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Taxing multi-nationals under union wage bargaining

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Abstract This paper investigates corporate taxation under separate accounting (SA) and formula apportionment (FA) in a model with union wage bargaining and multinational firms. Under SA, we find that increases in the corporate tax rate raise the wage level of domestic workers, while they lower the remuneration of foreign workers. The main insight emerging from a tax competition game is that the endogenous wage level gives rise to an ambiguous fiscal externality, which may dampen the race-to-the-bottom in corporate tax rates. A switch to a tax system with FA principles reverses the impact of corporate taxes on negotiated wages. While increases in the corporate tax rate reduce domestic wages, they raise the wage level of foreign workers. In a tax competition game, the endogenous wage level gives rise to a positive fiscal externality that enforces the race-to-the-bottom in corporate tax rates.

Keywords Corporate taxation · Multi-national firm · Union wage bargaining

JEL Classification H3 · H7 · J5

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1 Introduction

With increasing economic integration, the importance of multi-national entities (MNEs) has steadily grown for the last decades. Today, more than one-third of international trade flows through intra-firm channels (OECD 2002). The outward FDI stock of companies headquartered in the OECD has sextupled since the early 1990s (OECD 2007). Hence, it is not surprising that the public finance literature has extensively studied the interaction between corporate taxation and the behavior of MNEs. Key results are that a multi-national's investment and profit declaration decision depends on the prevailing corporate tax rates. MNEs are shown to reduce their overall tax burden by relocating investment to low-tax countries and shifting pre-tax profits through intra-firm channels (e.g. Hines 1996; Clausing 2003). As a consequence, governments compete to attract the mobile corporate tax base, which results in inefficiently low equilibrium tax rates (e.g. Eggert and Haufler 2006).

Although the interaction between corporate taxation and MNEs is well studied, the literature has so far neglected that corporate taxation may impact on the wage bargaining game between MNEs and labour unions. This analysis is particularly relevant since labour markets in the OECD are characterized by a high degree of unionization (see, e.g. Nickell et al. 2005). Union coverage tends to be especially high and stable in continental Europe and Scandinavia. Additionally, MNEs have become strong players in the markets for factor demand. In the manufacturing industry, for example, every fourth worker within the OECD is employed by an MNE (Bernard and Jensen 2007; Griffith et al. 2004; OECD 2005).

This paper's aim is to investigate corporate taxation in a model with union wage bargaining and MNEs, distinguishing between two alternative corporate tax schemes for multi-national firms: separate accounting (SA) and formula apportionment (FA). Currently, corporate taxation at the international level applies SA rules, i.e. an MNE's tax base is calculated separately in each country. The SA system has, however, come under attack by practitioners and researchers since it induces multi-national paper profit shifting in the direction of low-tax countries (see, e.g. Clausing 2003; Huizinga and Laeven 2008) and is thus prone to inefficiencies. The alternative to SA is commonly seen in a corporate tax regime with FA regulations. Under FA, the profit of an MNE is consolidated at the group level and is then apportioned to the affiliates on the basis of an apportionment formula that measures the relative corporate activity. FA systems have been in place for decades in the context of subnational corporate taxation of multi-jurisdictional firms in the US, Canada, and Germany. Moreover, the European Union currently discusses to switch from SA to FA within EU borders following an according proposal of the European Commission in 2001 (for details, see European Commission 2001, 2003).[1]

To compare SA and FA in a union wage bargaining context, we develop a theoretical model with two symmetric countries. Each country hosts the affiliate of a

[1] In recent years, the European Commission has channeled enormous resources to push the FA project ahead which underpins the importance it assigns to the topic. Besides the set-up of several workings groups, a significant number of working papers have been prepared by the Commission, academics, and European industry associations.

representative MNE. The MNE produces a homogeneous good using labour as an input factor. We assume that the corporation is led by a central management, which maximizes the MNE's total after-tax profit. For simplicity reasons, owners and management are assumed to be located in a third country. Our model considers a three stage game, in which labour demand, workers' wages, transfer prices for internally traded goods and corporate tax rates are endogenously determined. The structure of the game is as follows: At the first stage, the governments simultaneously choose their corporate tax rates ignoring the effect of their decision on the social welfare of the other country. At the second stage, the MNE and national labour unions bargain over the wage level in a standard right-to-manage setting. At the third stage, the MNE sets labour demand and the transfer price. The model is solved by backward induction.

For the union wage bargaining game under SA, we find that increases in the corporate tax rate *raise* the wage level of domestic workers and lower the negotiated wage rate of foreign workers. The former result is obtained from two effects. Firstly, increases in the corporate tax raise the MNE's corporate tax burden and therefore directly reduce the multi-national's after-tax profit. Since this decreases the pie that the parties are bargaining over, the wages of domestic workers tend to decline. Secondly, however, a rise in the corporation tax also implies that the MNE's after-tax profit becomes less sensitive to increases in the domestic wage rate. This is because—in line with prevailing legal regulations—we model payroll cost to be fully deductible from the corporate tax base. For the MNE, the value of this payroll deduction increases in the domestic corporate tax rate. Hence, the higher the corporate tax rate, the less sensitive the MNE's profit reacts to changes in the domestic wage rate since higher payroll costs become less detrimental. The latter effect globally dominates so that higher corporate taxes tend to increase domestic workers' wages.

In contrast, increases in the domestic corporate tax rate reduce the wage level which is negotiated at the foreign affiliate. Since foreign wages are deductible from the foreign tax base only, an increase in the *domestic* corporate tax does not impact on the MNE's profit sensitivity with respect to the *foreign* wage level. It lowers the MNE's after-tax profit though and through this channel reduces wages at the foreign affiliate.

Under SA, the tax competition game gives rise to two fiscal externalities. Firstly, we obtain the well-known positive profit shifting externality, which reflects that a rise in the domestic corporate tax rate induces the MNE to shift profits to the foreign country. Since this directly increases the foreign corporate tax base, the domestic tax policy imposes a positive fiscal externality on the foreign country. In addition, the tax competition game under SA derives an ambiguous wage income externality established by the endogenous remuneration level. As stated above, a rise in the domestic corporate tax rate lowers foreign workers' wages. On the one hand, this reduces the MNE's foreign payroll cost, and hence increases the affiliate's pre-tax profit and foreign corporate tax base. On the other hand, the wage reduction translates in a direct decline of foreign residents' utility from wage income. The sign of the wage income externality is analytically ambiguous. Nevertheless, the paper shows that the wage income externality under SA is negative for plausible parameter values (obtained from the relevant empirical literature), and hence tends to compensate for the positive profit shifting externality.

The introduction of a FA system with payroll apportionment reverses the impact of corporate taxation on workers' wages. While increases in the corporate tax rate tend to reduce the domestic wage level, they raise foreign workers' wages. The main intuition behind this result is that increases of the corporate tax rate make high domestic wages and, consequently, a high domestic payroll bill more costly for the MNE since the domestic affiliate's relative payroll share determines the share of the consolidated tax base which is apportioned to the home country. In contrast, a high foreign wage rate and, in consequence, a high foreign payroll bill become less detrimental since they induce an increased amount of profit to be apportioned to the foreign country, away from the increased domestic corporate tax burden.

Under FA, the tax competition game gives rise to two positive fiscal externalities. Firstly, we obtain the well-known formula externality, which reflects that a rise in the corporate tax rate induces the MNE to distort its apportionment formula in favor of the foreign country. Consequently, a larger fraction of the consolidated profit is apportioned to the foreign affiliate, which establishes a positive fiscal externality. Secondly, the wage bargaining game gives rise to a wage income externality, which captures that corporate taxes raise the wage rate negotiated at the foreign location, and thus increase foreign workers' utility from wage income. Hence, under FA, the wage income externality aggravates the positive externality of corporate taxation on foreign welfare and exacerbates the race-to-the-bottom in corporate tax rates.

Our paper touches upon several strands of the economic literature. Firstly, the model is closely related to the literature on international tax coordination. For example, Fuest and Huber (1999) and Koskela and Schöb (2002) investigate capital and labour taxation in open economies with union wage bargaining. However, both studies assume *nationally* operating firms, whereas our results are driven by the presence of multi-national corporations. Secondly, the paper can be connected to a set of studies that investigate union wage bargaining in models with MNEs (see, e.g. Zhao 1998; Leahy and Montagna 2000), but which in contrast to our analysis, abstract from taxation aspects.

