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THE CAPITAL STRUCTURE OF MULTINATIONAL COMPANIES UNDER TAX COMPETITION

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The Capital Structure of Multinational Companies under Tax Competition

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Abstract

This article studies the relationship between debt policies of multinational companies (MNCs) and governments' tax strategies. In the first part, it is shown that the ability to shift income from high- to low-tax countries affects MNCs' financial choices. In the second part we show how MNCs' financial decisions can affect the tax strategies of two governments competing to attract income.

JEL classification: G31, H25 and H32.

Keywords: capital structure, country risk, default, multinationals, tax competition.

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1 Introduction

The literature on multinational companies (MNCs) has gathered interesting pieces of evidence regarding both financing decisions and the ability to shift income from high- to low-tax jurisdictions.[1] It is well-known, indeed, that income can be shifted by means of debt policies, and that the amount of income shifted depends on tax rate differentials.[2] Moreover we know that debt policies are affected not only by tax factors but also by other determinants, such as distress costs and risk.[3]

The aim of this article is twofold: we address both a positive and a normative point. The former regards the interactions between income shifting and debt strategies in a stochastic context. It is worth noting that so far the literature on income shifting has mainly focused on financial strategies in a deterministic context (see e.g. Altshuler and Grubert, 2003, and Mintz and Smart, 2004). To enrich the analysis we introduce business, default and policy risk, as well as default costs. In doing so we provide a theoretical framework which, by accounting for the above evidence, allows to better understand the effects of income shifting on the financing strategies of a representative MNC.

The latter (normative) issue regards tax competition. We study how governments' fiscal policies can be affected by MNCs' strategies. In particular we analyze the behavior of two governments which compete to attract income. We then show that financial choices may affect the equilibrium tax rates levied by the competing governments.

This article is related to two streams of literature. The first deals with firms' optimal capital structure. According to this approach, optimal leverage is reached when the marginal benefit of debt financing (which is due to the deductibility of interest expenses) equates its marginal cost (which is related to the expected cost of default).[4] We thus analyze the effects of taxation on financial choices, and measure the impact of both default and policy risk on

[1] Income shifting activities are for instance dealt with by Altshuler and Grubert (2003), Graham and Tucker (2005), and Mintz (2000). Further evidence on the interactions between taxation and debt choices is provided by Mintz and Weichenrieder (2005).

[2] See e.g. Hines (1999), Mills and Newberry (2004) and Mintz and Smart (2004).

[3] Desai et al. (2004) show that political risk encourages MNCs to use greater debt. Fan et al. (2003) make a cross-country comparison supporting the idea that business risk discourages debt issues.

[4] For further details on this approach see e.g. Leland (1994).

the optimal capital structure of a representative MNC. To show this we will introduce two well-known default conditions, which refer to *protected debt*, and *unprotected debt* financing, respectively.[5]

Under protected debt financing default may be triggered when the firms' asset value falls to the debt's value. Under unprotected debt financing the MNC has a higher degree of financial flexibility. If indeed there is a threat of default, the parent firm could decide to convert intra-firm debt into equity in order to prevent default.[6] Therefore, unprotected debt financing implies that default timing is optimally chosen by the MNC. When the subsidiary's net cash flow is negative, the parent company can decide to inject further equity capital in order to meet the subsidiary's debt obligations and delay default. As long as it issues new capital and pays the interest rate it can thus exploit future recoveries in the firm's profitability.[7]

As pointed out by Leland (1994) both protected and unprotected debt are widely used. In particular, minimum net-worth requirements, implied by protected debt, are common in short-term debt financing, whereas long-term debt instruments are usually unprotected or only partially protected.

The second stream of research we refer to deals with tax competition.[8] It is worth noting that most of this literature does not deal with risk.[9] Moreover, as Wilson and Wildasin (2004, p.1084) point out, "analysis of the interaction between factor mobility, the structure of financial markets and institutions ... is still at an early stage". By merging the above streams we thus aim to provide a better understanding of possible interactions between MNCs' policies and governments' strategies. In particular, we show that the equilibrium tax rates of two competing governments depend on the default condition applied, namely on the characteristics of debt. We also prove that an increase in either the cost of default or the cost of income shifting raises tax rates. Moreover, we show that an increase in credibility, i.e. a lower risk of expropriation, allows governments to set higher tax rates. Finally, we find that

[5] For a detailed analysis of debt protection see e.g. Smith and Warner (1977).

