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Firms' financial choices and thin capitalization rules under corporate tax competition*

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Abstract

Thin capitalization rules have become an important element in the corporate tax systems of developed countries. This paper sets up a model where national and multinational firms choose tax-efficient financial structures and countries compete for multinational firms through statutory tax rates and thin capitalization rules that limit the tax-deductibility of internal debt flows. In a symmetric tax competition equilibrium each country chooses inefficiently low tax rates and inefficiently lax thin capitalization rules. We show that a coordinated tightening of thin capitalization rules benefits both countries, even though it intensifies competition via tax rates. When countries differ in size, the smaller country not only chooses the lower tax rate but also the more lenient thin capitalization rule.

Keywords: tax competition, thin capitalization, capital structure

JEL Classification: H73, H25, F23

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1 Introduction

Existing corporate tax systems permit deduction of interest payments from the tax base, whereas equity returns to investors are not tax-deductible. This asymmetric treatment of alternative means of financing investment offers firms a fundamental incentive to increase their reliance on debt finance. For multinational companies this incentive is further strengthened by the opportunity to use internal debt as a means to shift profits from high-tax to low-tax countries. Recent empirical research provides conclusive evidence that international tax differentials affect multinationals' financial structure in a way that is consistent with overall tax minimization.[1] Moreover, while profit shifting within multinationals can occur through a variety of channels, there are clear empirical indications that the use of financial policies plays an important role in this process (Grubert, 2003; Mintz, 2004). For this reason, international debt is suspected to be a core factor behind empirical findings that multinational firms seem to pay substantially lower taxes, as a share of pre-tax profits, as compared to nationally operating firms.[2]

In response to these developments, many countries have introduced thin capitalization rules, which limit the amount of interest payments to related entities that is deductible from the tax base. Table 1 lists all countries which included such constraints in their corporate tax codes in 2005. The general way to enact thin capitalization provisions is to specify a *safe haven* debt-to-equity ratio, and to limit the deduction of the cost of debt once this critical threshold level is surpassed.[3]

On the other hand, the move to stricter thin capitalization rules is not universal. The United States, for example, which was one of the first countries to introduce an

[1] Desai et al. (2004) show for U.S.-based multinational firms that a 10% higher corporate tax rate in the host country of a foreign affiliate raises the debt-to-asset ratio of this affiliate by about 3-4%. Similar evidence is obtained for European multinationals by Egger et al. (2009) and for German multinationals by Mintz and Weichenrieder (2005) and Buettner et al. (2006). Huizinga et al. (2008) provide more general evidence that the capital structure of European multinationals is adapted in a tax-minimizing way to international differences in corporate tax systems and corporate tax rates.

[2] For Europe, Egger et al. (2007) have estimated, using econometric matching techniques, that the tax burden of an otherwise similar manufacturing plant is reduced by more than 50% when the parent firm is foreign-owned, rather than domestically-owned. Hines (2007) finds related evidence that the effective tax payments of U.S. multinationals in their respective host countries have fallen more rapidly than the statutory tax rates in these countries.

[3] Detailed descriptions of existing thin capitalization rules are given by Gouthière (2005) for most OECD countries, and by Dourado and de la Feria (2008) for the EU member states.

Table 1. Thin capitalization rules in 2005

Country	safe haven debt-to-equity ratio (1)	debt in column (1) refers to (2)
Australia	3:1	total debt
Belgium	7:1	related party debt
Bulgaria	3:1	total debt [a)]
Canada	2:1	related party debt
Croatia	4:1	related party debt
Czech Republic	4:1	related party debt
Denmark	4:1	total debt
France	1.5:1	related party debt
Germany	1.5:1	related party debt
Hungary	3:1	total debt [a)]
Italy	4:1	related party debt
Japan	3:1	total debt
Latvia	4:1	total debt [a)]
Lithuania	4:1	total debt
Luxembourg	5.7:1	related party debt
Mexico	3:1	total debt
Netherlands	3:1	total debt
New Zealand	3:1	total debt
Poland	3:1	total debt
Portugal	2:1	related party debt
Romania	3:1	total debt [a)]
Slovakia (2003) [b)]	4:1	related party debt
Slovenia	8:1	related party debt
Spain	3:1[c)]	related party debt
South Korea	3:1	related party debt
Switzerland	6:1	total debt
Turkey	2:1	related party debt
UK	1:1[d)]	total debt
USA	1.5:1	total debt

Source: Buettner et al. (2009), Table 1.

[a)] Debt in column (1) refers to total debt, but loans from financial institutions are not considered.

[b)] Thin-capitalization rule was abolished in 2004.

[c)] Since 2004 the thin-capitalization rule applies only to related party debt from outside the European Union.

[d)] Since 2004 the UK applies anti-abuse rules employing an arm's length principle, but the safe haven debt-to-equity ratio is still used as a guideline.

earnings' stripping rule in 1989, has introduced changes to its tax code in 1997 that facilitated the use of internal debt as a tax savings instrument.[4] Ireland and, more recently, Spain have even abolished thin capitalization restrictions for loans from EU-based companies completely, in response to a 2002 ruling by the European Court of Justice that thin capitalization rules must be set up in a non-discriminatory way. In the case of Ireland, it is furthermore noteworthy that the relaxation of thin capitalization rules directly followed the forced termination of Ireland's split corporate tax rate, which had long been used as an instrument to provide preferential tax treatment to multinationals. This suggests that at least some countries might strategically use lax thin capitalization rules as a means to grant targeted tax relief to multinational firms.

These recent developments have led to an increasing awareness in the European Union of the potential inefficiencies that result from a decentralized setting of thin capitalization rules. In a communication, the European Commission (2007) has announced its willingness to take coordinated actions against 'wholly artificial arrangements' used to shift profits between establishments, and explicitly includes thin capitalization rules as a possible countermeasure at the EU level. A more detailed discussion at the EU level has taken place in conjunction with the proposal to introduce a Common Consolidated Corporate Tax Base (CCCTB). A working group preparing this proposal has evaluated various alternatives to limit the deductibility of interest payments within multinational groups (European Commission, 2008). While no specific thin capitalization rule has been proposed yet it is generally expected that the directive proposal to introduce a CCCTB will include thin capitalization provisions (see, e.g., Fuest, 2008).

Despite the policy relevance of the subject, and in contrast to a growing body of empirical research, we are unaware of a theoretical analysis that focuses on the positive and normative aspects of the choice of thin capitalization rules by countries engaged in tax competition. This is what we aim to do in the present paper.

We consider a model with two potentially asymmetric countries and national as well as multinational firms. Tax competition for internationally operating firms occurs through statutory tax rates and through thin capitalization rules that limit the tax-deductibility

[4]The main element among these tax changes were so-called 'check-the-box' provisions which introduced *hybrid entities* that are considered as corporations by one country, but as unincorporated branches by another. These rules can be used by U.S. multinationals to circumvent existing rules for controlled foreign corporations (CFC rules), which disallow the deferral of passive business income, including interest payments, for the affiliates of U.S. corporations. See OECD (2007), ch. 5.

of internal debt flows within the multinational enterprise. Both multinational and national firms can also respond to a higher domestic tax rate by increasing the level of external debt finance. We first consider the case of symmetric countries and show that tax competition leads to inefficiently low tax rates and inefficiently lax thin capitalization rules, relative to the Pareto efficient solution. This serves as a convenient benchmark from which our main results can be derived.

The first central result of our analysis is that, starting from the symmetric tax competition equilibrium, a coordinated tightening of thin capitalization rules is mutually welfare-increasing, even if countries are free to re-optimize their statutory tax rates in a non-cooperative fashion. Indeed we find that countries compete more aggressively via statutory tax rates when thin capitalization rules are coordinated. Nevertheless this partial coordination measure is beneficial because tax competition occurs primarily through thin capitalization rules in our model. Therefore the coordination of thin capitalization rules deprives countries of their most aggressive policy instrument and makes tax competition less severe, on average.