Additionally, we contribute to a literature that compares multi-national taxation systems based on SA and FA principles (see, e.g. McLure 1980; Gordon and Wilson 1986). While existing papers in this field usually assume perfectly competitive labour markets, we introduce union wage bargaining into our model. We replicate well-known fiscal externalities under the two taxation schemes (see, e.g. Kind et al. 2005; Riedel and Runkel 2007; Nielsen et al. 2010) and add new externalities under SA and FA which are established by union wage bargaining. Recently, Eichner and Runkel (2009) brought forward a closely related paper. They study corporate taxation under SA and FA with a minimum wage. While the minimum wage in their model does not induce a fiscal externality under SA, it enforces the race-to-the-bottom in corporate tax rates under FA. Thus, similar to our paper, they find that a labour market imperfection tends to be detrimental under FA.

The remainder of the paper is structured as follows: In Sect. 2, we present the setup of the theoretical model. Sections 3 and 4 analyze the interaction between corporate taxation and union wage bargaining under SA and FA regulations, respectively. In Sect. 5, we discuss our model assumptions, and Sect. 6 concludes.

2 Model setup

We consider a simple model with two symmetric countries a and b that have the same size, production technology and labour supply. Each country hosts the affiliate of a representative MNE, with the MNE being managed and owned by a party in a third country.[2] The MNE produces a homogeneous good with price 1. For simplicity, we additionally assume that labour is the only input factor. As thoroughly discussed in Sect. 5, this assumption is not decisive for the majority of our results. The labour demand of affiliate $i \in \{a, b\}$ is denoted by L_i and output is determined by the production function $F(L_i)$, which is identical across countries and has the usual properties $F'(L_i) > 0$ and $F''(L_i) < 0$. Moreover, the workers' remuneration in country i is symbolized by the wage rate w_i. Domestic labour supply N is assumed to be fixed since workers are immobile between the two countries.

Additionally, we assume that affiliate i delivers one good or service to the other affiliate j in the foreign country ($i, j \in \{a, b\}$ and $i \neq j$). The true price of the good is set equal to 1 for simplicity reasons and without loss of generality. We presume that the true price is not observable to the tax authorities and that the MNE can thus set a transfer price p_i which deviates from the true price to shift profits between its affiliates. Transfer pricing causes concealment cost though, which are captured by a u-shaped concealment cost function θ with a minimum at $p_i = 1$. Formally,

$$\theta(p_i = 1) = 0, \qquad \text{sign}(\theta') = \text{sign}(p_i - 1), \qquad \theta''(p_i - 1) > 0, \tag{1}$$

whereas θ' and θ'' denote the first and second derivative of the concealment cost function. Moreover, we assume that the concealment costs are not deductible from the corporate tax base. This is a natural assumption if the concealment costs reflect expected penalty fees that the MNE has to pay in case the tax authorities detect its profit shifting activities. In contrast, if the MNE spends effort to refrain the tax authority from observing its profit shifting activities, it might declare these expenditures (e.g. lawyer fees) as administration cost and may deduct them from the corporate tax base. There is no unique modeling in the economic literature, for a discussion of the approaches see Haufler and Schjelderup (2000). Nevertheless, our results would not qualitatively change if we assumed concealment cost to be tax deductible. Consequently, the MNE's after-tax profit reads

$$\Pi = \sum_i \Pi_{Ti} - \sum_i T_i - \sum_i \theta(p_i - 1), \quad i \in \{a, b\} \tag{2}$$

with Π_{Ti} and T_i describing pre-tax profits and tax payments in country i. Formally, the affiliate's pre-tax profit is given by

$$\Pi_{Ti} = F(L_i) - w_i L_i + (p_i - 1) - p_j, \quad i, j \in \{a, b\},\ i \neq j. \tag{3}$$

In the following, we will investigate a three stage game in which labour demand, wages, transfer prices, and tax rates are endogenously determined. The structure of

[2] Thus, the analysis abstracts from corporate tax incentives arising through ownership of foreign firms which are discussed in depth in Huizinga and Nicodème (2006).

the game is as follows: At the first stage, the governments of countries a and b simultaneously choose their corporate tax rates, ignoring the effect of their decisions on the tax base of the other country. At the second stage, the representative MNE and national labour unions bargain over the wage level in a standard right-to-manage setting. At the third stage, the MNE finally decides on labour demand and sets the intra-firm transfer prices for the goods traded. The model is solved by backward induction.

3 Separate accounting

Under SA, profit is taxed in the country where it is earned. Therefore, the multinational's tax payment in country i reads

$$T_i = t_i \Pi_{Ti}, \quad i \in \{a, b\}, \tag{4}$$

with t_i depicting the corporate tax rate in country $i \in \{a, b\}$.

3.1 Labour demand and transfer prices

At the third stage, the MNE maximizes its total after-tax profit, given by (2), under consideration of (1), (3), and (4), by choosing the optimal values for L_i and p_i. The following first order conditions can be derived

$$t_j - t_i = \theta'(p_i - 1), \tag{5}$$

$$F'(L_i) = w_i \tag{6}$$

with $i, j \in \{a, b\}$ and $i \neq j$. The MNE's optimal transfer pricing decision is determined by (5). If $t_j > t_i$, the marginal concealment cost θ' is positive and the MNE overstates its transfer price p_i ($p_i > 1$) to shift profits from the foreign affiliate in country j to the affiliate in country i. If $t_i > t_j$, the transfer price is understated and profits are shifted to the affiliate in country j. Since we—in line with prevailing legal regulations—model payroll cost to be fully deductible from the corporate tax base, labour demand is not distorted by corporate taxation under SA (see (6)).

3.2 Wage bargaining

In the following, we investigate the effects of corporate taxation on wage bargaining between the MNE and a national labour union in a standard right-to-manage bargaining model. Despite the growing importance of MNEs over the last two decades, labour unions did not adjust to this new development but to a large extent remained organized at the subnational level. Transnational union cooperation is restricted to few individual examples (Gordon and Turner 2000). Therefore, we model the interaction between an MNE and *national* labour unions. As a side result, we can show that this fragmentation of workers into local unions is inefficient from a workers' perspective since each union exerts an externality on foreign affiliate workers' wages.[3]

[3]There are two classic arguments for the merger of labour unions in an industry context. First, an industry-wide labour union is able to bargain for higher wages since its threat-point payoffs are larger. Second,

The workers' collective utility is assumed to be independent from the wage and employment level at the foreign affiliate, and national trade unions thus follow the objective to maximize national wage rents and national employment. The MNE, in contrast, is assumed to be led by a central management, and the MNE's objective is hence to maximize its total after-tax profit.We assume Nash bargaining between the MNE and the labour union. Consequently, the wage level w_i is a solution to

$$\max[\Pi - \gamma\Pi]^{1-\delta}\left[(w_i - \overline{w})L_i\right]^{\delta}, \quad i \in \{a, b\} \tag{7}$$

subject to $L_i < N$ and $w_i > \overline{w}$; $\Pi(w_a, w_b)$ represents the corporation's profit, w_i is the negotiated remuneration level, $\overline{w}$ symbolizes the reservation wage, δ the union's bargaining power, and N describes the overall national work force; all three assumed to be equal across the two countries. $L_i(w_i)$ defines the MNE's labour demand function in country i. Also note that, in equilibrium (along the Pareto frontier with respect to contracts between the union and the MNE if we explicitly modeled the bargaining game), it holds that $\partial U_i/\partial w_i > 0$, whereas $U_i = [(w_i - \overline{w})L_i]$ represents union i's utility. The reasoning is very simple. Since the corporate profit declines in the wage rate, the MNE always prefers lower remuneration. If the union also preferred a lower wage, the bargaining parties could improve their joint surplus by lowering the wage to zero. Consequently, it follows

$$\frac{\partial U_i}{\partial w_i} = L_i + (w_i - \overline{w})\frac{\partial L_i}{\partial w_i} = L_i\left(1 + \frac{(w_i - \overline{w})}{L_i}\frac{\partial L_i}{\partial w_i}\right) = L_i(1 + \epsilon_i) > 0, \tag{8}$$

with ϵ_i being the labour demand sensitivity with respect to the multi-national workers' wage rent. Moreover, we assume that the MNE's central management maximizes the corporation's overall after-tax profits. The MNE's outside option is thereby captured by $\gamma\Pi$, whereas γ is exogenously given with $\gamma \in [0, 1]$.[4]

Taking logs and differentiating (7) with respect to w_i, $i \in \{a, b\}$, gives the following first-order conditions

$$\Phi_a = \frac{\delta}{L_a}\frac{\partial L_a}{\partial w_a} + \frac{\delta}{w_a - \overline{w}} + \frac{1-\delta}{\Pi}\frac{\partial \Pi}{\partial w_a} = 0, \tag{9}$$

$$\Phi_b = \frac{\delta}{L_b}\frac{\partial L_b}{\partial w_b} + \frac{\delta}{w_b - \overline{w}} + \frac{1-\delta}{\Pi}\frac{\partial \Pi}{\partial w_b} = 0. \tag{10}$$

decentralized unions in oligopolistic markets do not internalize the positive impact of their wage rate increases on other firms employment (Davidson 1988). Note that these arguments refer to a setting in which decentralized labour unions bargain with *different* corporations for workers' wages. In our setting, decentralized labour unions bargain with one MNE over workers' wages and the source of inefficiency is therefore different from previous work.

