income in country j is altered. This is the wage income externality WE determined by (30). Second, also the profit income in country j is affected by tax rate changes in country i as shown by the profit income externality ZE given in (31). Third, as a reaction on an increase in country i's tax rate the MNE reduces both total investment and total labor demand with the consequence of a change in the consolidated tax base and tax revenue in both countries. Hence, we obtain the tax base externality TE in (32). Finally, a tax rate increase in country i induces the MNE to reallocate capital from country i to country j thereby improving tax revenue in country j. This is the formula externality FE defined in (33).

With the help of these fiscal externalities we can evaluate the efficiency properties of the corporate tax rates in the fully decentralized economy. This is done in

Proposition 3 *In a symmetric tax competition game of the fully decentralized economy the equilibrium tax rates are inefficiently low* ($\tau^d < \tau^*$) *if* $\rho = 1$ *but may be inefficiently low or high* ($\tau^d \gtrless \tau^*$) *if* $\rho \in [0, 1[$.

Proof: Remember from Proposition 2 that the jurisdictions choose an interior solution $\gamma^d > 0$ with respect to the formula weight. Hence, equation (27) implies the first-order condition $\partial V^i(\cdot)/\partial \gamma_i = 0$. Using the comparative static results (15) and (16) of the

MNE's behavior in this first-order condition gives

$$U_c \, \frac{\bar{\ell}\pi_t}{2(1-\tau^d)F_{kk}} \left(\frac{F_{kk}}{\bar{\ell}} + \frac{F_{k\ell}}{k} \right) + U_g \, \frac{\tau^d \gamma^d \pi_t^2}{2k^2(1-\tau^d)F_{kk}} = 0. \tag{34}$$

Summing the externalities in equations (30)–(33) yields

$$\begin{aligned} \frac{\partial V^j(\cdot)}{\partial \tau_i} &= U_c \, \frac{\tau^d \pi_t}{2(1-\tau^d)} + (U_c - U_g) \frac{\tau^d \sigma \bar{\ell} F_{k\ell}}{(1-\tau^d)F_{kk}} + U_g \frac{2\tau^d \sigma^2}{(1-\tau^d)F_{kk}} \\ &\quad - U_c \, \frac{\bar{\ell}\gamma^d \pi_t}{2(1-\tau^d)F_{kk}} \left(\frac{F_{kk}}{\bar{\ell}} + \frac{F_{k\ell}}{k} \right) - U_g \, \frac{\tau^d \gamma^{d2} \pi_t^2}{2k^2(1-\tau^d)F_{kk}}. \end{aligned} \tag{35}$$

The two terms in the second row of equation (35) are zero due to equation (34). If $\rho = 1$, we have $\sigma = 0$ so that only the first term on the RHS of (35) remains. This term is positive so that $\tau^d < \tau^*$ as claimed. In contrast, for $\rho \in [0, 1[$ and $\sigma > 0$ also the second and third term do not vanish and the cross effect of the tax rate may take any sign. This can be shown by way of example. Suppose capital cost is not deductible at all ($\rho = 0$) and the production function is Cobb-Douglas, i.e. $F(k_i, \ell_i) = k_i^\alpha \ell_i^\beta$ with $\alpha, \beta > 0$ and $\alpha + \beta < 1$. It is then straightforward to show

$$\frac{\partial V^j(\cdot)}{\partial \tau_i} \gtreqless 0 \qquad \Leftrightarrow \qquad \frac{U_g}{U_c} \lesseqgtr \frac{1-\alpha-\beta}{\alpha(1-\beta)} \tag{36}$$

It is clear from this relation that we can always construct examples with inefficient undertaxation ($\tau^d < \tau^*$) or inefficient overtaxation ($\tau^d > \tau^*$). ■