This finding implies that regulations specifically addressed at multinational corporations, such as thin capitalization rules, may be a more important determinant of foreign direct investment (FDI) than the statutory tax rate. This prediction receives support from recent empirical studies. Altshuler and Grubert (2006) show that the U.S. statutory tax rate ceased to have a significant impact on FDI flows, after the United States had effectively relaxed their thin capitalization rules in 1997 (see above). Related evidence is reported in Buettner et al. (2009). They find, for a sample of 24 OECD countries, that thin capitalization rules are effective in reducing firms' debt-to-equity ratios and thus have the potential to reduce international debt shifting. At the same time, the study also finds that the existence and the tightness of thin capitalization rules have significant, adverse effects on foreign direct investment.

Our second main result pertains to the case of asymmetric countries. We show that the country with the smaller population size not only chooses the lower tax rate, but also the more lenient thin capitalization rule in the non-cooperative tax equilibrium. This is because the smaller country faces the more elastic tax base for mobile capital, but the same is not true for immobile capital. Hence the small country will find it optimal to tax-discriminate more in favor of mobile, multinational firms. This finding is consistent with the stylized facts summarized in Table 1, which show that large countries such as Germany, France, the United Kingdom or the United States have rather elaborate

rules limiting the interest-deductibility of internal debt, whereas small countries such as Belgium, Ireland, Luxembourg and many countries in Eastern Europe have either no thin capitalization rules at all or very permissive ones.

The analysis in this paper builds on two strands in the literature.[5] First, there are several studies that analyze the effects of corporate taxation on multinational firms' financing and investment decisions (Mintz and Smart, 2004; Schindler and Schjelderup, 2008; Weichenrieder and Windischbauer, 2008; Buettner et al., 2009; Keuschnigg and Ribi, 2009). In these papers, however, the focus of the analysis is primarily on the adjustment of firms to a given tax environment. Hence, in contrast to our paper, the analyses do not endogenize the tax policies of countries competing for FDI.

Second, our analysis also relates to the theoretical literature that investigates whether the abolition of tax preferences for mobile tax bases raises or reduces tax revenues and welfare in the competing countries (Janeba and Peters, 1999; Keen, 2001; Janeba and Smart, 2003; Haupt and Peters, 2005; Bucovetsky and Haufler, 2008).[6] However, none of these studies addresses thin capitalization rules, or the choice of capital structure within national and multinational firms.[7] Moreover, virtually all of the existing literature on discriminatory tax competition confines itself to the case of fully symmetric countries. In contrast, our model allows to study the effects that differences in country size have on the optimal combination of tax instruments in a setting where countries can discriminate between the taxation of domestic and multinational firms.

The remainder of the paper is set up as follows. Section 2 presents the basic framework. In Section 3 we derive the Pareto efficient (fully coordinated) set of tax policies. Section 4 analyzes the non-cooperative solution. Section 5 turns to the welfare effects of a partial coordination of thin capitalization rules. Section 6 investigates asymmetric tax competition when countries differ in size, and Section 7 concludes.

[5] See Gresik (2001) for an overview of the issues involved in the taxation of multinational firms.

[6] A related issue is addressed by Peralta et al. (2006), who show that countries may have an incentive not to monitor profit shifting in multinational firms. Moreover, Slemrod and Wilson (2006) and Hong and Smart (2009) ask whether the presence of tax havens is desirable or not from the perspective of high-tax countries, by permitting them to tax mobile and immobile capital differentially.

[7] A theoretical analysis that explicitly incorporates thin capitalization rules is Fuest and Hemmelgarn (2005). But in this paper the thin capitalization rule is fixed and the analysis focuses on the effects that thin capitalization has on the relationship between corporate and personal income taxation.

2 The model

We analyze a model of two countries, labelled A and B, that simultaneously compete in capital tax rates and in thin capitalization rules. These policy instruments affect the choices of two types of firms: internationally immobile firms, which can only invest in the country where the owner resides, and internationally mobile firms, which can invest in either country. The difference in the cross-country mobility of firms is assumed to be exogenous, arising for example from differential fixed costs of setting up an 'internationalized' organizational structure.[8]

To keep our analysis as simple as possible, we identify each firm with one unit of (internationally mobile or immobile) capital. Hence the terms 'firms' and 'capital' are used interchangeably throughout our analysis. Capital endowments are exogenously given and owned by the residents of countries A and B. The total population in the region to normalized to unity and the population share in country i is denoted s_i. Each resident of country i owns one unit of mobile capital and $n > 0$ units of immobile capital. Initially, we focus on the symmetric case where countries are of equal size ($s_A = s_B = 0.5$), but we relax this assumption in Section 6.

Internationally mobile and immobile capital are perfect substitutes in the production of an output good. This good is produced in both countries and its price is normalized to unity. The per capita production function in country i is quadratic and given by

$$f(k_i) = ak_i - (b/2)k_i^2, \qquad a, b > 0, \tag{1}$$

where $k_i \in [0, a/b]$ is the total per capita amount of capital used for production in country i. We assume that the source principle of capital taxation is effective and hence capital is taxed in the country where it is employed.[9] Moreover, we model the

[8]This follows most of the literature on discriminatory tax competition, which assumes exogenous differences in the international mobility of capital tax bases. For an analysis that endogenizes the degree of mobility, see Bucovetsky and Haufler (2008).

[9]The source principle applies directly, if countries avoid international double taxation by exempting foreign-earned income from domestic tax. This is true for the majority of OECD members but several countries, including the United States, employ instead an international tax credit. Even in this case, however, foreign-earned profits are not taxed by the residence country until they are repatriated. This gives firms an incentive to defer repatriation, if an additional tax is due in their home country. With the possibility of deferral and similar strategies to avoid home country taxation, the evidence seems to be that the effective residence-based tax rate on foreign subsidiary profits is close to zero, and only source-based taxation is effective (see, e.g. Tanzi, 1995, Ch. 6-7).

tax as a unit tax on capital, rather than as a proportional tax on its return. It is well known that, in settings of competitive markets, this specification simplifies the algebra without affecting the main results.

Our analysis focuses on the financial structure of firms and the associated implications for the corporate tax base. We suppose that capital owners provide firms either with equity or debt and, in the absence of risk considerations, are indifferent between these two financing instruments. The overall tax payment, however, depends on the mix of debt and equity. Our modeling is based on the existing corporate tax codes of virtually all OECD countries, which permit the deduction of interest payments for external debt from the tax base, but do not allow a similar deduction for the cost of equity. This asymmetry in the tax treatment of equity and debt is central to our analysis.[10]

Let us first consider immobile national firms (superscript n). We denote by $\alpha_i^n \in [0,1]$ the share of debt financing that is chosen by national firms in country i. This share is fully deductible from the corporate tax base. We will label this source of finance *external* debt (i.e., debt owed to independent creditors), in order to distinguish it from internal debt flows within a multinational enterprise, as introduced below. While the financing of capital via external debt confers tax savings to the firm, it is associated with non-tax costs that are discussed in detail in the corporate finance literature (see Myers, 2001, for a survey). Specifically, a high level of external debt raises the possibility of financial distress, including the costs associated with possible bankruptcy. Moreover, a higher default risk will increase agency costs due to conflicting interests between managers and shareholders and, in more complex settings than the one studied here, between shareholders and debtholders of the firm. On the other hand, the agency literature also stresses that some level of external debt may be desirable in order to protect the firm from 'empire building' strategies of its managers. We model these different arguments in a highly stylized way, by specifying a target level of external debt, $\bar{\alpha} \in [0,1]$, at which the firm faces no extra costs of its financial structure. Any deviation from this target level will lead to agency costs that are convex in the distance to the target level $\bar{\alpha}$. For

[10] Of course, there would be no tax-induced distortions of firms' financial choices if the cost of equity were also deductible from the corporate tax base. See Auerbach et al. (2008) for a recent analysis of this and related proposals to change existing corporate tax systems. In practice, however, such schemes are rarely adopted. One potential problem is that such proposals entail a narrowing of the tax base and thus require higher corporate tax rates, if corporation tax revenue is to remain stable. Rising tax rates may in turn increase the incentives for multinational firms to shift profits out of the country that has adopted the corporate tax reform (see Haufler and Schjelderup, 2000).