[4]Our modeling strategy follows the standard literature on union Nash bargaining firstly, by assuming that workers earn an exogenous outside wage $\bar{w}$ which may reflect the wage rate in the national industry or an unemployment benefit and secondly, by setting the MNE's outside option to $\overline{\Pi} = \gamma\Pi$. The firm's outside options is in fact often assumed to be zero in the existing theoretical literature, which correspond to $\gamma = 0$. For internationally operating firms, it is reasonable though to assume a positive outside option which reflects that some production can be sustained despite the break-down of bargaining at one of the affiliates (e.g. Zhao 1995, 2001; Eckel and Egger 2009).

A comparative static analysis with respect to the tax rates leads to the first proposition.

Proposition 1 *Under SA, the corporate tax rate exerts a positive (negative) effect on domestic (foreign) workers' wages.*

Proof See Appendix A. □

A rise in the corporate tax rate exerts two effects on the domestic wage bargaining game. Firstly, a higher tax rate increases the MNE's tax bill and leads to a decline in the multi-national's after-tax profit. As this reduces the pie that the parties are bargaining over, the wage rate at the domestic affiliate tends to decline. In the following, we will refer to this effect as 'profit level effect'. Secondly, however, a higher corporate tax rate also implies that the MNE's after-tax profit becomes less sensitive to domestic wage increases. This is because—in line with prevailing legal regulations—we assume that payroll costs are deductible from the corporate tax base. Higher corporate taxes raise the value of this deduction, and hence reduce the MNE's profit sensitivity to wage increases. Formally, a higher wage rate w_i lowers the after-tax profit Π by $\partial\Pi/\partial w_i = -(1-t_i)L_i$, whereas this reduction is smaller the larger the corporate tax rate t_i: $\partial^2\Pi/\partial w_i \partial t_i = L_i > 0$. Put differently, if the corporate tax rate increases, the MNE has to transfer a larger fraction of its pre-tax profits as tax payments to the government in country i. Thus, a reduction in these pre-tax profits (through wage increases in i) becomes less detrimental for the multi-national and the negotiated wage rate at the domestic affiliate rises. In the following, we will refer to this effect as 'profit sensitivity effect'. We show in Appendix A that the 'profit sensitivity effect' dominates the 'profit level effect' and that a tax increase thus raises the wage level at the domestic affiliate.

In contrast, a corporate tax increase is shown to reduce the negotiated wage rate at the foreign affiliate. Since payroll costs are only deductible from the domestic corporate tax base, domestic tax increases do not exhibit any effect on the profit sensitivity with respect to the *foreign* wage rate. Thus, a domestic tax increase affects the foreign wage bargaining process by the reduction in after-tax profits only, and consequently, the wage level of foreign workers declines.[5]

3.3 Tax competition

At the first stage, we investigate a tax competition game between the countries' governments which are assumed to levy a corporate income tax on the MNE's profits. Each government maximizes a social welfare function comprising tax revenues multiplied by the marginal cost of public funds (ρ) and the residents' wage income. As noted above, we assume for simplicity reasons that the MNE is owned by a third party not being resident in countries a and b. Under SA, all profits earned are subject

[5]The strategic response to wage changes at the other affiliate amplifies the described wage effects. As shown above, a rise in the tax rate increases the domestic wage rate and lowers the foreign wage rate. The domestic wage increase lowers the MNE's after-tax profit, and hence amplifies the wage reduction at the foreign location. Equivalently, the wage reduction at the foreign affiliate enlarges the MNE's profit and induces domestic wages to increase.

to corporate taxation in the country where they accrue and the social welfare function is defined as

$$SW_i = \rho t_i \widetilde{\Pi}_{Ti} + (\widetilde{w}_i - \overline{w})\widetilde{L}_i + \overline{w}N \tag{11}$$

with $\widetilde{L}_i, \widetilde{w}_i, \widetilde{w}_j, \widetilde{p}_i, \widetilde{p_j}$, and $\widetilde{\Pi}_{Ti} = \widetilde{\Pi}_{Ti}(\widetilde{L}_i, \widetilde{w}_i, \widetilde{p}_i, \widetilde{p_j})$ representing the optimal values chosen at the second and third stage according to (5), (6), (9), and (10) for $i, j \in \{a, b\}$ and $i \neq j$. Each government is assumed to maximize the social welfare function given by (11), not taking into account the effects of its tax policy on the foreign country's social welfare. Therefore, it holds that

$$\frac{\partial SW_i(t_a, t_b)}{\partial t_i} = 0. \tag{12}$$

We focus on a symmetric Nash equilibrium with equal tax rates $\tilde{t} = t_a = t_b$ since the MNE's affiliates are structurally identical across countries and the workforce potential N and the reservation wage $\overline{w}$ are presumed to be equal in a and b. We write equilibrium social welfare in country i as

$$SW_i(\tilde{t}, \tilde{t}) =: SW(\tilde{t}). \tag{13}$$

Our analysis investigates whether the countries choose inefficiently high or low tax rates in equilibrium. Therefore, we determine the impact of a coordinated increase in the common tax rate $\tilde{t}$ on the countries' social welfare. Differentiating (13) yields

$$\frac{dSW(\tilde{t})}{d\tilde{t}} = \left.\frac{\partial SW_i(t_a, t_b)}{\partial t_i}\right|_{t_a=t_b=\tilde{t}} + \left.\frac{\partial SW_i(t_a, t_b)}{\partial t_j}\right|_{t_a=t_b=\tilde{t}} \tag{14}$$

whereas $\partial SW_i/\partial t_i = 0$ according to (12) and $\partial SW_i/\partial t_j$ represents the fiscal externality on the other country's welfare

$$\begin{aligned}\frac{\partial SW_i}{\partial t_j} = \rho t_i \left\{ \frac{\partial \widetilde{\Pi}_{Ti}}{\partial \widetilde{p}_i}\frac{\partial \widetilde{p}_i}{\partial t_j} + \frac{\partial \widetilde{\Pi}_{Ti}}{\partial \widetilde{p_j}}\frac{\partial \widetilde{p_j}}{\partial t_j} + \frac{\partial \widetilde{\Pi}_{Ti}}{\partial \widetilde{L}_i}\left(\frac{\partial \widetilde{L}_i}{\partial t_j} + \frac{\partial \widetilde{L}_i}{\partial \widetilde{w}_i}\frac{\partial \widetilde{w}_i}{\partial t_j}\right) + \frac{\partial \widetilde{\Pi}_{Ti}}{\partial \widetilde{w}_i}\frac{\partial \widetilde{w}_i}{\partial t_j} \right\} \\ + \widetilde{L}_i \frac{\partial \widetilde{w}_i}{\partial t_j} + (\widetilde{w}_i - \overline{w})\left(\frac{\partial \widetilde{L}_i}{\partial t_j} + \frac{\partial \widetilde{L}_i}{\partial \widetilde{w}_i}\frac{\partial \widetilde{w}_i}{\partial t_j}\right)\end{aligned} \tag{15}$$

for $j, i \in \{a, b\}$ and $i \neq j$. Since we investigate a symmetric equilibrium of the tax competition game, we evaluate (15) for equal corporate tax rates $t_a = t_b = \tilde{t}$. Equations (5), (6), (9), and (10) imply that under symmetry it holds that $\widetilde{L}_a = \widetilde{L}_b = \widetilde{L}$, $\widetilde{w}_a = \widetilde{w}_b = \widetilde{w}$ and $\widetilde{p}_a = \widetilde{p}_b = 1$. Moreover, it follows from (3), (5), and (6) that

$$\begin{aligned}&\left.\frac{\partial \widetilde{L}_i}{\partial t_j}\right|_{t_a=t_b=\tilde{t}} = 0, \qquad \left.\frac{\partial \widetilde{p}_i}{\partial t_j}\right|_{t_a=t_b=\tilde{t}} = -\left.\frac{\partial \widetilde{p_j}}{\partial t_j}\right|_{t_a=t_b=\tilde{t}} = \frac{1}{\theta''(1)} > 0, \\ &\frac{\partial \widetilde{\Pi}_{Ti}}{\partial \widetilde{L}_i} = F'(\widetilde{L}) - \widetilde{w} = 0, \quad \frac{\partial \widetilde{\Pi}_{Ti}}{\partial \widetilde{w}_i} = -\widetilde{L}\end{aligned} \tag{16}$$

for $i, j \in \{a, b\}$ and $i \neq j$. Consequently, (15) can be simplified to

$$\left.\frac{\partial SW_i}{\partial t_j}\right|_{t_a=t_b=\tilde{t}} = \frac{2\rho\,\tilde{t}}{\theta''(1)} + \{1+\widetilde{\epsilon}-\rho\,\tilde{t}\}\widetilde{L}\cdot\left.\frac{\partial \widetilde{w}_i}{\partial t_j}\right|_{t_a=t_b=\tilde{t}}, \quad i, j \in \{a, b\},\ i \neq j \tag{17}$$

with $\widetilde{\epsilon} = \partial \widetilde{L}_i/\partial \widetilde{w}_i \cdot (\widetilde{w}-\overline{w})/\widetilde{L}$ being the labour demand sensitivity with respect to the multi-national workers' wage rent. This leads to the following proposition.