[6] I wish to thank Clemens Fuest who raised this point when reading a previous version of this article.

[7] In this case, the MNC behaves as if it owned a put option, whose exercise leads to default.

[8] Recent evidence on tax competition is provided by Devereux et al. (2004).

[9] A few exceptions are Gordon and Varian (1989) and Lee (2004). See also Panteghini and Schjelderup (2006) who deal with MNCs' investment strategies and their interactions with governments' policies.

both business and default risk reduce the MNC's propensity to borrow and lead to higher tax rates.

The structure of the article is as follows. Section 2 describes the model. Section 3 deals with the financing strategies of a representative MNC, that can shift income from one country to another. Section 4 uses a two-country model to investigate how MNCs' strategies can affect governments' policies. Section 5 summarises the main findings and derives policy implications.

2 The model

In this section we introduce a model describing the financial strategies of a representative MNC resident in country A, and owning a subsidiary located in country B. The subsidiary can borrow from a perfectly competitive credit sector, which is characterized by a given risk-free interest rate r, and by symmetric information. The following assumptions hold:

1. the parent company produces a given amount Ψ_A of operating profits in its home country;

2. the EBIT (Earning Before Interest and Taxes) of the foreign subsidiary, defined as $\Pi_B(t)$, follows a geometric Brownian motion

$$\frac{d\Pi_B(t)}{\Pi_B(t)} = \sigma dz_B(t), \text{ with } \Pi_B(0) \geq 0, \tag{1}$$

   where σ is the instantaneous standard deviation of $\frac{d\Pi_B(t)}{\Pi_B(t)}$, and $dz_B(t)$ is the increment of a Wiener process;[10]

3. at time 0, the subsidiary borrows some resources and pays a constant coupon which cannot be renegotiated;

4. default occurs when the subsidiary does not meet its debt obligations;

5. the cost of default is proportional to the coupon received;

[10] The general form of the geometric Brownian motion is $d\Pi_B(t) = \mu\Pi_B(t)\,dt + \sigma\Pi_B(t)\,dz_B$ where μ is the expected rate of growth. If shareholders are risk neutral in equilibrium we have $\mu = r - \delta$, where r is the risk-free interest rate and δ is the convenience yield (see e.g. McDonald and Siegel, 1985). With no loss of generality, in (1) we set $\mu = r - \delta = 0$.

6. the MNC believes that there is some positive probability λdt that the foreign government expropriates its subsidiary during the short interval dt.

The above assumptions deserve some comments. Assumption 1 states that the operating profits of the parent company (Ψ_A) are exogenously given, whereas, according to Assumption 2, the subsidiary's EBIT is stochastic. These two hypotheses allow us not only to analyze the effects of foreign business risk on the parent company in a tractable way,[11] but also to account for the fact that MNCs are an important channel for the transmission of country-specific shocks.[12]

In line with Leland (1994), Assumption 3 entails that the MNC sets a coupon and then computes the market value of debt. In the absence of arbitrage, this is equivalent to first set, the value of debt and then, compute the effective interest rate under the non-arbitrage condition. For simplicity we also assume that debt cannot be renegotiated.[13]

Assumption 4 introduces the risk of default for the subsidiary. Given (1), it is assumed that if the subsidiary' EBIT falls to a given threshold value, the subsidiary is expropriated by the lender, and the parent company becomes a domestic firm with a gross cash flow equal to Ψ_A. As we pointed out in the introduction we will use the following alternative definitions of default.[14]

Definition 1 *Under protected debt financing, default takes place when* Π_B *falls to an exogenously given threshold point* $\overline{\Pi}_B^p$.

Definition 2 *Under unprotected debt financing, the threshold point* $\overline{\Pi}_B^u$ *is chosen optimally by shareholders at time 0.*

According to Definition 1, default may be triggered when the subsidiary's payoff falls to the exogenously given threshold point $\overline{\Pi}_B^p$. The second definition regards *unprotected debt*. This condition implies that default timing

[11] If both Ψ_A and Π_B were stochastic, the MNC's overall pre-tax operating profit $(\Psi_A + \Pi_B)$ would not follow the Markov Properties. Thus we would fail to obtain a closed-form solution.

[12] As shown by Desai and Foley (2004), rates of return and investment rates of affiliates are highly correlated with the rates of return and investment of the affiliate's parent and other affiliates within the same group.

[13] For an analysis of debt renegotiation see e.g. Goldstein et al. (2001).