simplicity, we consider quadratic agency costs $\beta(\alpha_i^n - \bar{\alpha})^2/2$ where $\beta > 0$ parameterizes the extra costs of a non-optimal financial structure.[11]

Let t_i be the statutory tax rate in country i. The effective tax rate faced by the domestic firm in country i is then $\tau_i^n = t_i(1 - \alpha_i^n)$. By using (1), the net return to immobile capital in country i (provided either as debt or as equity) reads

$$r_i^n = f'(k_i) - \tau_i^n - \frac{\beta}{2}\left(\alpha_i^n - \bar{\alpha}\right)^2 = a - bk_i - t_i(1 - \alpha_i^n) - \frac{\beta}{2}\left(\alpha_i^n - \bar{\alpha}\right)^2.$$

The firms in each country i maximize the common net return to their shareholders and bondholders. For national firms the only choice parameter is the share of external debt, α_i^n. Maximizing r_i^n with respect to α_i^n yields

$$\alpha_i^n = \bar{\alpha} + \frac{t_i}{\beta}. \tag{2}$$

In the firm's financial optimum the tax benefits of a higher level of external debt are traded off against the agency costs. Hence the debt ratio chosen by the firm is a falling function of the agency cost parameter β and a rising function of the tax rate t_i.[12]

Inserting (2) into τ_i^n and r_i^n gives the effective tax rate in the national firms' optimum

$$\tau_i^n = t_i\left(1 - \bar{\alpha} - \frac{t_i}{\beta}\right) \tag{3}$$

and the net return to immobile capital in country i

$$r_i^n = a - bk_i - t_i\left(1 - \bar{\alpha} - \frac{t_i}{2\beta}\right), \tag{4}$$

as functions of the tax rate t_i and per capita investment k_i in country i.

The fact that the corporation tax distorts the financing decisions of internationally immobile firms implies that no lump-sum taxes exist in our model. Hence, a non-distortive tax policy cannot simply be achieved by fully exempting mobile capital from tax. It should also be emphasized that our analysis of the tax advantages of external debt is confined to the level of the corporation and ignores the different tax treatment of equity and debt finance at the shareholder level. There is a general agreement in

[11] Our specification includes a zero target level of debt ($\bar{\alpha} = 0$) as a special case. For a similar modelling of agency costs see, e.g. Schindler and Schjelderup (2008).

[12] Empirical evidence for the positive relationship between the statutory tax rate and the share of external debt is given in Gordon and Lee (2001).

the literature, however, that a tax advantage of debt is still present, though reduced in size, when personal income taxes are also taken into account.[13]

Let us now turn to the internationally mobile firm. It is assumed that external debt finance has the same tax advantages and the same costs for this firm as for the firms that operate only on a national basis. However, the mobile firm also has the opportunity to set up affiliates in more than one country, and to engage in financial transactions between its affiliates. We model this in the simplest possible way and focus on the role that such transactions play in minimizing the aggregate tax burden. Hence we assume that the mobile firm in each of countries A and B can set up a financial subsidiary in a tax haven country C, which offers a zero tax rate on capital income. Hence the mobile firm acts as a multinational enterprise (MNE). Furthermore, suppose the subsidiary in country C can make an intra-company loan to the producing subsidiary, which is located in either country A or B. The interest paid for this loan is deductible in the country of production, whereas the interest income of the financial affiliate in the tax haven is taxed at a zero rate. Hence, the net effect of this transaction is to remove the share of capital that is financed by *internal* (i.e., intra-company) debt from the corporate tax base of the multinational firm.[14]

We further assume that internal debt financing is not associated with agency costs, or costs of financial distress, because the overall liquidity of the MNE is unaffected by the transaction.[15] The lack of agency costs implies that the ratio of internal debt chosen by the MNE in country i will always be at the maximum of what is permitted by the thin capitalization rules of this country. We thus model a thin capitalization rule as an upper limit on the share of *intra-firm* debt that the multinational firm receives from a subsidiary in the tax haven and that can be deducted from the MNE's tax base in the home country.[16] The permitted share of deductible intra-firm debt in country i is

[13]When taxes at the shareholder level are incorporated, the effective tax rate on capital financed by debt equals the personal income tax rate of the investor, whereas the tax rate on equity equals the sum of corporation and capital gains taxes (provided that no dividends are paid out). See Auerbach (2002) for more details and Fuest and Hemmelgarn (2005) for an analysis of tax competition when governments can choose both corporate and personal income taxes (but not thin capitalization rules).

[14]See Mintz (2004) and OECD (2007, chap. 5) for more detailed descriptions of triangular, or 'conduit' financing structures used by MNEs.

[15]This assumption is clearly a simplification, but it is supported by evidence that the costs of a higher debt-asset ratio are reduced when the debt is owed to an affiliated company (Desai et al., 2004).

[16]This modelling of thin capitalization rules seems to differ from the rules of several OECD countries, which restrict the *sum* of internal and external debt (see Table 1). The rationale behind the latter

denoted by $\lambda_i \in [0,1]$ and we restrict it to be non-negative.[17]

The effective tax rate on mobile firms (superscript m) is $\tau_i^m = t_i(1-\alpha_i^m-\lambda_i)$, where α_i^m is the share of external debt of a mobile firm in country i. The net return to mobile capital in country i, provided either as equity or as debt, reads

$$r_i^m = f'(k_i) - \tau_i^m - \frac{\beta}{2}\left(\alpha_i^m - \bar{\alpha}\right)^2 = a - bk_i - t_i(1-\alpha_i^m-\lambda_i) - \frac{\beta}{2}\left(\alpha_i^m - \bar{\alpha}\right)^2.$$

Maximizing this expression with respect to the MNE's share of external debt yields $\alpha_i^m = \bar{\alpha} + t_i/\beta$, and hence the same decision rule as for national firms [cf. eq. (2)]. The maximum permissible share of internal debt, λ_i, is instead set by the government of country i, and is fully exploited by the multinational in its financial optimum. Hence, the MNE's effective tax rate is lower than that of domestic firms, whenever a positive allowance is made for internal debt (i.e., when $\lambda_i > 0$). Using the optimized value for α_i^m, the effective tax rate on mobile firms in country i can be written as

$$\tau_i^m = t_i\left(1-\lambda_i-\bar{\alpha}-\frac{t_i}{\beta}\right), \tag{5}$$

yielding a net return to mobile capital equal to

$$r_i^m = a - bk_i - t_i\left(1-\lambda_i-\bar{\alpha}-\frac{t_i}{2\beta}\right). \tag{6}$$

These expressions show that MNEs are affected by both policy instruments in our analysis. In particular, a tightening of the thin capitalization rules (a reduction in λ_i) raises the effective tax rate and reduces the net return to mobile capital in this country.

In a capital market equilibrium, the worldwide capital demand must equal the sum of mobile and immobile capital endowments. Expressed in per capita terms, we obtain

$$s_A k_A + s_B k_B = 1 + n. \tag{7}$$

policy choice is that the distinction between internal and external debt is often difficult to draw in practice and hence it is administratively easier to specify an acceptable share of overall debt for each affiliate. However, when a company's debt-to-equity ratio is above the safe-haven ratio, so that it comes to restricting the level of deductible debt, then the distinction between internal and external debt is drawn and deductibility is denied only for internal loans. Hence, the final choice parameter of governments is indeed the deductible share of *internal* debt, as specified in our analysis.

[17] Allowing for negative values of λ_i would imply that countries could effectively restrict the tax-deductibility of *external* debt for multinational firms, but not for domestic firms. This is clearly incompatible with current principles of corporate income taxation.