Proposition 2 *Suppose the tax competition game under SA attains a symmetric equilibrium $t_a = t_b = \tilde{t}$; then the governments may either set too high or too low corporate tax rates, depending on the relative size of a positive profit shifting externality and an ambiguous wage income externality.*

Proof See Appendix B. □

We derive two fiscal externalities under SA. The first term on the right-hand side of (17) represents the well-known profit shifting externality. It reflects that corporate tax increases induce the MNE to shift profits to the foreign jurisdiction, which raises the foreign tax base. This imposes a positive fiscal externality on the other country and motivates a race-to-the-bottom in corporate tax rates.

Our model's contribution is the derivation of an ambiguous wage income externality established by the endogenous determination of wages in a bargaining process. Formally, the effect is represented by the second term on the right-hand side of (17). It is driven by the negative effect of corporate taxes on foreign workers' wages, which we derived in the previous section. Firstly, the decline in the foreign wage rate reduces the foreign location's payroll cost, and thereby raises the MNE's pre-tax profit and the foreign corporate tax base. This imposes a positive fiscal externality on the foreign country. Secondly, however, the reduction in foreign workers' remuneration also leads to a direct fall in workers' utility from wage income and imposes a negative fiscal externality on the foreign country.

Although the sign of the wage income externality is analytically ambiguous, the results suggest that the externality is negative for plausible parameter values. Precisely, the sign of the wage income externality depends on the term $1+\widetilde{\epsilon}-\rho\,\tilde{t}$ (see (17)) whereas $\widetilde{\epsilon}$ can be rewritten as $\widetilde{\epsilon} = \partial \widetilde{L}_i/\partial \widetilde{w}_i \cdot \widetilde{w}/\widetilde{L} \cdot (\widetilde{w}-\overline{w})/\widetilde{w} = \widetilde{\mu} \cdot (\widetilde{w}-\overline{w})/\widetilde{w}$, with $\widetilde{\mu}$ denoting the labor demand elasticity with respect to wage changes. Empirical studies suggest $\widetilde{\mu}$ to take on values around -0.6 (see Barba Navaretti et al. 2003). Moreover, assuming that the multi-national workers' outside option $\bar{w}$ reflects the wage level earned in the national industry allows us to derive an estimate for $(\widetilde{w}-\overline{w})/\widetilde{w}$. According to empirical studies (see, e.g. Aitken et al. 1996), workers in multi-national firms earn a wage premium of around 12%, which implies $(\widetilde{w}-\overline{w})/\widetilde{w} = 0.107$.[6] With a corporate tax rate of 30% and marginal costs of public funds of 1.65 (see Kleven and Kreiner 2006), we derive a negative wage income externality: $\{1+\widetilde{\epsilon}-\rho\,\tilde{t}\}\widetilde{L}\cdot\frac{\partial \widetilde{w}_i}{\partial t_j} = \{1-0.6\cdot 0.107-1.65\cdot 0.3\}\widetilde{L}\cdot\frac{\partial \widetilde{w}_i}{\partial t_j} = 0.44\cdot\widetilde{L}\cdot\frac{\partial \widetilde{w}_i}{\partial t_j} < 0$.

[6] From Aitken et al. (1996), it follows that $(\widetilde{w}-\overline{w})/\bar{w} = 0.12$. Moreover, it holds that $(\widetilde{w}-\overline{w})/\widetilde{w} = (\widetilde{w}-\overline{w})/\bar{w}\cdot\bar{w}/\widetilde{w}$. As $\widetilde{w}/\bar{w}-1 = 0.12$, and henceforth $\bar{w}/\widetilde{w} = 1/1.12$, it follows that $(\widetilde{w}-\overline{w})/\widetilde{w} = 0.12/1.12 = 0.107$.

Note, moreover, that this result is robust against a large range of parameter values. As the wage income externality increases in the marginal costs of public funds, in the corporate tax rate as well as in the labor demand sensitivity to wage changes and the wage premium of multi-national workers, this can be illustrated by plugging in large values (at the upper bound of empirical estimates) for these parameters. Assuming, for example, large marginal costs of public funds of 2, a high corporate tax rate of 40%, a labor demand elasticity of -0.9 and a wage premium of multi-national workers of 20% still derives a negative wage income externality of $0.05 \cdot \widetilde{L} \cdot \frac{\partial \widetilde{w}_i}{\partial t_j} < 0$.

Summing up, we can conclude that corporate taxation exerts opposing effects on domestic and foreign workers' wages under SA. While corporate taxes tend to raise the wage level of domestic workers, they lower negotiated wages in the foreign country. The main finding of a tax competition analysis is that union wage bargaining gives rise to an analytically ambiguous wage income externality of corporate taxation, which takes on negative values for empirically established parameter values though. A negative wage income externality tends to compensate for the positive profit shifting externality under SA and tends to dampen the race-to-the-bottom in corporate tax rates. Whether tax rates are set inefficiently low or high in equilibrium depends on the relative size of the profit shifting and the wage income externality. The sum of the two externalities tends to be positive if profit shifting costs are low while the marginal costs of public funds and the labor demand sensitivity to wage changes are large.

4 Formula apportionment

In the following, we will investigate how our model results change with a switch from SA to FA. Although SA principles govern the taxation of MNEs at the international level, several sub-national corporate tax systems have applied formula apportionment principles for decades. Moreover, the European Commission currently advocates the introduction of a FA regime within EU borders. Under FA, the MNE's profits are consolidated and apportioned to the affiliates according to a formula based on relative payroll cost, relative capital investment and/or relative sales. In the following, we will, for simplicity reasons, assume apportionment according to the relative payroll share. However, it can easily be shown that our qualitative results remain unchanged if a capital and/or a sales factor is introduced into the model (see the discussion in Sect. 5). The MNE's tax burden in country $i \in \{a, b\}$ can be calculated as

$$T_i = t_i \beta_i [\Pi_{Ta} + \Pi_{Tb}] \tag{18}$$

with β_i being the fraction of the consolidated tax base apportioned to country i, i.e. in our case the MNE's relative payroll share $\beta_i = w_i L_i / (w_a L_a + w_b L_b)$ with $i = a, b$.

4.1 Labour demand and transfer prices

At the third stage, the MNE maximizes (2), under consideration of (1), (3) and (18), by choosing the optimal transfer prices and labour demand. As is well known, the MNE has no incentive to shift profits under a FA system; therefore, the corporation

sets the transfer price equal to the true price ($p_i = 1$ for $i \in \{a, b\}$). Moreover, the MNE's optimal labour demand under FA in country i is implicitly defined by

$$F'(L_i) = w_i + \frac{(t_i - t_j)}{(1 - \overline{t})} \frac{\beta_j w_i}{\sum_i w_i L_i} [\Pi_{Ta} + \Pi_{Tb}] \tag{19}$$

with $\overline{t}$ being the MNE's average tax rate $\overline{t} = t_a \beta_a + t_b \beta_b$ and $i, j \in \{a, b\}$, $i \neq j$. The second term on the right-hand side represents a distortive formula effect, which implies that the MNE's labour demand is biased toward the low-tax country. The intuition can be described as follows: under FA, the consolidated corporate tax base is apportioned according to the affiliates' relative payroll shares; thus, the MNE has an incentive to employ an over-proportional number of workers at the low-tax location since this increases its relative payroll share and the profit taxed in the low-tax country and reduces the overall corporate tax burden.

