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
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 costs 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

¹Desai 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. (2010a) and for German multinationals by Mintz and Weichenrieder (2010, Chap. 5) and Buettner et al. (2010). 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 rates.

²For Europe, Egger et al. (2010b) 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.

³Detailed 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

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

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-saving instrument. 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 has taken place in conjunction with the directive proposal of the European Commission (2011) to introduce a Common Consolidated Corporate Tax Base (CCCTB). According to the directive proposal, interest paid to an associated enterprise resident in a third country shall not be tax deductible when the statutory tax rate in the third country is less than 40% of the average statutory corporate tax rate in the EU member states, or when the associated enterprise is subject to a special tax regime in the third country (European Commission, 2011, Article 81).

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

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4The 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, Chap. 5).

5See Fuest (2008) for an early commentary on the proposal to introduce a CCCTB that also discusses the role of thin capitalization rules.
multinational firms. Tax competition for internationally operating firms occurs through statutory tax rates and through thin capitalization rules that limit the tax-deductibility of internal debt flows within multinational enterprises. 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. 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 statutory tax rates. 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 tax-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. First, there are several studies that analyze the effects of corporate taxation on multinational firms’ financing and investment decisions in the presence of profit shifting (Mintz and Smart, 2004; Weichenrieder and Windischbauer, 2008; Buettner et al., 2009; Schindler and Schjelderup, 2012). 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. An exception is the paper of Davies and Gresik (2003) who analyze the implications of different financing sources for tax competition between countries. However, their focus is on double taxation regimes and they neither analyze internal debt as a means of profit shifting nor thin capitalization rules.

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). 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. More recently, one focus in the profit-shifting literature has been on the role of tax havens. Slemrod and Wilson (2009) and Hong and Smart (2010) 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. Johannesen (2012) considers profit shifting to a tax haven by intra-firm loans and shows that tax competition will drive optimal withholding taxes on interest payments from the haven to zero when multinational firms can engage in triangular financing structures.

However – with the partial exception of Hong and Smart (2010) – none of these studies addresses thin capitalization rules. Moreover, almost the entire literature on discrim-

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6See Gresik (2001) for an overview of the issues involved in the taxation of multinational firms.

7Hong and Smart (2010) derive an endogenous thin capitalization rule in an extension section of their basic model (Section 4.1). They focus on optimal policies in a small open economy, however.
inatory tax competition confines itself either to the case of a small open economy, or to fully symmetric countries. In contrast, our model allows us to study the effects that differences in country size have on the optimal combination of tax instruments when countries can discriminate between the taxation of national 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. Section 7 concludes.

2 The model

We analyze a model of two countries, labeled A and B. The country indices are $i, j \in \{A, B\}$ with $i \neq j$, if not stated otherwise. The countries simultaneously compete in capital tax rates and in thin capitalization rules. These policy instruments affect the choices of two types of firms: national firms, which can only invest in the country where the owner resides, and multinational enterprises (MNEs), which can invest in either country. The categorization of firms into national vs. multinational firms is exogenous to our analysis, 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 capital and link different firm types to different types of capital. Hence, national firms dispose of a unit of immobile capital, whereas multinational firms dispose of a unit of mobile capital. Mobile and immobile capital units have the same productivity and receive the same gross return, but their net return may differ as a consequence of a differential tax treatment. In particular, each country taxes the returns to mobile and immobile capital employed in its jurisdiction at the same tax rate, but the taxable base of a multinational

\(^8\)Consequently they neither analyze policy coordination with respect to thin capitalization rules nor the effects of asymmetric tax competition, which are at the heart of the present contribution. Another 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.

\(^8\)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 firm mobility, see Bucovetsky and Haufler (2008).
firm may be lower than that of a national firm. This is because, in addition to choosing where to invest its capital, the multinational firm is able to engage in international tax arbitrage through internal debt shifting (in a way described below). The extent to which debt shifting in the multinational firm can be used for tax-saving purposes is determined by the thin capitalization rules chosen by national governments.

Capital endowments are exogenously given and owned by the residents of countries $A$ and $B$. The total population size is normalized to unity and the population share in country $i$ is denoted $s_i$. Per-capita endowments are identical in the two regions: 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 ($s_i = 0.5$), but we relax this assumption in Section 6.

The capital units employed in different firms are aggregated to a country production function, where mobile and immobile units of capital are perfect substitutes in the production of an output good. The output good is produced in both countries and its price is normalized to unity. The aggregate production function in country $i$ is expressed in per-capita terms and is given by $f(k_i)$ with $f''(k_i) < 0 < f'(k_i)$ where $k_i$ is the total per-capita amount of capital used for production in country $i$.

Our analysis focuses on corporate taxes and assumes that the source principle is effective, implying that countries avoid international double taxation by exempting foreign-earned income from domestic tax. For the corporation tax, this is true for most OECD member states (see, e.g. Tanzi, 1995, Ch. 6-7). Moreover, we model the tax as a unit

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9A similar modelling component is used by Davies and Gresik (2003) who assume that capital from the home country and capital from the host country are perfect substitutes in the foreign production of MNEs. An alternative approach in our paper would be to model one integrated market for mobile capital and two national markets for immobile capital. In this setting the production of national and multinational firms is strictly separated. When production functions are the same and the output goods are perfect substitutes, the analysis of this setting is identical to the one carried out here, but the notation is slightly more involved. The calculations for the alternative case are available from the authors upon request.

10Moreover, even if corporate taxation follows the residence principle, additional taxes in the home country can be avoided by deferring the repatriation of income (see Gresik, 2001, p. 803). As a result, source taxation may be effective even in countries that legally tax resident corporations on their worldwide income (such as the United States). Matters are different for personal capital income taxes, where most countries adhere to the residence principle of taxation and the latter can be enforced by means of information sharing agreements. Taxes at the shareholder level are not incorporated in our analysis, however (see footnote 15 for further discussion).
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.