Proposition 3 shows that if capital cost is fully deductible tax competition in a decentralized economy leads to a race to the bottom with inefficiently low corporate tax rates and quantities of the local public goods. The rationale can be attributed to the interplay of the fiscal externalities identified in equations (30)–(33). If capital cost can fully be deducted the tax base effect identified in the comparative static analysis of the MNE's behavior vanishes and only the formula effect remains. This implies that the tax base externality TE disappears and the profit income externality ZE becomes negative. However, also the wage income externality WE is influenced by the formula effect only implying that WE has a positive sign. This positive externality together with the (always) positive formula externality FE overcompensates the negative profit income externality ZE thereby rendering equilibrium tax rates inefficiently low. With partial deductibility of capital cost, too, the jurisdictions in a fully decentralized economy fail to implement the cooperative tax policy as shown by Proposition 3. In contrast to the case of full deductibility, however, the tax base effect is now present. This effect generates a possibly negative tax base externality TE and renders the sign of the wage income externality WE and the profit income externality ZE ambiguous. Hence, the sum of externalities may be positive or negative thereby implying an indeterminate relationship between the equilibrium tax rate and the efficient tax rate.

It is again important to emphasize that this inefficiency result stands in contrast to the first intuition presented in the introduction. The first intuition would tell us that the jurisdictions place the whole formula weight on immobile labor and so turn the corporate income tax into a non-distortionary tax on immobile labor and implement the efficient tax policy. Our analysis shows that both is wrong. The countries partially use mobile apportionment factors and engage either in a race to the bottom or a race to the top with inefficient corporate tax rates.

5 Centralized Choice of Formula Weights

The inefficiency of a fully decentralized economy raises the question whether welfare gains can be realized by settling the decision on the apportionment formula at the central level while the jurisdictions retain fiscal autonomy regarding the tax rate. Such a decision structure lies in between the two polar cases of full decentralization and full centralization (cooperation). It is implemented in many existing Formula Apportionment system like the ones in Canada or Germany and it is also favored by the European Commission for a possible corporate tax reform within the Europe Union.

The decisions structure in this partially decentralized economy can be viewed as a two stage process. In the first stage, the central planner sets the (common) formula weight taking into account the impact of its choice on tax (rate) competition between the two countries on the second stage. To ensure a subgame perfect equilibrium we start with the second stage. Here each country non-cooperatively determines the tax rate in order to maximize its residents' welfare taking as given the tax rate chosen by the other country and the formula weight chosen by the central planner in the first stage. The first-order condition is again obtained by setting equation (26) equal to zero. Assuming a symmetric equilibrium of the tax competition game with $\tau_a = \tau_b =: \tau$ and using the relation $W = V^i + V^j$, country i's first-order condition can be rewritten as

$$\Psi(\tau) := \frac{\partial W(\cdot)}{\partial \tau_i} = \frac{\partial V^j(\cdot)}{\partial \tau_i} =: \Phi(\tau, \gamma). \tag{37}$$

The function Ψ is independent of the centrally chosen γ as we know from Proposition 1 that the joint welfare function W and, thus, its derivatives are not influenced by the formula weights. As the welfare function is assumed to be concave and the efficient solution is obtained by setting $\partial W(\cdot)/\partial \tau_i = 0$, it is clear from equation (37) that the social planner sets the formula weight such that the absolute value of the fiscal externalities is minimized. Hence, the optimization problem of the social planner reads

$$\min_{\gamma} |\Phi(\tau, \gamma)|. \tag{38}$$

Denoting the solution to this minimization problem by γ^c, we obtain

Proposition 4 *Welfare in the partially decentralized economy is larger than in the fully decentralized economy. Moreover, the central planner sets $\gamma^c \in]0, \gamma^d[$ if $\rho = 1$. For $\rho \in [0, 1[$, the formula weight γ^c is still positive and may even be larger than γ^d.*