Moreover, international arbitrage has to ensure that the net return to mobile capital is the same in the two countries. Setting $r_A^m = r_B^m$ in (6) and using (7) gives the per-capita amount of capital used in country i

$$k_i = 1 + n + \frac{s_j}{b}\left[t_j\left(1 - \lambda_j - \bar{\alpha} - \frac{t_j}{2\beta}\right) - t_i\left(1 - \lambda_i - \bar{\alpha} - \frac{t_i}{2\beta}\right)\right], \tag{8}$$

with $i, j \in \{A, B\}$ and $i \neq j$. Equation (8) shows that an increase in country i's statutory tax rate and a tightening of its thin capitalization rule both induce a capital outflow from country i to country j.

Each resident in country i consumes the numéraire output good in quantity x_i. Per capita after-tax income is composed of the net returns from the endowments of mobile and immobile capital and the residual remuneration of an inelastically supplied factor of production (e.g. labor). The latter equals the value of domestic output, less the competitive payments to all capital inputs. Hence per capita private consumption is

$$x_i = nr_i^n + r_i^m + f(k_i) - f'(k_i)\, k_i = nr_i^n + r_i^m + \frac{b}{2}\, k_i^2. \tag{9}$$

Each government collects taxes from both mobile and immobile capital. Mobile capital employed in country i is given by $k_i - n$. Per capita tax revenue in country i is thus

$$z_i = \tau_i^m(k_i - n) + \tau_i^n n = \tau_i^m k_i + nt_i\lambda_i, \tag{10}$$

where the second step has used $\tau_i^n - \tau_i^m = t_i\lambda_i$ from (3) and (5).

National welfare in each country is derived from private consumption and tax revenue, which is used to provide public goods. A convenient simplification is to assume a fixed marginal rate of substitution between private and public consumption where each Euro of tax revenue is worth $1 + \varepsilon$ Euros of private income (with $\varepsilon > 0$). This specification ensures that both countries levy positive capital taxes in equilibrium. One way to motivate this assumption is to think of z_i as a public good with a constant marginal valuation (in terms of the private numéraire good) that exceeds its cost. Alternatively, there is another distortionary tax in the background to finance public goods (a personal income tax, or a value-added tax), and this other tax has a marginal excess burden of ε. Revenue collections from the corporation tax thus allow to reduce the distortions resulting from this other tax, while keeping public good supply constant. Finally, a still different interpretation is that policy makers want to attract voters that perceive corporate taxes as being 'too low', and hence attach an extra value of ε to each Euro collected from corporation tax.

Per capita welfare in country i is then defined as

$$u_i = x_i + (1+\varepsilon)z_i = nr_i^n + r_i^m + \frac{b}{2}\,k_i^2 + (1+\varepsilon)(\tau_i^m k_i + nt_i\lambda_i), \tag{11}$$

where r_i^n and r_i^m must be substituted from (4) and (6), the effective tax rates τ_i^n and τ_i^m are given in (3) and (5) and k_i is given in (8).

3 Benchmark: Pareto efficient tax policy

As a benchmark, we derive the Pareto efficient tax policy when countries A and B can fully coordinate both their tax rates and their thin capitalization rules. We initially focus on the symmetric case with $s_A = s_B = 0.5$. Hence we can assume that each country sets its tax policy so as to maximize the sum of utilities, $u_A + u_B$. Denoting the Pareto efficient policy by the superscript PO, the appendix shows that

$$t^{PO} = \frac{\beta\varepsilon(1-\bar{\alpha})}{1+2\varepsilon}\,, \qquad \lambda^{PO} = 0. \tag{12}$$

Hence the efficient policy from the perspective of the two countries taken together is not to allow any tax deductibility for internal debt. Intuitively, in a symmetric situation common changes in the tax instrument affect neither the distribution nor the aggregate amount of capital. Hence relaxing the common thin capitalization rule by increasing λ_i only has the effect of lowering each country's tax base. This increases the net return obtained by mobile capital and thereby private income, but it reduces tax revenues by the same amount. Since tax revenues have the higher weight in the national welfare functions (as reflected by $\varepsilon > 0$), it is thus never optimal to increase λ_i above zero. In contrast, the Pareto efficient statutory tax rate is always positive. It is optimized when the marginal excess burden of corporate taxation, which is caused by national and multinational firms choosing inefficiently high levels of external debt finance, is equated to the extra value of corporate tax revenue. For this reason, t^{PO} is rising in ε. Moreover, it is rising in the agency cost parameter β, since high costs of financial distress make it unattractive for firms to pursue a high-debt policy for tax reasons, thus reducing the elasticity with which the tax base responds to the statutory tax rate.

4 Tax competition

Let us now turn to the case where the two governments in A and B simultaneously and non-cooperatively choose their tax policies. We assume that tax rates and thin

capitalization rules are chosen simultaneously, implying that they are equally flexible instruments from the perspective of each government. This specification is supported by several recent corporate tax reforms, where statutory tax rates and thin capitalization restrictions were changed simultaneously.[18]

With these assumptions, country i maximizes its per capita welfare (11) with respect to the policy instruments t_i and λ_i, taking as given the choices of t_j and λ_j in country $j \neq i$. The tax policies in the symmetric Nash equilibrium of the tax competition game are derived in the appendix and given by

$$t^* = \frac{\beta\,\varepsilon\,n\,(1-\bar{\alpha})}{(1+\varepsilon)(1+n)+\varepsilon n}\,, \tag{13}$$

$$\lambda^* = \frac{(1+\varepsilon)\,(1+n)(1-\bar{\alpha})}{(1+\varepsilon)(1+n)+\varepsilon n} - \frac{2b[(1+\varepsilon)(1+n)+\varepsilon n]}{\beta\,n\,(1+\varepsilon)\,(1-\bar{\alpha})}\,. \tag{14}$$

Equation (13) shows that the equilibrium tax rate is positive whenever there is a positive excess value of corporate tax revenue (ε). In contrast, the equilibrium level of the thin capitalization rule is composed of a positive and a negative term. An interior solution ($\lambda^* > 0$) will only be an equilibrium when the second term in (14) is sufficiently small. This is true, in particular, when the parameter b is small, so that mobile capital responds elastically to the effective tax rates [see equation (8)]. A low value of b thereby leads to strong incentives for each country to underbid the effective tax rate of its neighbor by relaxing the thin capitalization rule (i.e., by raising λ_i). In the following we will assume that tax competition is sufficiently 'strong' in this sense. Note also that the permitted share of internal debt is always less than $1-\bar{\alpha}$, since the first term in (14) is less than this value, and the second term is negative.

We are now in the position to compare the tax policies in the non-cooperative Nash equilibrium with the Pareto efficient taxes under full policy coordination:

Proposition 1 *Suppose $s_A = s_B = 0.5$ and the tax competition game attains a symmetric Nash equilibrium. Then the statutory tax rate is inefficiently low ($t^* < t^{PO}$). Moreover, if tax competition is sufficiently strong (b is sufficiently low), then the equilibrium thin capitalization rule is inefficiently lax ($\lambda^* > \lambda^{PO} = 0$).*

Proof: Follows directly from comparing (12) with (13) and (14). □

[18] One example is Ireland, which raised the corporate tax rate applicable to most of its MNEs from 10% to 12.5% in 2002 while at the same time abolishing its existing thin capitalization rule. The opposite set of changes occurred in the German corporate tax reform of 2008, which combined a reduction in the federal corporate tax rate with a tightening of existing thin capitalization rules.

The first part of Proposition 1 is a standard result in the tax competition literature. Our focus is on the second part, which highlights the role of the thin capitalization rule as a policy instrument in the tax competition for mobile capital. Relaxing the thin capitalization rule (increasing λ_i) reallocates income from the public sector to the private sector. This effect on its own is welfare-reducing for each country, for the reasons discussed above. When tax policies are non-cooperatively chosen, however, increasing λ_i attracts mobile capital from the neighboring country. Moreover, in contrast to the statutory tax rate, this instrument can be targeted directly at mobile, multinational firms. Hence, a policy of lenient thin capitalization rules can attract capital at a lower cost, in terms of the foregone tax revenue, than when only the (non-discriminatory) statutory tax rate is used. This positive tax allowance for internal debt implies that MNEs will be tax-favored over national firms in the non-cooperative tax equilibrium.