A central element of our analysis is 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. Importantly, and in line with the literature on debt shifting by MNEs quoted in the Introduction, we abstract from issues of asymmetric information.\footnote{Information asymmetries have, however, been incorporated in recent analyses focusing on other aspects of corporate taxation. For example, Keuschnigg and Ribi (2009) study different types of profit taxation with financial constraints due to moral hazard. Gresik (2010) incorporates information asymmetries in a setting of corporate tax competition, but this study does not focus on financial decisions of multinational firms, or on policies to affect them.}

Instead, we follow previous studies and adopt the deterministic ‘trade-off theory’ of corporate financial structure, according to which firms balance the tax advantage of debt against the non-tax costs of debt. The latter are explained in more detail below. The tax advantage of debt arises from 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 costs of equity. This asymmetry in the tax treatment of equity and debt is thus central to our analysis.\footnote{Of course, there would be no tax-induced distortions of firms’ financial choices if the costs of equity were also deductible from the corporate tax base. See Auerbach et al. (2010) 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 they entail a narrowing of the tax base and thus require higher corporate tax rates, if corporation tax revenues are 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).}

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 MNE, 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 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 absorb some of the free cash flow of firms via interest payments and protect the stockholders from overinvestment strategies of its managers (Jensen, 1986). We model these different arguments in a highly stylized way, by specifying a target level of external debt, $\tilde{\alpha} \in [0, 1]$, at which the firm faces no extra costs of its financial structure. Any deviation from this target level will lead to convex agency costs $C(\alpha^n_i - \tilde{\alpha})$ with sign $\{C'(\alpha^n_i - \tilde{\alpha})\} = \text{sign}\{\alpha^n_i - \tilde{\alpha}\}$ and $C''(\alpha^n_i - \tilde{\alpha}) > 0$.\footnote{Our specification includes a zero target level of debt ($\tilde{\alpha} = 0$) as a special case. For a similar modeling of agency costs see, e.g., Schindler and Schjelderup (2012).}

Let $t_i$ be the statutory tax rate in country $i$. The effective tax rate faced by the national firms in country $i$ is then $\tau^n_i = t_i (1 - \alpha^n_i)$. The net return to immobile capital in country $i$ (provided either as debt or as equity) reads

$$r^n_i = f'(k_i) - \tau^n_i - C(\alpha^n_i - \tilde{\alpha}).$$

Firms in each country maximize the common net return to their shareholders and bondholders. For national firms the only choice parameter is the share of external debt, $\alpha^n_i$. Maximizing $r^n_i$ with respect to $\alpha^n_i$ yields

$$t_i = C'(\alpha^n_i - \tilde{\alpha}).$$

In the firms’ financial optimum the tax benefit of a higher level of external debt are traded off against the agency costs. Hence, the debt ratio chosen by each firm is a rising function of the tax rate $t_i$. Formally, (1) implies $\alpha^n_i = \alpha^*_i(t_i)$ with $d\alpha^*_i/dt_i = 1/C'' > 0$.\footnote{Empirical evidence for the positive relationship between the statutory tax rate and the share of external debt is given in Gordon and Lee (2001).}

Inserting into $\tau^n_i$ and $r^n_i$ gives the effective tax rate in the national firms’ optimum

$$\tau^n_i = t_i [1 - \alpha^*_i(t_i)]$$

and the net return to immobile capital in country $i$

$$r^n_i = f'(k_i) - t_i [1 - \alpha^*_i(t_i)] - C [\alpha^*_i(t_i) - \tilde{\alpha}],$$

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

13Our specification includes a zero target level of debt ($\tilde{\alpha} = 0$) as a special case. For a similar modeling of agency costs see, e.g., Schindler and Schjelderup (2012).

14Empirical evidence for the positive relationship between the statutory tax rate and the share of external debt is given in Gordon and Lee (2001).
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 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.\footnote{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).}

Let us now turn to the multinational enterprises (MNEs). It is assumed that external debt finance has the same tax advantages and the same costs for these firms as for the nationally operating firms. However, the MNEs also have the opportunity to set up affiliates in more than one country, and to engage in financial transactions between the affiliates. We model this in the simplest possible way and focus on the role that intra-firm lending plays in minimizing the aggregate tax burden. Thus we assume that there is a complete separation of instruments, where only external debt is used to raise the overall liquidity in the firm, whereas internal debt is used exclusively for tax arbitrage.

More precisely, each MNE is assumed to set up a financial subsidiary in a tax haven country $C$, which offers a zero tax rate on corporate income. 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 multinational firms.\footnote{See Mintz (2004) and OECD (2007, chap. 5) for more detailed descriptions of triangular, or ‘conduit’ financing structures used by MNEs. In principle, countries $A$ and $B$ could offset the tax advantage offered by the tax haven by imposing a sufficiently high withholding tax on the interest income that flows from their jurisdiction to the tax haven. However, when no withholding taxes can be levied between $A$ and $B$, then tax competition between them will drive the optimal withholding tax rates to the haven to zero, as a result of triangular arbitrage by the MNE (see Johannesen, 2012).} Finally, we assume that internal financial transactions within MNEs are not associated with agency costs, because the overall
liquidity of the MNE is unaffected by the transaction.

Both countries can restrict this type of debt shifting within MNEs by means of thin capitalization rules. We model a thin capitalization rule as an upper limit on the share of *intra-firm* debt that can be deducted from the MNE’s tax base in the producing country A or B. The maximum permitted share of deductible intra-firm debt in country \( i \) is denoted by \( \lambda_i \in [0, 1] \) and it is restricted to be non-negative.

This modelling of thin capitalization rules applies directly for countries that restrict the ratio of *related party debt* to equity (see Table 1). However, even the remaining countries in Table 1, whose safe-haven ratio applies to *total debt*, generally do not restrict the tax-deductibility of debt for national firms.\(^{17}\) Given that national firms face no restrictions on the tax deductibility of their (external) debt, it can then be shown that the qualitative results of our analysis are the same, no matter whether multinational firms are constrained by a thin capitalization rule that applies to related party debt or by one that applies to total debt. In this sense our modelling choice for the policy instrument \( \lambda_i \) is thus not restrictive.\(^{18}\)

Finally, since tax savings are the only motivation for MNEs to use internal financial transactions in our model, there is no reason for them to use internal debt beyond the tax-deductible share \( \lambda_i \). These assumptions imply that the ratio of internal debt chosen by a MNE in country \( i \) will always coincide with the tax-deductible share \( \lambda_i \).\(^{19}\)

\(^{17}\)The reason why some countries use a total debt criterion even when targeting explicitly at debt shifting within MNEs is that the distinction between internal and external debt is often difficult to draw in practice. Hence specifying a threshold level of total debt grants full interest deductibility for all firms below this threshold, without the need to determine the composition of these firms’ debt. But when a company’s debt-to-equity ratio exceeds the safe-haven ratio, then the distinction between internal and external debt is drawn and deductibility is denied only for internal loans (see Gouthi`ere, 2005).

\(^{18}\)The effects of a constraint on total debt are formally analyzed in part A of a supplementary appendix to this paper, which is found on our homepages. In this case it remains true that the corporate tax distorts the financing decision of immobile firms, and that the thin capitalization rule can be used to tax-discriminate in favor of mobile firms. The main difference to the analysis in the main text is that MNEs will always choose an external debt level of \( \bar{\alpha} \) under a total debt rule. This is because, from the MNEs’ perspective, external and internal debt are perfect substitutes in claiming interest deductibility, but internal debt causes no agency costs \( C \). With the external debt level chosen optimally at \( \alpha^* = \bar{\alpha} \), it is intuitive that the constraint on the MNE’s total debt ratio has analogous effects as a constraint on its internal debt.