4.2 Wage bargaining

At the second stage, the MNE and national labour unions bargain over workers' wages. Analogously to our analysis under SA, the bargaining parties maximize the objective function given by

$$\max [\Pi - \gamma \Pi]^{1-\delta} \left[(w_i - \overline{w}) L_i \right]^{\delta}, \quad i \in \{a, b\} \tag{20}$$

with respect to the wage rate w_i, thereby considering (1) to (3), (18) and (19). Taking logs and differentiating (20) with respect to w_i, $i \in \{a, b\}$, derives the following first-order conditions

$$\Phi_a = \frac{\delta}{L_a} \frac{\partial L_a}{\partial w_a} + \frac{\delta}{w_a - \overline{w}} + \frac{1 - \delta}{\Pi} \frac{\partial \Pi}{\partial w_a} = 0, \tag{21}$$

$$\Phi_b = \frac{\delta}{L_b} \frac{\partial L_b}{\partial w_b} + \frac{\delta}{w_b - \overline{w}} + \frac{1 - \delta}{\Pi} \frac{\partial \Pi}{\partial w_b} = 0. \tag{22}$$

We exercise a comparative static analysis to determine the corporate tax effects on negotiated wages in equilibrium. Since we will focus on a symmetric equilibrium at the first stage of the tax competition game, we will derive the marginal tax effects on workers' wages for symmetric tax rates.

Proposition 3 *Suppose the tax competition game at the first stage attains an equilibrium with $t_a = t_b = \hat{t}$ and δ is sufficiently large. Then the corporate tax rate exerts a negative (positive) effect on domestic (foreign) workers' remuneration under FA.*

Proof See Appendix C. □

The marginal impact of the corporate tax rate on *domestic* workers' wages can be split in three sub-effects: Firstly, a rise in the local corporate tax rate induces the MNE to shift labour demand from the domestic to the foreign location since it thereby decreases the share of consolidated profit that is taxed domestically. This tends to reduce

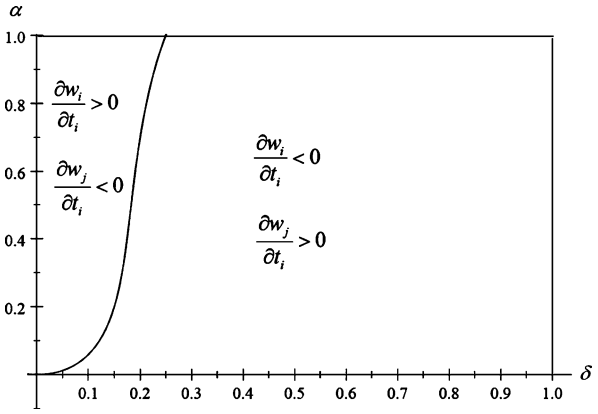

Fig. 1 Corporate tax effects on workers' wages under FA

the negotiated wage level of domestic workers. Secondly, increasing the corporate tax rate raises the MNE's tax burden and leads to a decline in the MNE's after-tax profits, which also tends to lower negotiated wages. Thirdly, increasing the domestic corporate tax exerts an ambiguous effect on the MNE's profit sensitivity with respect to domestic wages. On the one hand, payroll cost are deductible from the tax base, and hence, raising the corporate tax rate reduces the MNE's profit sensitivity with respect to the domestic wage level. On the other hand, increasing the domestic corporate tax rate raises the profit sensitivity since higher domestic wages induce a larger share of the consolidated tax base to be apportioned to the domestic affiliate and to be taxed at the increased corporate tax rate.

Since the sign of the relevant tax effect cannot be determined analytically, we simulate the model for a production function of the form $F(L, G) = G^{1-\alpha} L^{\alpha}$, with $\alpha \in [0, 1]$ and G being a fixed production factor, e.g. entrepreneurial knowledge, which ensures that the firm earns positive profits even under the assumption of perfect competition in product markets. We set G and the outside wage $\overline{w}$ in both countries equal to 1 and simulate the model for different parameter values of α and δ. The result is presented in Fig. 1. It is obvious that the impact of the corporate tax on domestic wages is negative if the bargaining power δ is sufficiently large and α is sufficiently small. For $\delta > 25\%$, the effect is negative irrespective of the size of α.[7] Since the union bargaining power is estimated to be well above this threshold level for European countries (Dumont et al. 2006), our model predicts a negative impact of corporate taxes on domestic wages in these countries.

Analogously, the impact of the corporate tax rate on *foreign* workers' wages can be divided into three sub-effects. Firstly, a rise in the local corporate tax rate induces the MNE to shift labour demand to the foreign affiliate, which tends to increase the wage level negotiated at the foreign location. Secondly, domestic corporate tax increases impact on the wage bargaining process at the foreign location since they lower the MNE's total after-tax profit. This tends to dampen the negotiated wage level of foreign workers. Thirdly, domestic tax increases affect the profit sensitivity with respect

[7] We exercised sensitivity checks with respect to the parameter values for G and $\overline{w}$, and found Fig. 1 to be very robust against variations in these parameters.

to changes in the foreign wage rate. On the one hand, foreign as well as domestic payroll cost are deductible from the MNE's consolidated corporate tax base. Domestic corporate tax increases raise the value of this deduction and make the MNE's profit less sensitive to foreign wage increases. Additionally, raising the local corporate tax rate makes foreign wage increases less costly since higher foreign wages raise the foreign relative payroll share, and thus the share of the consolidated profit that is apportioned to the foreign country and taxed at the constant corporate tax rate abroad.

To determine the sign of the overall effect, we again simulate the model making use of the assumptions described above. For symmetry reasons, the conditions for foreign wages to increase/decrease in the domestic corporate tax rate turn out to be equally captured by Fig. 1. For a sufficiently large union bargaining power ($\delta > 25\%$), the effect is positive, which is in line with the situation in Europe.

4.3 Tax competition

At the first stage, we consider a tax competition game under FA. The social welfare function is defined by

$$SW_i = \rho t_i \hat{\beta}_i [\hat{\Pi}_{Ta} + \hat{\Pi}_{Tb}] + (\hat{w}_i - \overline{w})\hat{L}_i + \overline{w}N, \quad i \in \{a, b\} \tag{23}$$

with $\hat{L}_i, \hat{w}_i, \hat{w}_j, \hat{p}_i, \hat{p_j}$, and $\hat{\Pi}_{Ti} = \hat{\Pi}_{Ti}(\hat{L}_i, \hat{w}_i, \hat{p}_i, \hat{p_j})$ representing the optimal values chosen at the second and third stage, for $i, j \in \{a, b\}$ and $i \neq j$. Analogously to SA, social welfare is assumed to comprise corporate tax revenues and residents' wage income. The corporate tax base under FA is determined by the relative payroll share β_i which represents the fraction of the consolidated profits apportioned to country i. Since both countries maximize their social welfare, it holds that $\partial SW_i(t_a, t_b)/\partial t_i = 0$. The countries are assumed to be identical. Therefore, it is reasonable to focus on the symmetric Nash equilibrium of the tax competition game. Let $\hat{t} = t_a = t_b$ be the equilibrium tax rates. Equilibrium social welfare is given by

$$SW_i(\hat{t}, \hat{t}) =: SW(\hat{t}). \tag{24}$$

To investigate whether the countries choose inefficiently high or low tax rates in equilibrium, we have to determine the impact of a coordinated increase in the common tax rate $\hat{t}$ on the countries' social welfare. Differentiating (24) yields

$$\frac{dSW(\hat{t})}{d\hat{t}} = \frac{\partial SW_i(t_a, t_b)}{\partial t_i}\bigg|_{t_a=t_b=\hat{t}} + \frac{\partial SW_i(t_a, t_b)}{\partial t_j}\bigg|_{t_a=t_b=\hat{t}}, \quad i, j \in \{a, b\},\ i \neq j \tag{25}$$

whereas $\partial SW_i/\partial t_i = 0$. The cross effect $\partial SW_i/\partial t_j$ reflects the fiscal externalities

$$\frac{\partial SW_i}{\partial t_j} = t_i \rho \left\{ \hat{\beta}_i \sum_{k=a,b} \left[\frac{\partial \hat{\Pi}_T}{\partial \hat{w}_k} \frac{\partial \hat{w}_k}{\partial t_j} + \frac{\partial \hat{\Pi}_T}{\partial \hat{L}_k} \frac{\partial \hat{L}_k}{\partial t_j} \right] + [\hat{\Pi}_{Ta} + \hat{\Pi}_{Tb}] \frac{\partial \hat{\beta}_i}{\partial t_j} \right\}$$
$$+ (1 + \hat{\epsilon})\hat{L}_i \frac{\partial \hat{w}_i}{\partial t_j} + (\hat{w}_i - \overline{w}) \frac{\partial \hat{L}_i}{\partial t_j}, \quad i, j \in \{a, b\},\ i \neq j \tag{26}$$

with $\hat{\epsilon} = \partial \hat{L}_i / \partial \hat{w}_i \cdot (\hat{w}_i - \overline{w}) / \hat{L}_i$. Evaluating (26) at the symmetric equilibrium leads to the following proposition.