Importantly for the ensuing analysis, common changes in the exogenous parameters of our model affect the policy instruments in the non-cooperative tax equilibrium in very different ways. To see this in more detail, we compute the effective tax rates on mobile and immobile firms by substituting (13) and (14) into (3) and (5). This yields

$$\tau^{n*} = \frac{\varepsilon\beta n(1-\bar{\alpha})^2(1+\varepsilon)(1+n)}{[(1+\varepsilon)(1+n)+\varepsilon n]^2}\,, \qquad \tau^{m*} = \frac{2b\varepsilon}{1+\varepsilon}\,. \tag{15}$$

We can then immediately state the following comparative static results:

Proposition 2 *In a symmetric tax competition equilibrium with $\lambda_i^* > 0$, the following holds: (i) A higher degree of international tax base mobility (a fall in b) reduces the effective tax rate on mobile firms, but does not change the effective tax rate on immobile firms. (ii) A higher domestic tax base elasticity (a fall in β) reduces the effective tax rate on national firms, but leaves the effective tax rate on mobile firms unchanged.*

Proof: Follows directly from eq. (15). □

The reason for part (i) of Proposition 2 is that more intense tax competition (a fall in b) induces each country to relax its thin capitalization rule [by (14)], but it does not alter statutory tax rates [eq.(13)]. Hence this parameter change unambiguously increases the degree of tax discrimination in favour of MNEs, which can be expressed as $\tau^{n*} - \tau^{m*} = t^*\lambda^*$. By relaxing only the thin capitalization rule, tax concessions can be targeted at the base that has become more mobile internationally, thus avoiding any revenue loss from the taxation of national firms. Conversely, the rationale behind part (ii) of the proposition is that a reduction in the costs of *external* debt (a fall in

β) lowers the statutory tax rate and thus the effective taxation of national firms. For multinational firms, however, this reduction is fully compensated by a tightening of the thin capitalization rule. The reason is that, with $\lambda_i^* > 0$, the international mobility of the tax base is the binding constraint for the effective taxation of mobile firms, and this constraint is unaffected by a fall in β. In sum, therefore, eq. (15) shows that the effective tax rate on national firms is driven by the agency costs of higher external debt, whereas the tax rate on multinational firms is solely determined by the degree of international tax base mobility.

5 Partial coordination of thin capitalization rules

In the previous section we have seen that tax competition will lead to inefficiently low tax rates and inefficiently lax thin capitalization rules. In the following we thus consider the effects of a coordinated tightening of thin capitalization rules in both countries. At the same time we assume that each country is free to adjust its tax rate in a nationally optimal way to the new thin capitalization restrictions. This partial policy coordination is the relevant scenario in the EU, where the European Commission proposes to introduce coordinated thin capitalization rules within the framework of the Common Consolidated Corporate Tax Base, but simultaneously emphasizes that member states remain free to set their tax rates autonomously (see Fuest, 2008). Outside the EU, it is even more obvious that any attempt to coordinate thin capitalization rules in order to combat profit shifting by MNEs will *not* be accompanied by simultaneous restrictions on countries' corporate tax rates. The constraint that not all policy instruments can be chosen in a coordinated fashion opens up the possibility that countries respond to the coordinated tightening of thin capitalization rules by competing more aggressively via tax rates. Since this will also reduce the taxation of immobile firms, the welfare effects of a partial coordination of thin capitalization rules are ambiguous a priori.

To analyze this issue, we initially maintain the assumption of symmetric countries and determine the total change in country j's utility caused by a small reduction in both countries' thin capitalization variables. Formally, we set $\mathrm{d}\lambda_i = \mathrm{d}\lambda_j = \mathrm{d}\lambda < 0$. This yields[19]

$$\frac{\mathrm{d}u_j}{\mathrm{d}\lambda} = \frac{\partial u_j}{\partial \lambda_i} + \frac{\partial u_j}{\partial t_i}\,\frac{\mathrm{d}t_i}{\mathrm{d}\lambda}, \qquad i \neq j. \tag{16}$$

[19] In deriving (16) we used $\partial u_j/\partial t_j = 0$ and $\partial u_j/\partial \lambda_j = 0$, since both instruments were chosen optimally from country j's perspective before the variation in the thin capitalization rules.

The total effect of the partial coordination on country j's welfare is composed of a direct effect and an indirect effect. The direct effect measures the impact of the reduction in country i's thin capitalization variable λ_i on country j's welfare. The indirect effect works through the impact of the partial coordination of thin capitalization rules on country i's tax rate, and the resulting effect of the change in t_i on country j's welfare. Note that the expression $\mathrm{d}t_i/\mathrm{d}\lambda$ is the response of country i's statutory tax rate to the simultaneous changes in λ_i and λ_j.

The direct effect is obtained from differentiating (11) as

$$\frac{\partial u_j}{\partial \lambda_i} = -\frac{(1+\varepsilon)\tau^{m,*}\, t^*}{2b} < 0 \qquad i \neq j. \tag{17}$$

Hence, the direct effect of a small reduction in λ_i is beneficial for country j. An isolated tightening of country i's thin capitalization rule increases the effective tax rate on mobile capital in this country and leads to a reallocation of mobile capital to country j. Similarly, a statutory tax increase in country i also benefits the neighboring country j. This is seen from (11), which implies

$$\frac{\partial u_j}{\partial t_i} = \frac{(1+\varepsilon)\tau^{m,*}}{2b}\left(1-\bar{\alpha}-\lambda^*-\frac{t^*}{\beta}\right) > 0 \qquad i \neq j. \tag{18}$$

To determine the overall sign of the indirect effect in (16), we have to establish whether partial policy coordination increases or decreases country i's statutory tax rate. It is shown in the appendix that

$$\frac{\mathrm{d}t_i}{\mathrm{d}\lambda} = \frac{\varepsilon(1+\varepsilon)\beta^2 n^2(1-\bar{\alpha})^2}{\Delta} > 0, \tag{19}$$

with

$$\Delta = (1+n+2\varepsilon n)n^2(1-\bar{\alpha})^2\beta(1+\varepsilon) + 2b(1+n+\varepsilon+2\varepsilon n)^2 > 0. \tag{20}$$

Hence each country responds to the coordinated tightening of thin capitalization rules ($\mathrm{d}\lambda < 0$) by lowering its statutory tax rate. Intuitively, as the partial policy coordination restricts each country's ability to attract mobile capital by means of lax thin capitalization rules, tax competition will shift to a more aggressive lowering of tax rates. Together with (18) this implies that the indirect effect of a coordinated tightening of thin capitalization rules in (16) is negative and counteracts the direct effect.

Can the net welfare effect of the coordination measure nevertheless be signed? In our model it turns out that the direct effect of a tightening of thin capitalization rules always dominates the indirect effect. Substituting (17)–(20) in (16) gives

$$\frac{\mathrm{d}u_j}{\mathrm{d}\lambda} = -\frac{(1+\varepsilon)\tau^{m,*}}{2b\Delta}\,\frac{\varepsilon n(1-\bar{\alpha})(1+n+2\varepsilon n)}{(1+n+\varepsilon+2\varepsilon n)} < 0 \qquad j \in \{A,B\}. \tag{21}$$

We summarize these results in:

Proposition 3 *Starting from a symmetric Nash equilibrium of the tax competition game, a coordinated tightening of thin capitalization rules increases welfare in both countries, even though statutory tax rates in both countries are reduced.*

To see why the partial coordination of thin capitalization rules is mutually welfare-increasing, despite the simultaneous reduction in statutory tax rates, we return to the properties of the Nash equilibrium in Proposition 2. We have seen there that international tax competition for mobile capital occurs primarily through thin capitalization rules, which can be targeted directly at the internationally mobile tax base. The statutory tax rate, while also being affected by international tax competition, will instead balance the overall efficiency losses from the corporation tax (caused by both an excess use of external debt and an international capital outflow) against the extra value of corporate tax revenues. Hence restricting the use of thin capitalization rules through international policy coordination deprives countries of their most aggressive instrument in international tax competition. Therefore, a coordinated tightening of thin capitalization rules reduces the overall intensity of tax competition, and hence also the associated welfare losses of the countries.