\(^{19}\)These assumptions are relaxed in part B of the supplementary appendix to this paper. There we incorporate additional benefits of internal debt (net of agency costs) into the model, which cause MNEs
With these specifications, the effective tax rate on MNEs (superscript \(m\)) is 
\[
\tau_i^m = t_i (1 - \lambda_i - \alpha_i^m),
\]
where \(\alpha_i^m\) is the share of external debt of a multinational firm in country \(i\). The net return to mobile capital in country \(i\), provided either as equity or as debt, reads
\[
r_i^m = f'(k_i) - \tau_i^m - C(\alpha_i^m - \bar{\alpha}).
\]
Maximizing this expression with respect to the MNE’s share of external debt yields \(\alpha_i^m = \alpha_i^*(t_i)\). Thus, external debt is the same as for national firms. The maximum permissible share of internal debt, \(\lambda_i\), is instead set by the government of country \(i\), and it is fully exploited by the MNE in its financial optimum. Hence, the MNE’s effective tax rate is lower than that of national firms, whenever a positive allowance is made for internal debt (i.e., whenever \(\lambda_i > 0\)). Using the optimized value \(\alpha_i^*(t_i)\), the effective tax rate on the MNE in country \(i\) can be written as
\[
\tau_i^m = t_i [1 - \lambda_i - \alpha_i^*(t_i)],
\]
yielding a net return to mobile capital in country \(i\) equal to
\[
r_i^m = f'(k_i) - t_i [1 - \lambda_i - \alpha_i^*(t_i)] - C[\alpha_i^*(t_i) - \bar{\alpha}].
\]
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 \(\lambda_i\)) 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
\[
s_i k_i + s_j k_j = 1 + n.
\]
Moreover, international arbitrage has to ensure that the net return to mobile capital is the same in the two countries, i.e. \(r_i^m = r_j^m\). This condition, together with (5) and (6), determines the capital allocation \((k_i, k_j)\) as a function of the policy instruments \((t_i, t_j, \lambda_i, \lambda_j)\). Totally differentiating and evaluating the resulting expressions at a symmetric situation with \(t_i = t, \lambda_i = \lambda, k_i = 1 + n\) and \(\alpha_i^* = \alpha^*\) yields the comparative static results
\[
\frac{\partial k_i}{\partial t_i} = - \frac{\partial k_j}{\partial t_i} = 1 - \lambda - \alpha^* > 0, \quad \frac{\partial k_i}{\partial \lambda_i} = - \frac{\partial k_j}{\partial \lambda_i} = - \frac{t}{2f''} > 0.
\]
to choose a level of internal debt in excess of the fraction that is tax-deductible. The supplementary appendix shows, however, that the location decisions of firms, and thereby the optimal policies of governments, depend only on the tax-deductible shares of internal debt, \(\lambda_i\) and \(\lambda_j\). Therefore, all our core results are unaffected by this model extension.
Equation (7) shows that an increase in country \( i \)'s tax rate and a tightening of its thin capitalization rule (a reduction in \( \lambda_i \)) 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

\[
x_i = nr_i^n + r_i^m + f(k_i) - f'(k_i)k_i, \tag{8}
\]

where \( r_i^n \) and \( r_i^m \) are given by (3) and (5), respectively. Differentiating (8) and evaluating the resulting expressions at a symmetric situation yields

\[
\frac{\partial x_i}{\partial t_i} = -n(1 - \alpha^*) - (1 - \lambda - \alpha^*) < 0, \quad \frac{\partial x_i}{\partial \lambda_i} = t > 0, \quad \frac{\partial x_j}{\partial t_i} = \frac{\partial x_j}{\partial \lambda_i} = 0. \tag{9}
\]

According to (9), reducing the tax rate or relaxing the thin capitalization rule in country \( i \) raises private income and thus private consumption in country \( i \), but leaves unchanged private income and private consumption in country \( j \).

Each government collects taxes from both mobile and immobile capital in order to finance the provision of local public goods. The quantity of mobile capital employed in country \( i \) is given by \( k_i - n \). Per-capita tax revenues in country \( i \) are 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 (2) and (4). Differentiating (10) and evaluating the resulting expressions at a symmetric situation gives

\[
\frac{\partial z_i}{\partial t_i} = n(1 - \alpha^*) + (1 - \lambda - \alpha^*) + t(1 - \lambda - \alpha^*) \frac{\partial k_i}{\partial t_i} - (1 + n) \frac{\partial \alpha^*}{\partial t_i}, \tag{11}
\]

\[
\frac{\partial z_i}{\partial \lambda_i} = -t + t(1 - \lambda - \alpha^*) \frac{\partial k_i}{\partial \lambda_i}, \tag{12}
\]

\[
\frac{\partial z_i}{\partial t_i} = t(1 - \lambda - \alpha^*) \frac{\partial k_i}{\partial t_i} > 0, \quad \frac{\partial z_i}{\partial \lambda_i} = t(1 - \lambda - \alpha^*) \frac{\partial k_i}{\partial \lambda_i} < 0. \tag{13}
\]

In contrast to private income, tax revenues and public consumption are influenced by the policy instruments not only via a direct effect, but also via changes in the capital allocation and external debt levels. Formally, the additional effects are represented by \( \frac{\partial \alpha_i^*}{\partial t_i}, \frac{\partial k_i}{\partial \alpha} \) and \( \frac{\partial k_j}{\partial v} \) with \( v \in \{t_i, \lambda_i\} \). They explain why country \( i \)'s tax rate and thin capitalization rule exert an ambiguous effect on country \( i \)'s tax revenues.

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Moreover, as (13) shows, both tax parameters of country \(i\) exert fiscal externalities on tax revenues in country \(j\).

The representative household in each country derives utility from the consumption of the private good and the local public good. Per-capita welfare in country \(i\) is therefore represented by the utility function \(u_i = U(x_i, z_i)\), which satisfies the usual properties \(U_x, U_z > 0, U_{xx}, U_{zz} \leq 0\) and \(U_{xz} \geq 0\). As is well-known from the literature on interjurisdictional competition, with general functional forms it is necessary to assume – rather than rigorously prove – that \(u_i\) is globally concave in the policy parameters \((t_i, \lambda_i)\).

When quadratic production and agency costs as well as a linear utility function are assumed, however, one can show that \(u_i\) is globally concave in the thin capitalization rule \(\lambda_i\) and locally concave in the tax rate \(t_i\).

### 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 \(s_i = 0.5\). Hence, we can assume that each country sets its tax policy so as to maximize the sum of utilities, \(w := u_i + u_j\). Denoting the Pareto efficient policy by the superscript \(PO\) and introducing \(\eta\) for the (positively defined) tax elasticity of the net-of-external-debt tax base, Appendix A.1 proves

**Proposition 1** Suppose \(s_i = 0.5\). Then the Pareto efficient tax policy in both countries is characterized by the condition

\[
\frac{U_z}{U_x} = \frac{1}{1 - \eta} > 1 \quad \text{with} \quad \eta \equiv \frac{t^{PO}}{1 - \alpha^*} \frac{d\alpha^*_i}{dt_i} > 0
\]

and by a zero thin capitalization rule \(\lambda^{PO} = 0\).