[14] For further details on default conditions see Smith and Warner (1977), and Leland (1994). For a study of corporate taxation under default risk see also Panteghini (2004, 2006).

is optimally chosen by the MNC. When the subsidiary's net cash flow is negative, indeed the parent company can decide to inject equity and exploit future recoveries in the subsidiary's payoff.

In the event of default, the lender faces a sunk cost, which is proportional to the coupon paid (Assumption 5). It is worth noting that the quality of results does not change if we assume that the cost of default is proportional to the firm value, rather than to the debt value.

Finally, Assumption 6 describes the MNC's beliefs on the credibility of future government policy. In particular, it is assumed that the MNC fears that the foreign government may expropriate its subsidiary. Since such an expropriation is a sudden event, we model policy risk as a Poisson process, where λdt is the instantaneous *a priori* probability that expropriation occurs in the short interval dt.

Let us next introduce taxation. For simplicity we assume that the tax system is fully symmetric and follows the source principle.[15] We also assume that the MNC can shift a percentage γ_A of the coupon paid by the foreign subsidiary. However, shifting income by means of intra-firm borrowing and lending is costly. The cost of income shifting is due to two main factors: one is related to advising activities and the other is due anti-avoidance rules. On the one hand, shifting income usually requires the costly advice of tax and financial experts. On the other hand, countries aim to prevent tax-avoiding practices by introducing *ad hoc* rules, such as thin capitalization and Controlled-Foreign-Company (CFC) rules.[16]

The cost function $\nu(\gamma_A)$ we use is convex in γ_A.[17] Defining τ_A and τ_B as the tax rate of country A and B, respectively, we can write the overall profit function of the MNC as

$$Y_A^N(\Pi_B(t)) = (1-\tau_A)\left[\Psi_A - \gamma_A C_B^j\right] + (1-\tau_B)\left[\Pi_B(t) - C_B^j + \gamma_A C_B^j\right] - \nu(\gamma_A)\, C_B^j, \tag{2}$$

where C_B^j is the coupon paid to the lender. The term $j = p, u$ stands for protected and unprotected, respectively. In line with Desai and Foley's (2004) empirical findings, the overall profit function (2) is affected by the transmis-

[15] Notice that the existence of deferral possibilities and limited credit rules leads to the application of the source principle (see e.g. Keen, 1993).

[16] For further details on this point see Fuest and Hemmelgarn (2005).

[17] In line with Panteghini and Schjelderup (2006) we assume that the cost of income shifting is non deductible. See also Haufler and Schjelderup (2000) for a discussion on this point.

sion of country B's shock. Manipulating (2) one obtains

$$Y_A^N\left(\Pi_B\left(t\right)\right)=\left(1-\tau_A\right)\Psi_A+\left(1-\tau_B\right)\Pi_B\left(t\right)-\left(1-\widetilde{\tau}\right)C_B^j,$$

where $\widetilde{\tau}\equiv\tau_B+\phi\left(\gamma_A\right)$ is the effective tax benefit arising from the deduction of the coupon. As can be seen, $\widetilde{\tau}$ accounts for the net benefit of income shifting, i.e. $\phi\left(\gamma_A\right)\equiv\left[\left(\tau_A-\tau_B\right)\gamma_A-\nu\left(\gamma_A\right)\right]$. A trade-off arises from debt financing. On the one hand, interest deductibility ensures a tax benefit. On the other hand, debt may cause default. Such a trade-off will then induce the MNC to choose the subsidiary's optimal leverage ratio. Since the tax benefit $\widetilde{\tau}$ depends on income reporting strategies, i.e. on $\phi\left(\gamma_A\right)$, it will then be straightforward to show that financial choices are affected by tax shifting activities.

With no loss of generality we assume that $\nu\left(\gamma_A\right)$ is a quadratic function, i.e.

$$\nu\left(\gamma_A\right)=\frac{n}{2}\gamma_A^2,$$

where $n\geq 0$ measures how costly it is for the MNC to shift income from one country to the other. If thus n goes to zero, the firm can shift profit at no cost. If, instead, n goes to infinity, income shifting is too costly.