The result that a *small* tightening of thin capitalization rules is welfare increasing in our model does not imply, however, that the best coordination policy is to completely abolish the tax-deductibility of internal debt. In fact, depending on the exogenous parameters choices of the model, coordinating thin capitalization rules at $\lambda_A = \lambda_B = 0$ may increase or reduce welfare in each country, relative to the non-cooperative equilibrium in which both policy instruments are unconstrained. This is shown in Table 2.

It is seen from Table 2 that the stronger is international tax competition (the lower is b), the less likely is it that disallowing the tax-deductibility of all internal debt ($\lambda_i = 0$) is an optimal policy. Intuitively, with strong international tax competition countries will find it in their interest to grant a substantial tax preference to multinational firms, in order to keep taxes on the internationally immobile tax base relatively high. Eliminating the possibility of tax discrimination will thus force countries to reduce tax rates on immobile firms strongly, leading to net losses of tax revenue and welfare. Also, the less elastic the firms' share of external debt responds to tax incentives (i.e., the higher is β) the less likely is it that a zero tax-deductibility for multinationals' internal debt is welfare increasing. The intuition is similar to the one given above. A high level

Table 2: Welfare effects of eliminating the tax deductibility of internal debt

case	b	β	λ	t	τ^m	τ^n	Δu
(1)	0.50	5.0	0.311	0.466	0.231	0.376	
	0.50	5.0	0.000	0.352	0.292	0.292	+
(2)	0.25	5.0	0.559	0.466	0.115	0.376	
	0.25	5.0	0.000	0.212	0.181	0.181	–
(3)	0.25	2.5	0.311	0.233	0.115	0.188	
	0.25	2.5	0.000	0.176	0.146	0.146	+
(4)	0.25	10.0	0.683	0.931	0.115	0.751	
	0.25	10.0	0.000	0.233	0.204	0.204	–

Note: Parameter values held constant: $n = 1$, $\bar{\alpha} = 0.1$, $a = 3$, $\varepsilon = 0.3$.

of β implies that each country wants to maintain high taxes on the immobile base, and hence chooses a high level of λ in the initial, unconstrained tax equilibrium.

These findings can be linked to some of the results from the previous literature on discriminatory tax competition. Janeba and Peters (1999) have shown that a coordinated move to eliminate all tax preferences is collectively welfare increasing when the highly taxed base is completely inelastic, both domestically and internationally. Janeba and Smart (2003, Proposition 1) have generalized this result and have shown that a small, coordinated reduction in tax preferences is the more likely to be welfare increasing, the lower is the international mobility of the highly taxed base. This setting corresponds most closely to our Proposition 3 above. On the other hand, Keen (2001) has shown that coordinated policies to prevent tax discrimination are mutually self-defeating when all tax bases are fixed in the aggregate. Our model approaches this special case when $\beta \to \infty$ so that the use of external debt is prohibitively costly above $\bar{\alpha}$.[20] More generally our simulation results in Table 2 show that the abolition of all tax preferences for mobile firms is more likely to reduce welfare, if β is large and hence the marginal cost of external debt are high [cases (2) and (4)].

Our analysis thus applies the theory of discriminatory tax competition to the specific scenario that is relevant for the study of thin capitalization rules. In this setting international tax base mobility is confined to MNEs, as only the latter can use internal debt as an instrument of international profit shifting, whereas nationally operating firms can reduce their overall tax burden by increasing the share of external debt.

[20] In this case the effect of a marginal, coordinated reduction in λ is zero from eqs. (20)–(21).

6 Asymmetries between countries

Virtually all of the existing literature on discriminatory tax competition is confined to the case of symmetric countries. In contrast, our model allows to derive algebraic results for how asymmetries in country size affect equilibrium tax rates and thin capitalization rules. While discrete differences in country characteristics are difficult to handle analytically in our framework, we can obtain some important analytical insights by focusing on small differences between the two countries.

Starting from an initially symmetric Nash equilibrium of the tax competition game, we analyze the effects of a marginal decrease in country i's population size, which is accompanied by an equal increase in the population size of country j. Formally, we compute the effects of $\mathrm{d}s_i = -\mathrm{d}s_j < 0$ and evaluate these effects at the symmetric equilibrium ($s_i = s_j = 0.5$), as characterized in Section 4. It is shown in the appendix that

$$\frac{\mathrm{d}(t_i - t_j)}{\mathrm{d}s_i} = \frac{1}{|J|} \frac{4n^2\beta\varepsilon^3(1+\varepsilon)(1-\alpha)^2}{b(1+n+2\varepsilon n+\varepsilon)^2} > 0, \tag{22}$$

$$\frac{\mathrm{d}(\lambda_i - \lambda_j)}{\mathrm{d}s_i} = -\frac{1}{|J|} \frac{4\varepsilon(1+n+2\varepsilon n-\varepsilon)}{\beta} < 0 \quad \text{for} \quad 1+n+2n\varepsilon-\varepsilon > 0, \tag{23}$$

where $|J| > 0$ is given in eq. (A.17) in the appendix.

Equation (22) shows that the smaller country imposes a lower statutory tax rate and thereby also has a lower effective tax rate on domestic firms than the larger country. The effect of country size on the difference in thin capitalization rules depends on the sign of $1+n+2n\varepsilon-\varepsilon$ and is thus not unambiguous when ε can become arbitrarily large and n is small. However, a sufficient condition for this term to be positive is that $\varepsilon < 1$ and hence the *extra* value of one unit of corporate tax revenue is less than 100 percent. Precluding extreme cases, this condition can be expected to hold and we assume in the following that it is indeed met.[21] A fall in s_i will then lead to a more lenient thin capitalization rule in the smaller country (a higher level of λ_i), in comparison to the policy of the larger neighbor j. With a lower statutory tax rate and a lower tax base in the smaller country, we also get the unambiguous result that the smaller country levies the lower effective tax rate on mobile firms. These results are summarized in:

[21] In one of the interpretations given above, $\varepsilon < 1$ implies that the excess burden of the overall tax system is less than 100 per cent. This is clearly met in developed countries. Existing studies for, e.g., the U.S. estimate the average excess burden of the tax system at 18% (Jorgenson and Yun, 1993).

Proposition 4 *Starting from a symmetric tax competition equilibrium, suppose that the population size of one country is increased while the size of the other country is reduced by the same amount. In the asymmetric Nash equilibrium, (i) the smaller country levies the lower statutory tax rate; (ii) if ε is not too large ($\varepsilon < 1$), the smaller country also chooses the more lenient thin capitalization rule.*

The first part of this proposition is in accordance with the results of the asymmetric tax competition models in Bucovetsky (1991) and Wilson (1991). They show that, with equal per capita endowments, the smaller country faces a higher elasticity of the mobile capital tax base with respect to its own tax rate and hence finds it optimal to choose the lower (effective) tax rate. The new result in part (*ii*) of Proposition 4 is that the smaller country also offers mobile firms the larger reduction in their tax base and thus discriminates more in favor of MNEs. This is again a result of targeting. In comparison to its larger neighbor, the small country faces the higher tax base elasticity only for mobile, but not for immobile firms. Hence, the *relative* taxation of mobile vis-a-vis immobile firms must be lower in the small country. This allows the smaller country to compete aggressively for internationally mobile capital, while at the same time limiting the tax revenue loss from a reduced taxation of its immobile tax base.

The prediction that smaller countries have more lenient thin capitalization rules is supported by the empirical evidence. Table 1 shows that existing thin capitalization rules differ by the threshold value of the debt-to-equity ratio, below which all interest payments are deductible from the corporate tax base, and by the specification of which part of debt is considered. Clearly, for any given debt-to-equity ratio a thin capitalization rule is more lenient if this ratio applies only to related party debt (internal debt), rather than to total debt. Hence the most generous thin capitalization rules are those where the safe haven debt-to-equity ratio is high and it refers to internal debt only. This is the case, for example, in Luxembourg, Belgium, or Slovenia, all of which are small countries. Moreover, several of the small European countries have no thin capitalization rule at all and hence are not listed in Table 1. These are, for example, Austria, Ireland, Norway, and Sweden. On the other hand, most of the large OCED countries have rather restrictive thin capitalization rules. This applies to the United Kingdom and the United States (despite the caveat mentioned in footnote 4), but also to France and Germany.[22] Overall, therefore, a rather clear pattern emerges from Table 1 that supports the prediction in our Proposition 4 (ii).