According to equation (14), the efficient corporate tax policy takes into account the effect of the statutory tax rate on external debt (formally represented by \(\eta\)). In the

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20 This is proved in part C of the supplementary appendix found on our homepages. For this set of specifications we have also performed simulations, which show the governments’ objective function to be globally concave in \((t_i, \lambda_i)\) for a wide variety of parameter constellations. For some of the few papers in the tax competition literature that explicitly check (local) concavity of the underlying optimal tax problems, see Bucovetsky (1991) and Bayindir-Upmann and Ziad (2005).
Pareto optimum the marginal rate of substitution between public and private consumption, $U_z/U_x$, therefore exceeds the marginal rate of transformation, which is equal to one in our model. Hence, relative to a fully undistorted world, the supply of public goods is distorted downwards. Moreover, the efficient policy is not to allow any tax deductibility for internal debt. Intuitively, in a symmetric situation relaxing the common thin capitalization rule by increasing $\lambda_i$ and $\lambda_j$ does not change the distribution or aggregate amount of capital, but only lowers each country’s tax base and thus reallocates resources from the public sector into the private sector. Since the marginal rate of substitution between public and private consumption is larger than one, according to equation (14), it is therefore never optimal to increase $\lambda_i$ and $\lambda_j$ above zero.

4 Tax competition

Let us now turn to the case where the two governments in countries $A$ 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.\(^{21}\)

With these assumptions, country $i$ maximizes its per-capita welfare $u_i = U(x_i, z_i)$ with respect to the policy instruments $t_i$ and $\lambda_i$, taking as given the choices of $t_j$ and $\lambda_j$ in country $j \neq i$. This behavioral assumption constitutes a Nash tax competition game with two policy instruments. We first stick to the case of identical countries with $s_i = 0.5$ and therefore focus on the symmetric equilibrium of the tax competition game with the equilibrium policy instruments $t_i = t^*$ and $\lambda_i = \lambda^*$. The question in this section is how the Nash equilibrium outcome differs from the Pareto efficient solution.

The first-order condition for the equilibrium tax rate is $\partial u_i/\partial t_i = (\partial x_i/\partial t_i)U_x + (\partial z_i/\partial t_i)U_z = 0$. Using the symmetry assumption, (7), (9) and (11) yields

$$\frac{U_z}{U_x} = \frac{n(1 - \alpha^*) + 1 - \lambda^* - \alpha^*}{\Gamma} > 1,$$

\(^{21}\)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.
\[ \Gamma := n(1 - \alpha^*) + 1 - \lambda^* - \alpha^* - (1 + n)t^* \frac{\mathrm{d} \alpha^*_i}{\mathrm{d} t_i} + t^*(1 - \lambda^* - \alpha^*) \frac{\partial k_i}{\partial t_i} > 0. \quad (16) \]

Comparing this condition with the Pareto optimal solution characterized in (14) shows that the core difference between the two expressions lies in the last term of (16). This term captures the effects of tax competition and is negative from (7), implying inefficient undertaxation of capital in the Nash equilibrium. Note that this is true independent of whether the equilibrium thin capitalization rule \( \lambda^* \) is zero or positive.\(^{22}\)

The derivative of country \( i \)'s welfare function with respect to its thin capitalization rule is given by 
\[ \frac{\partial u_i}{\partial \lambda_i} = \frac{t^* U_x}{\Gamma} \left[ -(1 + n)t^* \frac{\mathrm{d} \alpha^*_i}{\mathrm{d} t_i} + t^* n(1 - \alpha^*)(1 - \lambda^* - \alpha^*) \right]. \quad (17) \]

We obtain \( \lambda^* > 0 \) if \( (\partial u_i/\partial \lambda_i)|_{\lambda=0} > 0 \). According to (17), this holds if \( t^*(1 - \alpha^*)/[2(1 + n)f'] < -t^*(\mathrm{d} \alpha^*_i/\mathrm{d} t_i)/[n(1 - \alpha^*)] \). Introducing \( \zeta := -t^*(\partial k_i/\partial t_i)(t_i/k_i) > 0 \) as the (positively defined) elasticity of capital input in a country with respect to the corporate tax rate in this country, this condition can be succinctly expressed as \( \zeta|_{\lambda=0} > \eta/n \), where \( \eta \) is given in (14). We summarize our results in

**Proposition 2** Suppose \( s_i = 0.5 \) 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 in the sense that \( \zeta|_{\lambda=0} > \eta/n \), then the equilibrium thin capitalization rule is inefficiently lax \( (\lambda^* > \lambda^{PO} = 0) \).

The first part of Proposition 2 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 \( \lambda_i \)) reallocates income from the public sector to the private sector. This effect on its own is welfare-reducing for each country, for the reasons already discussed in the previous section. When tax policies are non-cooperatively chosen, however, increasing \( \lambda_i \) attracts mobile capital from the neighboring country and thus serves as a tax competition device. Formally, this can be seen from equation (7).

Intuitively, in contrast to the statutory tax rate, the thin capitalization rule can be

\(^{22}\)An alternative proof of inefficiently low tax rates relies on the fiscal externality which one country’s tax rate exerts on welfare in the other country. Formally, this externality is given by (20) below. It is always positive, regardless of whether \( \lambda^* \) is zero or strictly positive.
targeted directly at mobile capital in multinational firms. Hence, a policy of lenient
thin capitalization rules can attract capital at lower costs, in terms of the foregone
tax revenues, than when only the (non-discriminatory) statutory tax rate is used. If
the countries’ incentive for tax competition is strong enough, in the sense that for a
zero thin capitalization rule capital inputs react more elastically to tax rate changes
than the net-of-external-debt tax base (i.e. \( \zeta|_{\lambda=0} > \eta/n \)), then the tax-deductible ratio
of internal debt is strictly positive in the Nash equilibrium and thus lies above its
efficient level. The positive tax allowance for internal debt implies that MNEs will be
tax-favored over national firms in the non-cooperative tax equilibrium.

In case of an interior solution, the first-order condition \( \partial u_i/\partial \lambda_i = 0 \), obtained with
the help of (17), yields information about the conditions under which \( \lambda^* \) is high and
hence tax discrimination in favor of MNEs will be particularly strong. This will be the
case when the positive second term in the squared bracket in (17) is large, relative
to the negative first term. Other things being equal, this requires \( f'' \) to be small in
absolute terms, implying that the marginal product of capital falls only slowly in a
country as more capital inputs are used. Hence, attracting foreign capital is particularly
attractive and tax competition for mobile capital will be intense. Each country then
has the incentive to set lax thin capitalization rules (i.e. a high level of \( \lambda^* \)), in order to
target tax concessions at the internationally mobile tax base. On the other hand, an
increase in the elasticity with which the share of external debt financing responds to
statutory tax rate changes (\( d\lambda^*_i/d\tau_i \)) increases the first term in (17) and thus reduces
tax concessions to MNEs, other things being equal. The reason is that the statutory
tax rate causes a higher excess burden in this case, aggravating the undersupply of
public goods.\(^{23} \) Thus countries will be less likely in their national optimum to grant
substantial tax concessions to MNEs by means of generous thin capitalization rules.