Proof: The function $\Phi(\tau, \gamma)$ is identical to the expression in equation (35) if we replace τ^d by τ and γ^d by γ. This expression is quadratic and, thus, U-shaped in γ. The first derivative reads

$$\frac{\partial \Phi(\cdot)}{\partial \gamma} = -U_c \frac{\bar{\ell}\pi_t}{2(1-\tau)F_{kk}} \left(\frac{F_{kk}}{\bar{\ell}} + \frac{F_{k\ell}}{k} \right) - U_g \frac{\tau \pi_t^2}{k^2(1-\tau)F_{kk}} \gamma. \tag{39}$$

Consider first the case $\rho = 1$. We then have $\sigma = 0$ and

$$\Phi(\tau, 0) = U_c \frac{\tau \pi_t}{2(1-\tau)} > 0, \qquad \left. \frac{\partial \Phi(\cdot)}{\partial \gamma} \right|_{\gamma=0} = -U_c \frac{\bar{\ell}\pi_t}{2(1-\tau)F_{kk}} \left(\frac{F_{kk}}{\bar{\ell}} + \frac{F_{k\ell}}{k} \right) < 0. \tag{40}$$

The sign of the second expression follows from $F_{kk}/\bar{\ell} + F_{k\ell}/k < 0$ already used in equation (16). Starting at $\gamma = 0$, equation (40) shows that the central planner can reduce $|\Phi(\tau, \gamma)|$ by increasing γ to a positive value. It follows $\gamma^c > 0$. Similar, for $\gamma = \gamma^d$ we know that the countries choose $\tau = \tau^d$ and that the pair (γ^d, τ^d) satisfies equation (34). From equations (35) and (39) it then follows

$$\Phi(\tau^d, \gamma^d) = U_c \frac{\tau^d \pi_t}{2(1-\tau^d)} > 0, \qquad \left. \frac{\partial \Phi(\cdot)}{\partial \gamma} \right|_{\gamma=\gamma^d} = -U_g \frac{\tau^d \pi_t^2}{2k^2(1-\tau^d)F_{kk}} \gamma^d > 0. \tag{41}$$

This implies $\gamma^c < \gamma^d$ and completes the proof for the case $\rho = 1$. If $\rho \in [0, 1[$ and $\sigma > 0$, the sign of the derivatives of Φ at $\gamma = 0$ and $\gamma = \gamma^d$ are the same as in equations (40) and (41), respectively. However, equation (35) shows that both $\Phi(\tau, 0)$ and $\Phi(\tau^d, \gamma^d)$ may be positive or negative. In addition, we need the property that $\gamma = 0$ implies $\tau = \tau^d$ since equations (34), (35) and (37) imply $\Phi(\tau^d, 0) = \Phi(\tau^d, \gamma^d) = \Psi(\tau^d)$, i.e. $\tau = \tau^d$ has to be the solution to equation (37) if $\gamma = 0$. Since $\Phi(\tau^d, 0)$ and $\Phi(\tau^d, \gamma^d)$ are equal, they are either both positive or both negative. If they are positive, we have the same result as in case of $\rho = 1$, i.e. $\gamma^c \in]0, \gamma^d[$. But if they are negative, it is always better for the social planner to choose $\gamma^c > \gamma^d$ since, according to $[\partial\Phi(\cdot)/\partial\gamma_i]|_{\gamma=\gamma^d} > 0$ and the U-shape of Φ, the function $\Phi(\tau^d, \gamma)$ then comes closer to zero than for any other formula weight $\gamma \in [0, \gamma^d]$. ■

Proposition 4 states that the partially decentralized economy dominates the fully decentralized economy in terms of welfare. Of course, this result does not come as a surprise as in the partially decentralized economy the central planner controls more policy instruments than in the fully decentralized case. More surprising is the insight that, similar to full decentralization, the central planner improves welfare by putting a positive weight on the mobile apportionment factor, i.e. $\gamma^c > 0$. Hence, the first intuition that the apportionment formula should contain immobile factors only, since that turns the corporate income tax into a non-distortionary labor tax, is wrong not only for the decentralized choice of apportionment factors but also for the centralized choice. The rationale is that the central planner uses the formula weight as corrective instrument to minimize the distortions caused by the decentralized choice of tax rates.