Proposition 4 *Suppose the tax competition game under FA attains a symmetric equilibrium $t_a = t_b = \hat{t}$, and it holds that $\partial w_i / \partial t_j > 0$; then, the countries set inefficiently low corporate tax rates due to a positive formula externality and a positive wage income externality.*

Proof See Appendix D. □

Two fiscal externalities are derived under FA. Firstly, we find a positive externality which is caused by the MNE's distortion of the apportionment formula. If a country raises its corporate tax rate, it induces the MNE to shift labour demand to the foreign location, thereby increasing the relative payroll share of the foreign affiliate and the fraction of consolidated profit that is taxed in the foreign country. Moreover, the increased corporate tax rate tends to lower domestic wages and simultaneously increases negotiated wages at the foreign affiliate. The wage adjustments further increase the relative payroll share of the foreign affiliate and imply that a larger fraction of the MNE's consolidated profit is apportioned to the foreign country. These two effects give rise to a positive externality of corporate taxation on the foreign country's welfare, which we call formula externality. Secondly, we derive a positive externality which results from the endogenous determination of the wage rate. If a country raises its corporate tax rate, the negotiated wage level at the foreign multi-national affiliate increases and raises foreign workers' utility. This externality is additionally magnified since a rise in the domestic corporate tax rate also increases the MNE's employment at the foreign location, which additionally raises the foreign utility from multi-national labour income.[8] This establishes a positive fiscal externality that we again call wage income externality.

Summing up, we found that under plausible parameter assumptions, the switch from SA to a FA regime reverses the corporate tax effects on negotiated domestic and foreign wages. Precisely, under FA, increases in the corporate tax rate tend to reduce the negotiated wages for local workers and tend to increase the negotiated wages for foreign workers. A tax competition game under FA establishes the existence of a positive formula externality and a positive wage income externality, and thus suggests that union wage bargaining enforces the race-to-the-bottom in corporate tax rates. This is in contrast with the SA scenario, where the wage externality is negative under plausible parameter assumptions, and hence tends to compensate for the positive profit shifting effect and dampen the race-to-the-bottom in corporate tax rates (or may theoretically even overcompensate it and induce a race-to-the-top in corporate tax rates).

In the policy debate, a switch from SA to FA is commonly considered to be welfare increasing, as the positive profit shifting externality under SA is perceived to quantitatively outweigh the positive formula externality under FA. Mintz and

[8] Note that in contrast to SA the corporate tax effect on foreign workers' wages does not alter the foreign multi-national tax base; see Appendix D.

Smart (2003) present empirical evidence in line with this notion. The quantitative gap between the externalities may be rather small, however (see also Riedel 2010; Buettner et al. 2011). Our theoretical model suggests that accounting for union wage bargaining may, moreover, significantly diminish or even erase these welfare benefits. As the wage income externality presented in our model adds to the positive formula externality under FA, while it tends to compensate for the positive shifting externality under SA, it renders FA less attractive compared to SA.[9]

5 Discussion of the model assumptions

Our analysis relies on the simplifying assumption that labour is the only corporate production factor. Although this may be a good description of firms in the service industry, it surely does not apply to all corporations. If capital is introduced into the model, it is straightforward to show that our qualitative results remain unchanged if capital costs are fully deductible from the corporate tax base. Precisely, full deductibility implies that the corporation tax is a pure profit tax and that the firm's optimal capital demand is not directly dependent on corporate tax rates under both SA and FA with payroll apportionment. Note that this result holds irrespective of the specification of the production function, and consequently, the qualitative findings concerning the effects of corporate taxation on negotiated wages and the fiscal externalities derived from the tax competition game remain unaltered (see an earlier working paper version for a short formal derivative of this result).

If capital costs are in contrast only partially deductible from the corporate tax base, it can be shown that the effect of corporate taxes on domestic wages becomes ambiguous under SA, while all other qualitative wage and welfare effects remain unchanged. The intuition is the following: Under SA, partial deductibility induces corporate taxes to exert a negative impact on the MNE's domestic capital demand. If capital and labour are complements, an increase in the corporate tax rate will reduce the MNE's domestic capital demand and, in consequence, also its domestic labour demand (again, see an earlier working paper version for a short formal derivative of this result). This tends to dampen the domestic wage increase derived in Proposition 1, whereas this dampening effect is larger the higher the degree of complementarity between the production factors. In general, the corporate tax rate may still exert a positive effect on domestic wages though. Moreover, the corporate tax effect on *foreign* wages under SA remains unchanged since foreign capital and labour demand are not directly affected by domestic corporate taxes even with partial deductibility of capital costs. Consequently, the fiscal externalities derived under SA also remain unaltered. Analogously, it can be shown that the qualitative corporate tax effects on negotiated wages under FA continue to hold with partial deductibility of capital costs. Precisely, the negative tax effect on domestic wages increases in absolute terms since corporate taxation now exerts a direct negative effect on domestic capital demand, which under

[9] Intuitively, for international welfare losses under SA to fall short from international welfare losses under FA, the wage income externalities under the two taxation regimes must not be too small compared to the quantitative gap between the profit shifting and the formula externality.

complementarity of the production factors, enforces the negative tax effect on domestic labor demand and wages. Moreover, the positive tax effect on foreign wages carries over from the baseline model as foreign capital demand is not directly dependent upon domestic taxes. The same is therefore true for the wage income externality under FA. The results are available from the authors upon request.

Another assumption which merits some discussion is that we consider payroll to be the only apportionment factor under FA. While some of the existing FA regimes apportion according to the relative payroll share only (e.g. the German local business tax), others additionally account for a capital and/or a sales factor in the apportionment formula. In the context of our model, it is straightforward to show that the introduction of a capital and/or sales factor into the model does not qualitatively change the corporate tax effect on workers' wages and the wage income externality although the effects are quantitatively attenuated. The intuition is simple: with capital and sales apportionment, capital demand, and sales are distorted in favor of low-tax countries under FA. If labour is complementary to these factors, it is equally distorted by corporate taxation although the indirect impact of corporate taxation in this case is quantitatively smaller than the direct impact under full payroll apportionment. This translates into attenuated corporate tax effects on domestic and foreign wages and into an attenuated wage income externality in the tax competition game.

Last, our model abstracts from any differences in the skill or productivity level of the workers or, put differently, we assume labor to be homogeneous within and across countries. Papers which assume heterogeneous labor within a country commonly assess bargaining between *individual* workers and firms under asymmetric information (see, e.g. Strand 2002). Incorporating these assumptions in our framework would considerably increase the complexity of the analysis while the mechanisms of main interest, i.e. the effect of corporate taxes on wages, remain unaltered. Precisely, differences in worker productivity are expected to affect the negotiated wage level (with higher skill and productivity levels inducing larger wage rates), while the corporate tax effects on the wage bargaining outcome continue to hold. Moreover, we assume labour to be homogeneous *across* countries. This assumption may, in the context of comparing SA and FA in the European Union, be justified by the fact that multinational firm structures in the EU are considered to be predominantly horizontal in nature which suggests no major skill differences between affiliate workers (see, e.g. Egger 2004). However, we again consider that introducing exogenous skill differences between workers of the two firms may alter the negotiated wage rate but do not fundamentally change the effect of corporate taxes on the wage bargaining game and the associated fiscal externalities. Rigorously incorporating skill differences between affiliate workers in the analysis would, moreover, come at the costs of introducing asymmetry in the model, which greatly adds to the complexity of the analysis, especially under the FA regime. As asymmetric FA models are, to the best of our knowledge, still lacking in the tax competition literature, a rigorous formal analysis has to await future work.[10]

[10]In models with vertical MNEs and heterogeneous labor, the MNE may additionally choose in which country to employ its high- and low-skilled work force. Corporate taxation may in this context potentially affect the location decision. Precisely, the MNE may have an incentive to employ high-skilled (low-skilled)

6 Conclusion

This paper analyses union wage bargaining in a tax competition framework with MNEs. We derive the results distinguishing between corporate taxation systems that follow SA and FA regulations, respectively. Under SA, we show that the corporate tax rate exerts a positive (negative) impact on domestic (foreign) workers' wages. The effects are reversed under FA, where increases in the corporate tax rate tend to reduce domestic workers' wages and raise foreign workers' wages. The main insight emerging from a tax competition game is that wage bargaining establishes an analytically ambiguous fiscal externality under SA that is negative for plausible parameter values, and thus tends to dampen the race-to-the-bottom in corporate tax rates. In contrast, under FA, we find a positive externality caused by union wage bargaining that enforces the race-to-the-bottom in corporate taxes.