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 – when the competition for mobile capital is sufficiently strong – also to
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

\(^{23}\) Notice that a rise in \( d\lambda^*_i/d\tau_i \) causes \( \Gamma \) defined in (16) to fall. This in turn leads to an increase in
the marginal rate of substitution \( U_z/U_x \) given by (15).
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 European Union (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 European Commission, 2011). 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 national firms, the welfare effects of a partial coordination of thin capitalization rules are ambiguous a priori.

To analyze this issue, we initially maintain the symmetry assumption and determine the total change in country $i$’s utility caused by a small reduction in both countries’ thin capitalization variables. Formally, we set $d\lambda_i = d\lambda_j = d\lambda < 0$. This yields

$$\frac{du_j}{d\lambda} = \frac{\partial u_j}{\partial \lambda_i} + \frac{\partial u_j}{\partial t_i} \frac{dt^*}{d\lambda}.$$  

(18)

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 $\lambda_i$ on country $j$’s welfare. The indirect effect works through the impact of the partial coordination of thin capitalization rules on country $i$’s equilibrium tax rate $t_i = t^*$, and the resulting effect of the change in $t_i = t^*$ on country $j$’s welfare. Note that the expression $dt^*/d\lambda$ is the response of country $i$’s statutory tax rate to the simultaneous changes in $\lambda_i$ and $\lambda_j$.

The direct effect is obtained from differentiating country $j$’s welfare $u_j = U(x_j, z_j)$ taking into account equations (7), (9) and (12). This yields

$$\frac{\partial u_j}{\partial \lambda_i} = \frac{(t^*)^2(1 - \lambda^* - \alpha^*)}{2f''} U_z < 0.$$  

(19)

Hence, the direct effect of a small reduction in $\lambda_i$ is beneficial for country $j$. An isolated tightening of country $i$’s thin capitalization rule increases the effective tax rate on

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24In deriving (18) 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 thin capitalization rules.
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 differentiating country $j$’s welfare $u_j = U(x_j, z_j)$ and taking into account equations (7), (9) and (12), which implies

$$\frac{\partial u_j}{\partial t_i} = -\frac{t^* (1 - \lambda^* - \alpha^*)^2}{2 f''} U_z > 0. \quad (20)$$

To determine the overall sign of the indirect effect in (18), we have to establish whether partial policy coordination increases or decreases country $i$’s equilibrium statutory tax rate. It is shown in Appendix A.2 that

$$\frac{dt^*}{d\lambda} = \frac{1}{\Delta} \left\{ U_z - U_x + t^* [n(1 - \alpha^*) + 1 - \lambda^* - \alpha^*] \frac{(U_x + U_z)U_{xx} - U_zU_{xx} - U_zU_{zz}}{U_z} \right\}, \quad (21)$$

where $\Delta > 0$ if the elasticity of the marginal external debt, $\rho$, satisfies\(^{25}\)

$$\rho \equiv t^* \frac{d^2 \alpha^*_i}{dt_i^2} > -\frac{U_x + n(2U_z - U_x)}{(1 + n)U_z} < 0. \quad (22)$$

Condition (22) together with the properties of the utility function $U$ and the condition $U_z > U_x$ from (15) implies that (21) is positive. Hence, each country responds to the coordinated tightening of thin capitalization rules ($d\lambda < 0$) by lowering its statutory tax rate ($dt^* < 0$). As the partial policy coordination restricts each country’s ability to attract mobile capital by means of lax thin capitalization rules, tax competition will therefore be shifted to a more aggressive lowering of tax rates. Intuitively, tighter thin capitalization rules imply a higher effective tax rate on the MNEs for any given level of $t_i$, and this increases the elasticity with which the tax base responds to changes in the statutory tax rate. Together with (20) this implies that the indirect effect of a coordinated tightening of thin capitalization rules in (18) is negative and counteracts the direct effect in (18).

Can the net welfare effect of the coordination measure nevertheless be signed? Substituting (19)–(21) in (18) and using the first-order condition $\partial u_i/\partial \lambda_i = 0$ gives after some rearrangements

$$\frac{du_j}{d\lambda} = \frac{t^*(U_x - U_z)}{\Delta} \left\{ (1 + n)U_z \frac{d\alpha^*_i}{dt_i} \left[ \rho + \frac{U_x + n(2U_z - U_x)}{(1 + n)U_z} \right] \right\} - \frac{n(1 - \alpha^*) [n(1 - \alpha^*) + 1 - \lambda^* - \alpha^*] U_z^2 U_{zz} - 2U_z U_x U_{xx} + U_x^2 U_{xx}}{U_z^2} \right\} < 0. \quad (23)$$

\(^{25}\)For example, under a quadratic agency cost function $C(\alpha_i - \bar{\alpha}) = \beta(\alpha_i - \bar{\alpha})^2/2$ we obtain $\alpha^*_i(t) = \bar{\alpha} + t_i/\beta$ and thus $d^2 \alpha^*_i/dt_i^2 = 0$ and $\rho = 0$. Under this specification, (22) is therefore satisfied.
The curly bracket in (23) is unambiguously positive when condition (22) is fulfilled. Since $U_z < U_z$ from (15) and $\Delta > 0$, we can sign $du_j/d\lambda < 0$. This is summarized in Proposition 3. Suppose (22) is satisfied. Then 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 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. Our discussion of this proposition has shown 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.

These findings can be linked to some of the results from the previous literature on discriminatory tax competition. In particular, Proposition 3 stands in direct contrast to an influential result by Keen (2001), who finds that countries which cannot coordinate their tax rates should not enter into a partial coordination agreement that eliminates preferential tax regimes. In Keen’s analysis, aggregate tax competition is less severe, in the sense of allowing each of two symmetric countries to collect more tax revenues, if countries remain free to tax discriminate in favor of the more mobile tax base. In contrast, our Proposition 3 shows that both countries can gain from a coordinated tightening of thin capitalization rules that reduces the degree of tax discrimination between the mobile and the immobile capital tax base.