More specific, consider first the case where capital cost is completely deductible ($\rho = 1$ and $\sigma = 0$). Here, the central planner realizes the welfare gain by reducing the formula weight below the value γ^d chosen by the jurisdictions in a fully decentralized economy. The reason is that the decline in the formula weight reduces the formula externality FE by more than the wage income externality WE increases (confer equations (30)–(33)). This is beneficial as the sum of externalities falls. However, it is never optimal for the central planner to reduce to formula weight to zero. At the margin where $\gamma = 0$, the sum of externalities is positive, too, and marginally increasing the formula weight reduces the wage income externality WE and leaves the formula externality FE as well as the profit income externality ZE unchanged. The sum of externalities again falls. Hence, the central planner always chooses a value of the formula weight that lies between zero and the value chosen by the jurisdictions in a fully decentralized economy.

In case of partial deductibility of capital cost, this basic line of reasoning goes through with one important exception. For $\rho \in [0, 1[$ and $\sigma > 0$ the tax base externality emerges. This externality may be negative thereby rendering the sum of externalities at $\gamma = 0$ or $\gamma = \gamma^d$ possibly negative. In such a case, the central planner can improve welfare compared to the fully decentralized economy by shifting the formula weight above the value decentrally chosen by the jurisdictions. Hence, with incomplete deductibility the formula weight chosen by the central planner may even be higher than its value under a decentralized choice of apportionment factors.

6 Conclusion

Based on a model with two countries and a multinational firm that has subsidiaries in both countries, we study the choice of apportionment factors under different decision structures. Three central results emerged. First, in a fully decentralized economy with both tax rates and formula weights chosen at the local level it is optimal for each jurisdiction to use positive weights on both mobile (capital/investment) and immobile (labor/land) apportionment factors. As shown in our analysis, including capital in the apportionment formula implies that labor becomes relatively cheaper domestically and as a consequence the MNE expands labor demand with the end result that wages go up. The rise in wage income causes national income and welfare to increase. Second, in the resulting tax equilibrium corporate income tax rates and the public goods supply may be inefficiently high or low. Finally, if the central government is responsible for setting the apportionment weight it uses this instrument as corrective devise in order to reduce the distortions caused by the jurisdictions' competition in corporate tax rates. Welfare is therefore always higher than in the case of full decentralization. Interestingly, it is never optimal for the central planner to use immobile apportionment factors only, similar to the choice of apportionment factors in the fully decentralized economy.

Appendix

We start by deriving the changes in the effective tax rate $\bar{\tau}$ and its derivatives in (9). Employing the symmetry assumption in (9) immediately implies

$$\frac{\partial\bar{\tau}}{\partial k_i} = \frac{\partial\bar{\tau}}{\partial \ell_i} = 0 \tag{42}$$

for $i \in \{a, b\}$. Differentiating (6) and then using the symmetry property yields

$$\frac{\partial\bar{\tau}}{\partial \tau_i} = \frac{1}{2}, \qquad \frac{\partial\bar{\tau}}{\partial \gamma_i} = 0 \tag{43}$$

for $i \in \{a, b\}$. From (9) and the symmetry assumption we obtain

$$\frac{\partial^2\bar{\tau}}{\partial k_i \partial k_j} = \frac{\partial^2\bar{\tau}}{\partial \ell_i \partial \ell_j} = \frac{\partial^2\bar{\tau}}{\partial k_i \partial \ell_j} = 0 \tag{44}$$

for $i, j \in \{a, b\}$ and

$$\frac{\partial^2\bar{\tau}}{\partial k_i \partial \tau_i} = -\frac{\partial^2\bar{\tau}}{\partial k_i \partial \tau_j} = \frac{\gamma}{4k}, \qquad \frac{\partial^2\bar{\tau}}{\partial k_i \partial \gamma_i} = -\frac{\partial^2\bar{\tau}}{\partial k_i \partial \gamma_j} = \frac{\tau}{4k}, \tag{45}$$