Given the importance of union wage bargaining in the European Union, our results have two implications for the EU Commission's plan to introduce FA within the EU: Firstly, they indicate that a switch from SA to FA within EU borders would fundamentally alter the rent sharing within multi-national companies. While under the current SA system, high corporate tax rates do not harm domestic workers but diminish wages at foreign affiliates, the opposite scenario is predicted for FA. This implies that countries with a high corporate tax rate are predicted to suffer from wage reductions in the wake of a regime switch from SA to FA, while countries with a low corporate tax rate are predicted to observe wage rate gains. Secondly, union wage bargaining gives rise to a fiscal externality that is likely to dampen the race-to-the-bottom in corporate tax rates under SA, but that, in contrast, intensifies tax competition in a FA setting. This may cast some doubt on the hope that the introduction of FA will reduce tax competition behavior between EU countries.

Appendix A: Proof of Proposition 1

Totally differentiating (9) and (10) and applying Cramer's rule derives the marginal corporate tax effects on domestic and foreign workers' wages

$$\frac{dw_i}{dt_i} = -\frac{\partial \Phi_i/\partial t_i \cdot \partial \Phi_j/\partial w_j - \partial \Phi_j/\partial t_i \cdot \partial \Phi_i/\partial w_j}{\partial \Phi_i/\partial w_i \cdot \partial \Phi_j/\partial w_j - \partial \Phi_i/\partial w_j \cdot \partial \Phi_j/\partial w_i}, \tag{A.1}$$

$$\frac{dw_i}{dt_j} = -\frac{\partial \Phi_i/\partial t_j \cdot \partial \Phi_j/\partial w_j - \partial \Phi_j/\partial t_j \cdot \partial \Phi_i/\partial w_j}{\partial \Phi_i/\partial w_i \cdot \partial \Phi_j/\partial w_j - \partial \Phi_i/\partial w_j \cdot \partial \Phi_j/\partial w_i} \tag{A.2}$$

with $i, j \in \{a, b\}$ and $i \neq j$. For the objective function (7) to be concave, the second derivative with respect to the wage rate must be negative $\partial \Phi_i/\partial w_i < 0$ with $i \in \{a, b\}$.

workers who tend to earn high (low) wages in countries with a large (small) tax rate under SA, while under a FA regime with payroll apportionment, the MNE has an incentive to employ high-skilled (low-skilled) workers with high (low) wages in countries with a small (large) tax rate to distort the apportionment formula in favor of the low-tax country. However, as mentioned above, in the EU context, MNEs are perceived to be predominantly horizontal in nature.

Moreover, $\partial\Phi_i/\partial w_j = -(1-\delta)/\Pi^2 \cdot \partial\Pi/\partial w_i \cdot \partial\Pi/\partial w_j < 0$ for $i, j \in \{a, b\}$ and $i \neq j$ as it follows from (2) and (6) that

$$\frac{\partial L_i}{\partial w_j} = 0, \qquad \frac{\partial \Pi}{\partial w_i} = -(1-t_i)L_i < 0, \quad i, j \in \{a, b\},\ i \neq j. \tag{A.3}$$

Since our analysis focuses on stable equilibria, the determinant of the equation system is assumed to be positive, $\partial\Phi_i/\partial w_i \cdot \partial\Phi_j/\partial w_j - \partial\Phi_i/\partial w_j \cdot \partial\Phi_j/\partial w_i > 0$ for $i, j \in \{a, b\}$ and $i \neq j$.[11] Thus, the signs of (A.1) and (A.2) depend on the sign of the numerator, explicitly on $\partial\Phi_i/\partial t_i$ and $\partial\Phi_i/\partial t_j$, with

$$\frac{\partial\Phi_i}{\partial t_i} = \frac{\delta}{L_i}\frac{\partial^2 L_i}{\partial w_i \partial t_i} - \frac{\delta}{L^2}\frac{\partial L_i}{\partial w_i}\frac{\partial L_i}{\partial t_i} + \frac{(1-\delta)}{\Pi}\frac{\partial^2\Pi}{\partial w_i \partial t_i} - \frac{1-\delta}{\Pi^2}\frac{\partial\Pi}{\partial w_i}\frac{\partial\Pi}{\partial t_i}, \tag{A.4}$$

$$\frac{\partial\Phi_i}{\partial t_j} = \frac{\delta}{L_i}\frac{\partial^2 L_i}{\partial w_i \partial t_j} - \frac{\delta}{L^2}\frac{\partial L_i}{\partial w_i}\frac{\partial L_i}{\partial t_j} + \frac{(1-\delta)}{\Pi}\frac{\partial^2\Pi}{\partial w_i \partial t_j} - \frac{1-\delta}{\Pi^2}\frac{\partial\Pi}{\partial w_i}\frac{\partial\Pi}{\partial t_j}. \tag{A.5}$$

Taking into account (A.3) and that it additionally follows from (2) and (6) that

$$\frac{\partial L_i}{\partial w_i} = \frac{1}{F''(w_i)}, \qquad \frac{\partial L_i}{\partial t_i} = \frac{\partial L_i}{\partial t_j} = \frac{\partial L_i}{\partial w_i \partial t_i} = \frac{\partial L_i}{\partial w_i \partial t_j} = 0 \tag{A.6}$$

$$\frac{\partial\Pi}{\partial t_i} = -\Pi_{Ti}, \qquad \frac{\partial^2\Pi}{\partial w_i \partial t_i} = L_i, \qquad \frac{\partial^2\Pi}{\partial w_i \partial t_j} = 0 \tag{A.7}$$

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

$$\frac{\partial\Phi_i}{\partial t_i} = \frac{(1-\delta)L_i(1-t_j)\Pi_{Tj}}{\Pi^2} > 0, \tag{A.8}$$

$$\frac{\partial\Phi_i}{\partial t_j} = -\frac{(1-\delta)L_i(1-t_i)\Pi_{Tj}}{\Pi^2} < 0 \tag{A.9}$$

with $i, j \in \{a, b\}$, $i \neq j$. Hence, $\partial w_i/\partial t_i > 0$ and $\partial w_i/\partial t_j < 0$.

Appendix B: Proof of Proposition 2

It follows from (16) and Proposition 1 that $1/\theta''(1) > 0$ and $\widetilde{L} \cdot \partial\widetilde{w}_i/\partial t_j < 0$. Moreover, it must hold that $1 + \widetilde{\epsilon} > 0$ as was demonstrated in (8). Therefore, the profit shifting externality $2\rho\,\tilde{t}/\theta''(1)$ is positive while the wage income externality $\{1 + \widetilde{\epsilon} - \rho\,\tilde{t}\}\widetilde{L} \cdot \partial\widetilde{w}_i/\partial t_j$ carries an ambiguous sign.

[11] See, for example Hammond et al. (2005).

Appendix C: Proof of Proposition 3

Analogously to SA, wage rates under FA are determined by the first order conditions

$$\Phi_a = \frac{\delta}{L_a}\frac{\partial L_a}{\partial w_a} + \frac{\delta}{w_a - \overline{w}} + \frac{1-\delta}{\Pi}\frac{\partial \Pi}{\partial w_a} = 0, \tag{C.1}$$

$$\Phi_b = \frac{\delta}{L_b}\frac{\partial L_b}{\partial w_b} + \frac{\delta}{w_b - \overline{w}} + \frac{1-\delta}{\Pi}\frac{\partial \Pi}{\partial w_b} = 0. \tag{C.2}$$

Totally differentiating (C.1) and (C.2) and applying Cramer's rule derives the marginal corporate tax effects on domestic and foreign workers' wages

$$\frac{\partial w_i}{\partial t_i} = -\frac{\partial \Phi_i/\partial t_i \cdot \partial \Phi_j/\partial w_j - \partial \Phi_j/\partial t_i \cdot \partial \Phi_i/\partial w_j}{\partial \Phi_i/\partial w_i \cdot \partial \Phi_j/\partial w_j - \partial \Phi_i/\partial w_j \cdot \partial \Phi_j/\partial w_i}, \tag{C.3}$$

$$\frac{\partial w_i}{\partial t_j} = -\frac{\partial \Phi_i/\partial t_j \cdot \partial \Phi_j/\partial w_j - \partial \Phi_j/\partial t_j \cdot \partial \Phi_i/\partial w_j}{\partial \Phi_i/\partial w_i \cdot \partial \Phi_j/\partial w_j - \partial \Phi_i/\partial w_j \cdot \partial \Phi_j/\partial w_i} \tag{C.4}$$

for $i, j \in \{a, b\}$ and $i \neq j$. For the objective function to be concave, it must hold that $\partial \Phi_i/\partial w_i < 0$, with $i \in \{a, b\}$. Additionally, $\partial \Phi_i/\partial w_j = -(1-\delta)/\Pi^2 \cdot \partial \Pi/\partial w_i \cdot \partial \Pi/\partial w_j < 0$ since it follows from (2) and (19) under consideration of (18) and the symmetry assumption ($t_a = t_b$) that

$$\begin{aligned} &\frac{\partial L_i}{\partial w_j} = \frac{\partial L_i}{\partial w_j \partial t_j} = \frac{\partial \Pi}{\partial w_i \partial w_j} = 0, \\ &\frac{\partial \Pi}{\partial w_i} = -(1-t_i)L_i < 0, \quad i, j \in \{a, b\},\ i \neq j. \end{aligned} \tag{C.5}$$