The reason for these differences in results is that Keen (2001) assumes the aggregate tax base in the two competing countries to be fixed. In our setting, this assumption would imply that the ratio of external debt finance chosen by firms does not respond to the corporate tax rate and hence $\alpha_i^*/\alpha_i = 0$. In this case, the optimal choice of thin capitalization rules in the non-cooperative tax equilibrium would be $\lambda^* = 1 - \alpha^*$ from (17). This implies that profits of multinational firms are fully exempted from tax
(the tax base is zero). Thus the corporate tax falls only on immobile capital and turns into a lump-sum tax. From (15) and (16) it then follows that $U_z/U_x = 1$, so that the Nash equilibrium in taxes is Pareto efficient. Obviously, therefore, a coordination of thin capitalization rules cannot be welfare-improving in this special case.\(^{26}\)

It should be stressed that Keen’s (2001) scenario is somewhat more complex than the one described above, because the second tax base is not fully immobile internationally in his analysis. Therefore, his analysis features imperfect tax discrimination and taxes are still distortive, yielding a Pareto inefficient solution in the non-cooperative equilibrium with preferential regimes. Nevertheless, the basic argument given above is still valid and it remains true that Keen’s (2001) result depends critically on the assumption that the global size of the different tax bases is fixed in his analysis.\(^{27}\) As our above analysis shows, it is thus crucial for an evaluation of the welfare effects of thin capitalization rules to allow for a responsiveness of the aggregate tax base through the choice of external debt. Intuitively, broadening the tax base of multinational firms by a coordinated tightening of thin capitalization rules allows governments to reduce corporate tax rates for any given level of tax revenues and public good supply. This reduces the excess burden of taxation if and only if the aggregate tax base is affected by tax rate changes.

### 6 Asymmetries between countries

Virtually all of the existing literature on discriminatory tax competition is confined to the case of symmetric countries. In contrast, the present model allows us to derive algebraic results for how asymmetries in country size affect equilibrium tax rates and thin capitalization rules. To obtain these results, however, we need to place specific functional forms on the utility, production and agency costs functions.

We therefore assume that the per-capita production function in country $i$ is quadratic and given by $f(k_i) = ak_i - (b/2)k_i^2$ with $a, b > 0$. Moreover, the agency cost function that

\(^{26}\)More precisely, a small, coordinated reduction in $\lambda_i$ and $\lambda_j$ will not have first-order welfare effects because the initial equilibrium is first-best efficient. This is seen from (23) when $U_x = U_z$ holds initially. However, a ‘large’, coordinated reduction in $\lambda_i$ and $\lambda_j$ – which cannot be captured by (23) – will re-establish a positive effective tax rate on mobile firms and thus re-introduces international tax competition between countries $A$ and $B$. Since the latter leads to inefficiently low taxes it must reduce global welfare, relative to the initial non-cooperative equilibrium.

\(^{27}\)This has been worked out in detail by Janeba and Smart (2003).
limits external debt financing is also quadratic and given by $C(\alpha_i - \bar{\alpha}) = \beta(\alpha_i - \bar{\alpha})^2/2$, where $\beta$ parameterizes the extra costs of a non-optimal tax structure. Finally, the utility function assumes a fixed marginal rate of substitution between private and public consumption where each Euro of tax revenues is worth $1 + \varepsilon$ Euros of private income (with $\varepsilon > 0$). This specification ensures that both countries levy positive capital taxes in equilibrium. A motivation for $\varepsilon > 0$ is that the receipts from the corporate income tax can be used to reduce the excess burden of other, more distortionary taxes. Per-capita welfare in country $i$ is then defined as $U(x_i, z_i) = x_i + (1 + \varepsilon)z_i$.

With these assumptions, reduced-form solutions for the tax policies in the symmetric Nash equilibrium of the tax competition game can be obtained. The equilibrium tax policies are derived in Appendix A.3. and given by

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

where $\lambda^*$ is positive when the parameter $b$ [which corresponds to $-f''$ in (17)] is sufficiently small, implying intensive competition for mobile capital.

Starting from this 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 $d_{si} = -d_{sj} < 0$ and evaluate these effects at the symmetric equilibrium, using (24) and (25). It is shown in the appendix that

$$\frac{d(t_i - t_j)}{ds_i} = \frac{1}{|J|} \frac{4n^2 \beta \varepsilon^2 (1 + \varepsilon)(1 - \alpha)^2}{b(1 + n + 2\varepsilon n + \varepsilon)^2} > 0,$$
$$\frac{d(\lambda_i - \lambda_j)}{ds_i} = -\frac{1}{|J|} \frac{4\varepsilon (1 + n + 2\varepsilon n - \varepsilon)}{\beta} < 0 \text{ for } 1 + n + 2n\varepsilon - \varepsilon > 0,$$

where $|J| > 0$ is given in (A.24) in the appendix.

Equation (26) shows that an increase in country size leads to a higher statutory tax rate on national firms, in comparison to the smaller neighbour. 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 $\varepsilon$ 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 revenues 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. A fall in $s_i$ will then lead to a more lenient thin capitalization rule in the smaller country (a higher level of $\lambda_i$), 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 capital. These results are summarized in:

**Proposition 4** Starting from a symmetric tax competition equilibrium with quadratic production and agency costs functions and a linear utility function, suppose that the population size of one country is marginally 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 $\varepsilon$ 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 tax rate. The new result in part (ii) of Proposition 4 is that the smaller country also offers multinational 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 capital. Hence, the relative taxation of mobile vis-a-vis immobile capital 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

---

28 In the interpretation given above, $\varepsilon < 1$ implies that the excess burden of the overall tax system is less than 100 percent. This is clearly met in developed countries. Existing studies for, e.g., the United States estimate the average excess burden of the tax system at 18% (Jorgenson and Yun, 1993).
Table 2: Simulation results for partial coordination among asymmetric countries

<table>
<thead>
<tr>
<th>popul. size</th>
<th>tax rates in initial non-cooperative equilibrium</th>
<th>variant I</th>
<th>variant II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dλ_A = dλ_B = −0.050</td>
<td></td>
<td>( \bar{\lambda} = \min[\lambda^<em>_A, \lambda^</em>_B] )</td>
</tr>
<tr>
<td>( s_A )</td>
<td>( \Delta u_A )</td>
<td>( \Delta u_B )</td>
<td>( \Delta u_A )</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>0.50</td>
<td>0.466</td>
<td>0.466</td>
<td>0.311</td>
</tr>
<tr>
<td>0.40</td>
<td>0.455</td>
<td>0.473</td>
<td>0.334</td>
</tr>
<tr>
<td>0.30</td>
<td>0.438</td>
<td>0.478</td>
<td>0.330</td>
</tr>
<tr>
<td>0.25</td>
<td>0.425</td>
<td>0.481</td>
<td>0.314</td>
</tr>
</tbody>
</table>

Note: Parameters held constant: \( \varepsilon = 0.3, n = 1, a = 3, b = 0.5, \beta = 5, \bar{a} = 0.1 \). 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 2. Under variant I of the

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. Overall, therefore, a rather clear pattern emerges from Table 1 that supports the prediction in our Proposition 4 (ii).
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 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 immobile capital.