$$\frac{\partial^2\bar{\tau}}{\partial \ell_i \partial \tau_i} = -\frac{\partial^2\bar{\tau}}{\partial \ell_i \partial \tau_j} = \frac{1-\gamma}{4\ell}, \qquad \frac{\partial^2\bar{\tau}}{\partial \ell_i \partial \gamma_i} = -\frac{\partial^2\bar{\tau}}{\partial \ell_i \partial \gamma_j} = -\frac{\tau}{4\ell} \tag{46}$$

for $i, j \in \{a, b\}$ and $i \neq j$. With the help of (42)–(46), totally differentiating (7) and (8) yields the matrix equation

$$\begin{bmatrix} (1-\tau)F_{kk} & 0 & 0 & 0 \\ 0 & (1-\tau)F_{kk} & 0 & 0 \\ (1-\tau)F_{k\ell} & 0 & -(1-\tau) & 0 \\ 0 & (1-\tau)F_{k\ell} & 0 & -(1-\tau) \end{bmatrix} \begin{bmatrix} \mathrm{d}k_a \\ \mathrm{d}k_b \\ \mathrm{d}w_a \\ \mathrm{d}w_b \end{bmatrix}$$

$$= \begin{bmatrix} \sigma + \frac{\gamma\pi_t}{2k} & \sigma - \frac{\gamma\pi_t}{2k} & \frac{\tau\pi_t}{2k} & -\frac{\tau\pi_t}{2k} \\ \sigma - \frac{\gamma\pi_t}{2k} & \sigma + \frac{\gamma\pi_t}{2k} & -\frac{\tau\pi_t}{2k} & \frac{\tau\pi_t}{2k} \\ \frac{(1-\gamma)\pi_t}{2\bar{\ell}} & -\frac{(1-\gamma)\pi_t}{2\bar{\ell}} & -\frac{\tau\pi_t}{2\bar{\ell}} & \frac{\tau\pi_t}{2\bar{\ell}} \\ -\frac{(1-\gamma)\pi_t}{2\bar{\ell}} & \frac{(1-\gamma)\pi_t}{2\bar{\ell}} & \frac{\tau\pi_t}{2\bar{\ell}} & -\frac{\tau\pi_t}{2\bar{\ell}} \end{bmatrix} \begin{bmatrix} \mathrm{d}\tau_a \\ \mathrm{d}\tau_b \\ \mathrm{d}\gamma_a \\ \mathrm{d}\gamma_b \end{bmatrix} \tag{47}$$

with σ defined in (12). Applying Cramer's rule and rearranging gives (10)–(15).

In order to prove equation (16) note that since $F(k_i, \ell_i)$ is homogenous of degree η, there exists a function $H(k_i/\ell_i) = F(k_i/\ell_i, 1)$ with $H'(k_i/\ell_i) = F_k(k_i/\ell_i, 1) > 0$ and $H''(k_i/\ell_i) = F_{kk}(k_i/\ell_i, 1) < 0$ such that the production function and its derivatives can be written as

$$F(k_i, \ell_i) = \ell_i^{\eta} H(k_i/\ell_i), \quad F_k(k_i, \ell_i) = \ell_i^{\eta-1} H'(k_i/\ell_i), \tag{48}$$

$$F_{kk}(k_i, \ell_i) = \ell_i^{\eta-2} H''(k_i/\ell_i), \quad F_{k\ell}(k_i, \ell_i) = (\eta - 1)\ell_i^{\eta-2} H'(k_i/\ell_i) - \ell_i^{\eta-3} k_i H''(k_i/\ell_i). \tag{49}$$

Applying Cramer's rule to the matrix equation (47) and using the information from equation (49) yields the expression in equation (16).

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