[22]Thin capitalization rules in Germany have been further tightened in the 2008 corporate tax reform.

Table 3: Simulation results for partial coordination among asymmetric countries

popul. size	tax rates in initial non-cooperative equilibrium				variant I $\mathrm{d}\lambda_A = \mathrm{d}\lambda_B = -0.050$		variant II $\bar{\lambda} = \min[\lambda_A^*, \lambda_B^*]$	
s_A	t_A	t_B	λ_A	λ_B	Δu_A^I	Δu_B^I	Δu_A^{II}	Δu_B^{II}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0.50	0.466	0.466	0.311	0.311	> 0	> 0	0	0
0.40	0.455	0.473	0.334	0.260	> 0	> 0	> 0	> 0
0.30	0.438	0.478	0.330	0.161	> 0	> 0	< 0	> 0
0.25	0.425	0.481	0.314	0.079	> 0	> 0	< 0	> 0

Note: Parameters held constant: $\varepsilon = 0.3$, $n = 1$, $a = 3$, $b = 0.5$, $\beta = 5$, $\bar{\alpha} = 0.1$.

Let us finally turn to partial policy coordination in the asymmetric case. With asymmetries between countries, different coordination scenarios arise. A first variant is that each country reduces the tax-deductible share of internal debt by the same amount, starting from different initial levels of λ_i. Formally, this implies $\mathrm{d}\lambda_A = \mathrm{d}\lambda_B = \mathrm{d}\lambda < 0$. In practice, however, tax coordination is rarely understood as a uniform change in the countries' tax instruments. Instead, tax harmonization often takes the form of a minimum requirement imposed on the tax instruments, or an agreement is reached on specific values for the tax instruments. As a second variant of coordination, we therefore assume that the two countries agree on the stricter of the two thin capitalization rules that are chosen in the non-cooperative equilibrium. Formally, both countries are supposed to choose $\bar{\lambda} = \min[\lambda_A^*, \lambda_B^*]$ where λ_A^* and λ_B^* stand for the equilibrium values of the thin capitalization rules before coordination takes place.

While no analytical results can be provided for coordination in the asymmetric case, we have carried out comprehensive numerical simulations that can offer some useful insights. We present some representative results in Table 3.[23]

Under variant I of the partial coordination measure, we see that a simultaneous and equal tightening of thin capitalization rules, starting from the different initial values given in columns (4) and (5) of the table, is always welfare increasing for both countries. These results have been confirmed for several other scenarios using different parameter values. Hence, for this tax coordination scenario, the welfare results from Proposition 3

[23]The tax entries in columns (2)–(5) refer to the values in the initial, non-cooperative tax equilibrium. In contrast, columns (6)–(9) give the welfare changes for each country that arise from the different coordination measures, relative to the welfare levels in the non-cooperative equilibrium.

can be expected to carry over to a large number of asymmetric initial Nash equilibria. In contrast, the same may not be true for variant II of the partial coordination measure. If the difference in the two countries' population size is sufficiently large ($s_A \leq 0.3$), adopting the same thin capitalization rule as the large country will be welfare-reducing for the smaller region. The reason is that the small country benefits from tax competition in the initial equilibrium with unconstrained tax competition, by attracting more mobile firms per capita than the larger region. If the small country is forced to match the more restrictive thin capitalization rule of its larger neighbor, it will instead compete more aggressively via its statutory tax rate. This strategy is more costly for the small country, however, because it also leads to falling tax receipts from the taxation of its internationally immobile capital.

7 Conclusions

This paper has introduced a model where countries compete for internationally mobile firms through both statutory tax rates and thin capitalization rules that limit the tax-deductibility of internal debt flows within multinational enterprises. For the symmetric case, and starting from a tax competition equilibrium with inefficiently low tax rates and inefficiently lax thin capitalization rules, we have shown that a coordinated policy of tightening thin capitalization rules will benefit both countries, even though it induces them to compete more aggressively via statutory tax rates. The reason is that tax competition occurs primarily through thin capitalization rules, whereas statutory tax rates balance the (domestic and international) excess burden of taxation with the extra value of collecting corporate tax revenue. Therefore, even an isolated coordination of thin capitalization rules is an effective way to reduce the overall intensity of corporate tax competition.

These results of our model correspond to some recent developments and empirical findings in the literature. Altshuler and Grubert (2006) provide data for the United States showing that the introduction of "hybrid entities" in 1997, which made it easier for U.S. multinationals to avoid taxes on intercompany payments like interest and royalties, induced a large growth in such payments and substantially increased the disparity in the reported profitability of subsidiaries in high-tax and low-tax jurisdictions. At the same time the authors find that the link between international tax rate differentials and foreign direct investment was significantly weakened by this change in tax rules.

This is consistent with the implication of our model that tax competition for multinational firms occurs mostly through tax rules that are explicitly targeted at mobile capital, whereas statutory corporate tax rates may be of secondary importance in this process. In a tax competition environment we can thus expect that countries indeed set their thin capitalization rules less strictly than they otherwise would, for fear of losing foreign direct investment to other regions. Our model thus supports some coordinated tightening of thin capitalization rules, as is envisaged in the recent proposals for corporate tax reform in the European Union.

A well-known problem in international tax coordination is, however, that countries with different characteristics have diverging national interests and individual countries may veto coordination measures. Our analysis has therefore incorporated asymmetries between countries with respect to population size. In particular, we have shown that small countries will not only choose lower corporate tax rates, but they will also opt for more lenient thin capitalization rules than their larger neighbors. A comparison with the thin capitalization regulations in different OECD countries seems to be consistent with this prediction. As a consequence, a partial coordination of thin capitalization rules need not be welfare-improving for all countries. In particular, small countries benefit from tax competition via thin capitalization rules and may therefore lose from a coordinated minimum level of thin capitalization provisions.

Our analysis can be extended in several ways. First, we have assumed that intra-firm financial transactions are exclusively driven by tax considerations while ignoring any non-tax reasons for such flows. Empirical research shows, however, that U.S. multinationals use internal capital markets to overcome market imperfections in the external credit markets of their host countries (see Desai at al., 2004; Buettner et al., 2006). Incorporating such productive purposes of intra-firm financial transactions may have interesting repercussions on the optimal setting of thin capitalization rules. Second, thin capitalization rules may also be driven by 'fairness' considerations, in the sense that (some) governments may perceive an extra benefit of taxing national and multinational firms at similar effective rates. Developing the implications of tax competition between fair-minded governments, or between one government that is fair-minded and one that is not, is a further possible issue for future research.

Appendix

A.1. Pareto efficient tax policy

Symmetry ($s_A = s_B = 0.5$) implies $t_A = t_B = t$ and $\lambda_A = \lambda_B = \lambda$. Equation (8) then yields $k_A = k_B = 1 + n$. Using (3), (4), (5) and (6) in (11), we obtain

$$\begin{aligned} u_A + u_B &= 2(1+n)\left[a - b(1+n) - t\left(1 - \bar{\alpha} - \frac{t}{2\beta}\right)\right] - 2\varepsilon t\lambda \\ &\quad + 2t(1+\varepsilon)(1+n)\left(1 - \bar{\alpha} - \frac{t}{\beta}\right). \end{aligned} \tag{A.1}$$

The derivative of (A.1) with respect to λ reads

$$\frac{\partial(u_A + u_B)}{\partial\lambda} = -2\varepsilon t < 0.$$

Hence, we obtain the corner solution $\lambda^{PO} = 0$ as stated in (12). Inserting $\lambda^{PO} = 0$ into (A.1) and differentiating with respect to t gives

$$\frac{\partial(u_A + u_B)}{\partial t} = 2(1+n)\left[(1+\varepsilon)\left(1 - \bar{\alpha} - \frac{2t}{\beta}\right) - \left(1 - \bar{\alpha} - \frac{t}{\beta}\right)\right] = 0.$$

Solving this condition with respect to t gives the efficient tax rate t^{PO} in (12).