Since our analysis focuses on stable equilibria, the determinant of the equation system is assumed to be positive. Thus, the signs of (C.3) and (C.4) are determined by $\partial \Phi_i/\partial t_i$ and $\partial \Phi_i/\partial t_j$, with

$$\frac{\partial \Phi_i}{\partial t_i} = \frac{\delta}{L_i}\frac{\partial^2 L_i}{\partial w_i \partial t_i} - \frac{\delta}{L^2}\frac{\partial L_i}{\partial w_i}\frac{\partial L_i}{\partial t_i} + \frac{(1-\delta)}{\Pi}\frac{\partial^2 \Pi}{\partial w_i \partial t_i} - \frac{1-\delta}{\Pi^2}\frac{\partial \Pi}{\partial w_i}\frac{\partial \Pi}{\partial t_i}, \tag{C.6}$$

$$\frac{\partial \Phi_i}{\partial t_j} = \frac{\delta}{L_i}\frac{\partial^2 L_i}{\partial w_i \partial t_j} - \frac{\delta}{L^2}\frac{\partial L_i}{\partial w_i}\frac{\partial L_i}{\partial t_j} + \frac{(1-\delta)}{\Pi}\frac{\partial^2 \Pi}{\partial w_i \partial t_j} - \frac{1-\delta}{\Pi^2}\frac{\partial \Pi}{\partial w_i}\frac{\partial \Pi}{\partial t_j}. \tag{C.7}$$

As described in the main text, we will not be able to determine the signs of (C.6) and (C.7) analytically. Therefore, we simulate the model for a production function of the form $F = L^{\alpha} G^{1-\alpha}$, with $\alpha \in [0, 1]$ and G being a fixed production factor. It moreover follows from (2) and (19), under consideration of (18), the tax symmetry assumption ($t_a = t_b$) and the specification of the production function that

$$\frac{\partial L_i}{\partial w_i} = \frac{1}{F''(L)} < 0, \qquad \frac{\partial^2 L_i}{\partial w_i \partial t_i} = -\frac{\partial^2 L_i}{\partial w_i \partial t_j} = -\frac{[F''(L)L^2 + 2\Pi_T]}{4(1-t)F''(L)^2 L^2}, \tag{C.8}$$

$$\frac{\partial L_i}{\partial t_i} = -\frac{\partial L_i}{\partial t_j} = \frac{\Pi_T}{2(1-t)F''(L)L} < 0, \qquad \frac{\partial \Pi}{\partial t_i} = \frac{\partial \Pi}{\partial t_j} = -\Pi_T < 0, \tag{C.9}$$

$$\frac{\partial^2 \Pi}{\partial w_i \partial t_i} = \frac{1}{2}\left[L - \frac{\Pi_T}{w} - \frac{\Pi_T}{F''(L)L}\right],$$
$$\frac{\partial^2 \Pi}{\partial w_i \partial t_j} = \frac{1}{2}\left[L + \frac{\Pi_T}{w} + \frac{\Pi_T}{F''(L)L}\right]. \tag{C.10}$$

Note thereby that plugging in the tax symmetry assumption into (19), (C.1), (C.2), and (2) gives $L_a = L_b = L$, $w_a = w_b = w$ and $\Pi_{Ta} = \Pi_{Tb} = \Pi_T$. Accounting for (C.5) and (C.8) to (C.10), we find that (C.6) and (C.7) can be rewritten

$$\frac{\partial \Phi_i}{\partial t_i} = \frac{[F''(L)L^2 + 4\delta\Pi_T]}{4(1-t)F''(L)^2L^3} + \frac{1-\delta}{4(1-t)w}, \tag{C.11}$$
$$\frac{\partial \Phi_i}{\partial t_j} = -\frac{[F''(L)L^2 + 4\delta\Pi_T]}{4(1-t)F''(L)^2L^3} - \frac{1-\delta}{4(1-t)w} \tag{C.12}$$

for $i, j \in \{a, b\}$ and $i \neq j$. Simulating (C.11) and (C.12) for different values of δ and α derives Fig. 1. We find that for a sufficiently large union bargaining power δ, it holds that $\partial \Phi_i / \partial t_i < 0$ and $\partial \Phi_i / \partial t_j > 0$, and thus $\partial w_i / \partial t_i < 0$ and $\partial w_i / \partial t_j > 0$.

Appendix D: Proof of Proposition 4

Equation (26) can be simplified since it follows from Appendix C that the corporate tax rate exerts a symmetric impact on domestic and foreign workers' wages $\partial \hat{w}_j / \partial t_i = -\partial \hat{w}_i / \partial t_i$ whereas the hat-symbol indicates the optimal values chosen at stage 2 and stage 3 of the game and $i, j \in \{a, b\}$, $i \neq j$. Changes in the domestic corporate tax rate do therefore not exhibit any effect on the MNE's consolidated tax base. Additionally, we find that (19) implies for the tax symmetry case ($t_a = t_b = \hat{t}$) that $\partial \hat{\Pi}_{Ti} / \partial L_k = F'(\hat{L}) - \hat{w} = 0$ for $i, k \in \{a, b\}$. Hence,

$$\sum_k \left[\frac{\partial[\hat{\Pi}_{Ta} + \hat{\Pi}_{Tb}]}{\partial \hat{w}_k}\frac{\partial \hat{w}_k}{\partial t_j} + \frac{\partial[\hat{\Pi}_{Ta} + \hat{\Pi}_{Tb}]}{\partial \hat{L}_k}\frac{\partial \hat{L}_k}{\partial t_j}\right] = 0, \quad j, k \in \{a, b\}. \tag{D.1}$$

Accounting for tax symmetry and (D.1), we modify (26) to

$$\left.\frac{\partial SW_i}{\partial t_j}\right|_{t_a = t_a = \hat{t}} = \rho\hat{t} \cdot 2\hat{\Pi}_T \left.\frac{\partial \hat{\beta}_i}{\partial t_j}\right|_{t_a = t_a = \hat{t}} + (1 + \hat{\epsilon})\hat{L} \left.\frac{\partial \hat{w}_i}{\partial t_j}\right|_{t_a = t_a = \hat{t}}$$
$$+ (\hat{w} - \overline{w}) \left.\frac{\partial \hat{L}_i}{\partial t_j}\right|_{t_a = t_a = \hat{t}} \tag{D.2}$$

with $i, j \in \{a, b\}$ and $i \neq j$. The first term on the right-hand side represents the formula externality. The externality is unambiguously positive since in a symmetric Nash equilibrium $\partial \hat{\beta}_i / \partial t_j$ reads

$$\left.\frac{\partial \hat{\beta}_i}{\partial t_j}\right|_{t_a=t_a=\hat{t}} = \left[\frac{\partial \hat{\beta}_i}{\partial \hat{w}_i} + \frac{\partial \hat{\beta}_i}{\partial \hat{L}_i}\frac{\partial \hat{L}_i}{\partial \hat{w}_i}\right]\frac{\partial \hat{w}_i}{\partial t_j} + \left[\frac{\partial \hat{\beta}_i}{\partial \hat{w}_j} + \frac{\partial \hat{\beta}_i}{\partial \hat{L}_j}\frac{\partial \hat{L}_j}{\partial \hat{w}_j}\right]\frac{\partial \hat{w}_j}{\partial t_j}$$

$$= \frac{1}{4\hat{w}}\left[1 + \frac{\partial \hat{L}_i}{\partial \hat{w}_i}\frac{\hat{w}}{\hat{L}}\right]\frac{\partial \hat{w}_i}{\partial t_j} - \frac{1}{4\hat{w}}\left[1 + \frac{\partial \hat{L}_j}{\partial \hat{w}_j}\frac{\hat{w}}{\hat{L}}\right]\frac{\partial \hat{w}_j}{\partial t_j} > 0. \quad \text{(D.3)}$$

Note thereby that $\partial \hat{L}_i/\partial \hat{w}_j = 0$ (see (C.5)) and $1 + \partial \hat{L}_i/\partial \hat{w}_i \cdot \hat{w}/\hat{L} > 1$ for standard labour demand functions and $i, j \in \{a, b\}$, $i \neq j$. The second and third term on the right-hand side of (D.2) represent the wage income externality. This externality is unambiguously positive since it follows from Proposition 3 that $\partial \hat{w}_i/\partial t_j > 0$, from (8) that $(1 + \hat{\epsilon}) > 0$ and from (C.10) that $\partial \hat{L}_i/\partial t_j > 0$.

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