Finally, we briefly discuss another scenario within the setting of asymmetric tax competition where debt shifting occurs between the two union countries, rather than to a tax haven country \(C\). For concreteness, let country \(A\) be again the small country, which levies the lower tax rate. A first implication of this alternative setting is that the thin capitalization rule of the small country \(A\) will be irrelevant, since MNEs will never find it optimal to give a loan from the high-tax country \(B\) to the low-tax country \(A\). Hence the only remaining question is whether the high-tax country \(B\) will decide to tax-discriminate in favor of mobile capital (i.e., to set \(\lambda_B > 0\)). From the perspective of country \(B\), the tax losses from granting discriminatory tax relief to its MNE continue to be \(\lambda_B t_B\), but the tax savings for MNEs in country \(B\) are now reduced to \(\lambda_B (t_B - t_A)\). The reduction in tax savings reduces private income in country \(B\) and thus makes it less attractive for country \(B\) to choose a positive level of \(\lambda_B\), as compared to the case where debt shifting occurs to a tax haven with a zero tax rate.

Tax discrimination will become even less attractive for country \(B\), if MNEs owned by residents of the low-tax country \(A\) can grant an internal loan to their subsidiaries in country \(B\), the interest on which is tax-deductible in \(B\). In this case the tax receipts that country \(B\) collects from the subsidiary of these MNEs will fall by \(\lambda_B t_B\), with no offsetting gains for country \(B\) when the owners of these units of mobile capital reside in
country $A$. Moreover, since tax savings from profit shifting are the same for all MNEs, the capital allocation no longer depends on the thin capitalization rules, implying that country $B$’s tax competition effect for a positive $\lambda_B$ disappears. Hence, in this case it is always optimal for country $B$ to choose $\lambda_B = 0$ and thus not to grant any tax favors to mobile capital.\textsuperscript{29}

This discussion shows that the use of thin capitalization rules as an instrument in the competition for mobile capital can be much more readily explained, if debt shifting to an outside tax haven is the main constraint on tax policies in an asymmetric union. This insight supports our initial modeling approach with the tax haven $C$. Incorporating tax havens is also consistent with the empirical fact that, in relation to population size, the international portfolio investment in some tax havens is several hundred times larger than that in developed economies (see Hines, 2010, Table 2). This suggests that tax havens play an important role for multinational companies, who set up subsidiaries or ‘conduit’ companies there in order to shift interest income, or profits, to the haven.

7 Conclusions

This paper has introduced a model where countries compete for mobile and immobile capital through both statutory tax rates and thin capitalization rules that limit the tax-deductibility of internal debt flows within MNEs. 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 revenues. 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

\textsuperscript{29}A detailed formal discussion of these results is found in part D of the supplementary appendix.
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., 2010). 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.
Another important extension is to endogenize the optimal tax treatment of debt and equity in an agency setting with asymmetric information. For example, when firms differ in expected profitability and the productivity of each firm is private information to the managers, then the more profitable firms will use debt financing. The reason is that equity investors will base their valuation of all firms on average productivities, thus undervaluing the productive firms. In this setting an argument arises to favor equity finance over debt finance through the tax system (see Fuest et al., 2003). Similarly, the tax system should favor equity finance when rising debt ratios give managers an incentive to reduce effort or increase risk-taking, given the presence of limited liability in case of bankruptcy. How such corrective roles of the tax system resulting from imperfect information interact with thin capitalization rules to reduce debt shifting in multinational firms in a setting with international tax competition is an interesting issue for further study.

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Appendix

A.1. Proof of Proposition 1

Taking the derivative of the joint welfare \( w := u_i + u_j \) with respect to \( t_i \) and then focusing on the symmetric solution with \( t_i = t_{PO}, \lambda_i = \lambda_{PO}, k_i = 1 + n, x_i = x_{PO} \) and \( z_i = z_{PO} \) yields the first-order condition
\[
\frac{\partial w}{\partial t_i} = U_x \left( \frac{\partial x_i}{\partial t_i} + \frac{\partial x_j}{\partial t_i} \right) + U_z \left( \frac{\partial z_i}{\partial t_i} + \frac{\partial z_j}{\partial t_i} \right) = 0. \tag{A.1}
\]

If we insert (7), (9), (11) and (12) into (A.1), we obtain
\[
\frac{U_z}{U_x} = \frac{n(1 - \alpha^*) + 1 - \lambda_{PO} - \alpha^*}{n(1 - \alpha^*) + 1 - \lambda_{PO} - \alpha^* - (1 + n)t_{PO}(da^*/dt_i)} > 1. \tag{A.2}
\]

The derivative of \( w \) with respect to \( \lambda_i \) evaluated at the symmetric solution is
\[
\frac{\partial w}{\partial \lambda_i} = U_x \left( \frac{\partial x_i}{\partial \lambda_i} + \frac{\partial x_j}{\partial \lambda_i} \right) + U_z \left( \frac{\partial z_i}{\partial \lambda_i} + \frac{\partial z_j}{\partial \lambda_i} \right). \tag{A.3}
\]

With the help of (7), (9) and (12) this expression reduces to
\[
\frac{\partial w}{\partial \lambda_i} = t_{PO}(U_x - U_z) < 0, \tag{A.4}
\]
where the sign follows from (A.2). Given the restriction \( 0 \leq \lambda_i \leq 1 \), we thus obtain the corner solution \( \lambda_{PO} = 0 \). Inserting this into (A.2) yields (14).

A.2. Proof of Equation (21)

Notice first that in the symmetric equilibrium, (17) turns into \( \partial u_i / \partial \lambda_i = 0 \) or
\[
\frac{t^*(1 - \lambda^* - \alpha^*)}{2f''} = \frac{U_x - U_z}{U_z}. \tag{A.5}
\]

Ignoring the symmetry property in the first place, the other first-order condition \( \partial u_i / \partial t_i = 0 \) from (15) and (16) can be written as
\[
T = - \left\{ n[1 - \alpha^*_i(t_i)] + 1 - \lambda_i - \alpha^*_i(t_i) - (1 + n - k_i)f''(k_i/dk_i/dt_i) \right\} U_x(x_i, z_i)
\quad + \left\{ n[1 - \alpha^*_i(t_i)] + (k_i - n)[1 - \lambda_i - \alpha^*_i(t_i)]
\quad \quad + t_i[1 - \lambda_i - \alpha^*_i(t_i)]\frac{dk_i}{dt_i} - k_i t_i \frac{d\alpha^*_i}{dt_i} \right\} U_z(x_i, z_i) = 0, \tag{A.6}
\]
where \( \partial k_i / \partial t_i = [1 - \lambda_i - \alpha_i^*(t_i)]/[f''(k_i) + f''(k_j)] \) and where \( x_i \) and \( z_i \) are defined in (8) and (10), respectively. Equation (A.6) defines country \( i \)'s equilibrium tax rate \( t_i = t^* \) as a function of \( t_j = t^* \), \( \lambda_i \) and \( \lambda_j \). Notice that the influence of \( t_j = t^* \) and \( \lambda_j \) on \( t_i = t^* \) works only through \( k_i \) and \( k_j \). However, if we start at a symmetric equilibrium and then partially coordinate the thin capitalization rules, we have \( d k_i = d k_j = 0 \) according to (7), since \( d \lambda_i = d \lambda_j = d \lambda \) from coordination and \( dt_i = dt_j \) from symmetry. Hence we can use \( k_i = k_j = 1 + n \) and (A.6) defines \( t_i = t^* \) as a function of \( \lambda_i \) only. It then follows that \( dt^* / d \lambda = - (\partial T / \partial \lambda_i) / (\partial T / \partial t_i) \) where \( \partial T / \partial \lambda_i \) equals the numerator in (21) and where \( \partial T / \partial t_i = - \Delta \) with