A.2. Symmetric tax competition

Differentiating (11) and taking into account (3) – (8) and $s_i + s_j = 1$ yields

$$\frac{\partial u_i}{\partial t_i} = s_i(k_i - 1 - n)\mu_i + \varepsilon(k_i\mu_i + n\lambda_i) - (1+\varepsilon)t_i\left(\frac{k_i}{\beta} + \frac{(1-s_i)\mu_i^2}{b}\right) \tag{A.2}$$

with $i \in \{A, B\}$ and

$$\mu_i = 1 - \lambda_i - \bar{\alpha} - \frac{t_i}{\beta}. \tag{A.3}$$

Employing the symmetry assumption $k_i = 1 + n$ yields the equilibrium condition

$$\varepsilon\left[(1+n)\left(1 - \bar{\alpha} - \frac{t^*}{\beta}\right) + n\lambda^*\right] = (1+\varepsilon)t^*\left[\frac{1+n}{\beta} + \frac{1}{2b}\left(1 - \lambda^* - \bar{\alpha} - \frac{t^*}{\beta}\right)^2\right]. \tag{A.4}$$

Analogously differentiating (11) with respect to λ_i yields

$$\frac{\partial u_i}{\partial \lambda_i} = -s_i(k_i - 1 - n)t_i + \varepsilon t_i(n - k_i) + (1+\varepsilon)\frac{(1-s_i)\mu_i t_i^2}{b} \tag{A.5}$$

with $i \in \{A, B\}$. Symmetry yields the second equilibrium condition

$$\frac{(1+\varepsilon)\,t^*}{2b}\left(1 - \lambda^* - \bar{\alpha} - \frac{t^*}{\beta}\right) - \varepsilon = 0. \tag{A.6}$$

Equations (A.4) and (A.6) constitute a system of two equations in the two unknowns t^* and λ^*. Solving this equation system yields (13) and (14) in the main text.

A.3. Partial tax coordination

We totally differentiate (A.2) and use $\mathrm{d}k_i = 0$, since $\mathrm{d}\lambda_i = \mathrm{d}\lambda_j = \mathrm{d}\lambda$ from the coordinated change in the thin capitalization rules and $\mathrm{d}t_i = \mathrm{d}t_j$ follows from symmetry. This yields in a first step

$$\left[-\varepsilon + \frac{(1+\varepsilon)t^*\mu^*}{b}\right]\mathrm{d}\lambda = \left[\frac{(1+2\varepsilon)(1+n)}{\beta} + \frac{(1+\varepsilon)\mu^*(\beta\mu^* - 2t^*)}{2b\beta}\right]\mathrm{d}t_i \tag{A.7}$$

where $\mu^* = 1 - \lambda^* - \bar{\alpha} - t^*/\beta$. Substituting the values for t^* and λ^* in the intial equilibrium [eqs. (13) and (14)] yields eqs. (19) and (20) in the main text.

A.4. Asymmetric tax competition

Totally differentiating (8), (A.2) and (A.5) and evaluating the resulting expressions at the symmetric equilibrium yields

$$\gamma_1 \mathrm{d}t_i + \gamma_2 \mathrm{d}\lambda_i + \gamma_3 \mathrm{d}k_i + \gamma_4 \mathrm{d}s_i = 0, \tag{A.8}$$

$$\gamma_5 \mathrm{d}t_i + \gamma_6 \mathrm{d}\lambda_i - \gamma_7 \mathrm{d}k_i + \gamma_8 \mathrm{d}s_i = 0, \tag{A.9}$$

$$\mathrm{d}k_i = \gamma_9(\mathrm{d}t_j - \mathrm{d}t_i) + \gamma_{10}(\mathrm{d}\lambda_j - \mathrm{d}\lambda_i), \tag{A.10}$$

with $i, j \in \{A, B\}$, $i \neq j$ and

$$\gamma_1 = -\frac{\beta n^2(1+\varepsilon)(1-\bar{\alpha})^2(1+n+2\varepsilon n) + 2b(1+n+\varepsilon+2\varepsilon n)^2}{\beta^2 n^2(1+\varepsilon)(1-\bar{\alpha})^2}, \quad \gamma_2 = \varepsilon, \tag{A.11}$$

$$\gamma_3 = \frac{b(1+n+\varepsilon+2\varepsilon n)^2(1+2\varepsilon) - \beta\varepsilon n^2(1+\varepsilon)^2(1-\bar{\alpha})^2}{\beta n(1+\varepsilon)(1-\bar{\alpha})(1+n+\varepsilon+2\varepsilon n)}, \tag{A.12}$$

$$\gamma_4 = \frac{4b\varepsilon(1+n+\varepsilon+2\varepsilon n)}{\beta n(1+\varepsilon)(1-\bar{\alpha})}, \; \gamma_5 = \frac{2b(1+n+\varepsilon+2\varepsilon n)^2 - \beta\varepsilon n^2(1+\varepsilon)(1-\bar{\alpha})^2}{2b\beta n(1-\bar{\alpha})(1+n+\varepsilon+2\varepsilon n)}, \tag{A.13}$$

$$\gamma_6 = -\frac{\beta\varepsilon n(1+\varepsilon)(1-\bar{\alpha})}{2b(1+n+\varepsilon+2\varepsilon n)}, \; \gamma_7 = \frac{1+2\varepsilon}{2}, \; \gamma_8 = -2\varepsilon, \; \gamma_9 = \frac{1+n+\varepsilon+2\varepsilon n}{\beta n(1+\varepsilon)(1-\bar{\alpha})}, \tag{A.14}$$

$$\gamma_{10} = -\frac{\beta\varepsilon n(1-\bar{\alpha})}{2b(1+n+\varepsilon+2\varepsilon n)}. \tag{A.15}$$

In computing (A.11) – (A.15) we used the equilibrium values (13) and (14). Next we derive (A.8) for country j, subtract the resulting expression from (A.8) and use (A.10) to replace $\mathrm{d}k_i$ and $\mathrm{d}k_j$. Proceeding in the same way with (A.9) yields

$$\underbrace{\begin{pmatrix} \gamma_1 - 2\gamma_3\gamma_9 & \gamma_2 - 2\gamma_3\gamma_{10} \\ \gamma_5 + 2\gamma_7\gamma_9 & \gamma_6 + 2\gamma_7\gamma_{10} \end{pmatrix}}_{=:J} \begin{pmatrix} \mathrm{d}(t_i - t_j) \\ \mathrm{d}(\lambda_i - \lambda_j) \end{pmatrix} = \begin{pmatrix} -\gamma_4 \\ -\gamma_8 \end{pmatrix} \mathrm{d}(s_i - s_j). \tag{A.16}$$

After some tedious computations, the determinant of the matrix J can be written as

$$|J| = \frac{\varepsilon n(1-\bar{\alpha})[b(2+3\varepsilon)(1+n+\varepsilon+2\varepsilon n)^3 - \beta\varepsilon^2 n^2(1+\varepsilon)^2(1-\bar{\alpha})^2]}{2b^2(1+n+\varepsilon+2\varepsilon n)^3}. \tag{A.17}$$

Stability of the Nash equilibrium implies $|J| > 0$.[24] To derive (22) and (23), we set $\mathrm{d}s_i = -\mathrm{d}s_j$ in (A.16). Applying Cramer's rule then immediately gives (22) and (23).

[24]Stability requires that the Jacobian determinant of the system of equations consisting of (A.2) and (A.5) for $i \in \{A, B\}$, evaluated at the symmetric Nash equilibrium, has to be negative semidefinite. It can be shown that this stability condition implies $|J| > 0$. Details can be obtained upon request.

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