\[
\Delta = (1 + n) \frac{d \alpha_i^*}{dt_i} U_z \left( \rho + \frac{U_x + n(2U_z - U_x)}{(1 + n)U_z} \right) - U_z \left( 1 - \lambda^* - \alpha^* \right)^2 \frac{2f''}{2f''} \\
- n(1 - \lambda^* + 1 - \lambda^* - \alpha^*) \left\{ n(1 - \alpha^*) + 1 - \lambda^* - \alpha^* \right\} \frac{U_z U'_{z} - U_z U_{zz}}{U_z} \\
+ \left[ n(1 - \alpha^*) + 1 - \lambda^* - \alpha^* - (1 + n) t^* \frac{d \alpha_i^*}{dt_i} \right] \frac{U_z U_{zz} - U_z U_{zz}}{U_z}. \tag{A.7}
\]

Notice that the term \( n(1 - \alpha^*) + 1 - \lambda^* - \alpha^* - (1 + n) t^* (d \alpha_i^* / dt_i) \) has to be positive since \( \Gamma > 0 \) from (16). Hence (22) ensures \( \Delta > 0 \) and completes the proof of (21).

### A.3. Asymmetric tax competition

Under the specification made for the agency costs function we obtain \( \alpha_i^*(t_i) = \bar{\alpha} + t_i / \beta \). This together with the quadratic production function, \( r_i^m = r_j^m \), (5) and (6) yields

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

From (8), (10) and the linear utility function, it follows

\[
u_i = x_i + (1 + \varepsilon) z_i = n r_i^n + r_i^m + \frac{b}{2} k_i^2 + (1 + \varepsilon)(r_i^m k_i + n t_i \lambda_i), \tag{A.9}
\]

where \( k_i \) must be substituted from (A.8), along with reduced-form expressions for \( r_i^n, r_i^m, \tau_i^n \) and \( \tau_i^m \) given in (2)–(5).

Differentiating (A.9) and taking into account \( s_i + s_j = 1 \) yields

\[
\frac{\partial u_i}{\partial t_i} = s_i (k_i - 1 - n) \mu_i + \varepsilon (k_i \mu_i + n \lambda_i) - (1 + \varepsilon)t_i \left( \frac{k_i}{\beta} + \frac{(1 - s_i) \mu_i^2}{b} \right), \tag{A.10}
\]

with

\[
\mu_i = 1 - \lambda_i - \bar{\alpha} - \frac{t_i}{\beta}. \tag{A.11}
\]
Employing the symmetry property $k_i = 1 + n$ yields the equilibrium condition

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

(A.12)

Analogously differentiating (A.9) with respect to $\lambda_i$ gives

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

(A.13)

Symmetry yields the second equilibrium condition

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

(A.14)

Equations (A.12) and (A.14) constitute a system of two equations in the two unknowns $t^*$ and $\lambda^*$. Solving this equation system yields (24) and (25) in the main text.

To derive the comparative static results in (26) and (27), we totally differentiate (A.8), (A.10) and (A.13) and evaluate the resulting expressions at the symmetric equilibrium. This yields

$$
\gamma_1 dt_i + \gamma_2 d\lambda_i + \gamma_3 dk_i + \gamma_4 ds_i = 0,
$$

(A.15)

$$
\gamma_5 dt_i + \gamma_6 d\lambda_i - \gamma_7 dk_i + \gamma_8 ds_i = 0,
$$

(A.16)

$$
dk_i = \gamma_9(dt_j - dt_i) + \gamma_{10}(d\lambda_j - d\lambda_i),
$$

(A.17)

with

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

(A.18)

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

(A.19)

$$
\gamma_4 = \frac{4b\varepsilon(1 + n + \varepsilon + 2\varepsilon n)}{\beta n(1 + \varepsilon)(1 - \bar{\alpha})}, \quad \gamma_5 = \frac{2b(1 + n + \varepsilon + 2\varepsilon n)^2 - \beta \varepsilon n^2(1 + \varepsilon)(1 - \bar{\alpha})^2}{2b\beta n(1 - \bar{\alpha})(1 + n + \varepsilon + 2\varepsilon n)},
$$

(A.20)

$$
\gamma_6 = -\frac{\beta \varepsilon n(1 + \varepsilon)(1 - \bar{\alpha})}{2b(1 + n + \varepsilon + 2\varepsilon n)}, \quad \gamma_7 = \frac{1 + 2\varepsilon}{2}, \quad \gamma_8 = -2\varepsilon, \quad \gamma_9 = \frac{1 + n + \varepsilon + 2\varepsilon n}{\beta n(1 + \varepsilon)(1 - \bar{\alpha})},
$$

(A.21)

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

(A.22)

In computing (A.18)–(A.22) we used the equilibrium values (24) and (25). Next we derive (A.15) for country $j$, subtract the resulting expression from (A.15) and use (A.17) to replace $dk_i$ and $dk_j$. Proceeding in the same way with (A.16) yields

$$
\begin{pmatrix}
\gamma_1 - 2\gamma_3\gamma_9 & \gamma_2 - 2\gamma_3\gamma_{10} \\
\gamma_5 + 2\gamma_7\gamma_9 & \gamma_6 + 2\gamma_7\gamma_{10}
\end{pmatrix}
\begin{pmatrix}
d(t_i - t_j) \\
d(\lambda_i - \lambda_j)
\end{pmatrix}
= \begin{pmatrix}
-\gamma_4 \\
-\gamma_8
\end{pmatrix}
\begin{pmatrix}
ds_i - s_j
\end{pmatrix}.
$$

(A.23)
After some tedious computations, the determinant of the matrix $J$ can be written as

$$|J| = \frac{\varepsilon n (1 - \bar{\alpha}) [b(2 + 3\varepsilon)(1 + n + \varepsilon + 2\varepsilon n)^3 - \beta \varepsilon^2 n^2 (1 + \varepsilon)^2 (1 - \bar{\alpha})^2]}{2b^2(1 + n + \varepsilon + 2\varepsilon n)^3}. \quad (A.24)$$

Stability of the Nash equilibrium implies $|J| > 0$. To derive (26) and (27), we set $d s_i = -d s_j$ in (A.23). Applying Cramer’s rule then gives (26) and (27).

\footnote{Stability requires that the Jacobian determinant of (A.10) and (A.13) 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.}
References