As we pointed out, the cost of income shifting is due to institutional determinants as well as to tax and financial advising activities. In particular, the introduction of thin capitalization and CFC devices, aiming to prevent tax avoiding activities, raises n. Moreover the decrease in the cost of tax sheltering operations, which is linked to the degradation of book and tax profits,[18] leads to a decrease in n. The MNC's income shifting problem is thus as follows

$$\phi\left(\gamma_A^*\right)\equiv\max_{\gamma_A}\left[\left(\tau_A-\tau_B\right)\gamma_A-\nu\left(\gamma_A\right)\right]. \tag{3}$$

Solving (3) we obtain the optimal level of income shifting

$$\gamma_A^*=\frac{\tau_A-\tau_B}{n}. \tag{4}$$

As shown in (4), the optimal percentage of income shifted is reached when the marginal gain in terms of tax savings, here expressed by tax rate differential

[18]In particular, financial engineering has reduced the cost of recharacterizing profits to avoid taxation. On this point see e.g. Desai (2003, 2005).

$(\tau_B - \tau_A)$, is equal to the marginal cost of income shifting.[19] If therefore $\tau_A > \tau_B$ the firm shifts income from country A to country B and vice versa.[20] Substituting (4) into (3) we have

$$\phi\left(\gamma_A^*\right) = \frac{\left(\tau_A - \tau_B\right)^2}{2n}. \tag{5}$$

3 The MNC's capital structure

The framework so far obtained accounts for interesting characteristics of MNCs, such as the use of debt for tax-motivated income reporting strategies, under business, default and policy risk. In this section we show how these features may affect the financing strategies of the representative MNC. For simplicity, hereafter we will omit the time variable t.

In order to find the MNC's optimal capital structure, we must first compute the value function

$$V_A^j\left(\Pi_B\right) = D_A^j\left(\Pi_B\right) + E_A^j\left(\Pi_B\right), \text{ with } j = p, u, \tag{6}$$

where $D_A^j\left(\Pi_B\right)$ and $E_A^j\left(\Pi_B\right)$ are the value of debt and equity, respectively.

Let us first calculate the value of debt, under the assumption that, before default, the lender is tax exempt.[21] When, in the event of default, the lender becomes shareholder, however, it is subject to the source-based tax levied on the subsidiary. According to Assumption 5, moreover, we set the cost of default equal to υC_B, where the parameter $\upsilon > 0$ measures the impact of default on the lender's profitability.

[19] The fact that statutory tax rates are a fairly important factor that influences income shifting decisions is well supported by empirical findings. On this point see e.g. Hines (1999), Desai et al. (2004), and Mills and Newberry (2004).

[20] In our model the optimal percentage of income shifting γ_A^* is not state contingent. This symplifying assumption implies that the choice of γ_A^* affects the MNC's financial decisions but does not depend on such decisions.

[21] It is well-known that effective tax rates on capital income are fairly low. With no loss of generality we thus assume that the lender's pre-default tax burden is nil.

3.1 The debt value

Given the default threshold point $\overline{\Pi}_B^j$, the value of debt is thus equal to (see Appendix A)

$$D_A^j(\Pi_B) = \begin{cases} \frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} & \text{after default,} \\ \\ \frac{C_B^j}{r+\lambda} + \left[\frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} - \frac{C_B^j}{r+\lambda} - \upsilon C_B^j\right]\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2} & \text{before default,} \end{cases} \tag{7}$$

where $\beta_2 = \frac{1}{2} - \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} < 0$. As shown in (7), the value of debt accounts for the risk of expropriation (i.e. parameter λ). In line with Dixit and Pindyck (1994), we account for this risk as follows: we regard the lender's claim as an infinitely-lived one, but we raise the discount rate from r to $(r+\lambda)$.

Before default, $D_A^j(\Pi_B)$ consists of two terms. The first one, $\frac{C_B^j}{r+\lambda}$, is a perpetual rent computed with the augmented discount rate $(r+\lambda)$. The second term accounts for any future expected change in profitability caused by default. In particular, the term $\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}$ measures the present value of 1 Euro contingent on the event default. After default, the lender becomes shareholders and the value of her claim is $\frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda}$, with $j = p, u$.

3.2 The equity value

Let us next compute the value of equity. According to Assumption 4, when default occurs the parent company loses its subsidiary and receives a net operating profit equal to $(1-\tau_A)\Psi_A$. Thus the value of equity is simply equal to the perpetual rent $\frac{(1-\tau_A)\Psi_A}{r}$.[22] Before default, the MNC must account for the risk of expropriation of its subsidiary. As shown in Appendix B, therefore, we have

[22] Notice that, given the discount rate r, the MNC assumes that the risk of expropriation in its home country is null.

$$E_A^j\left(\Pi_B\right)=\begin{cases}\frac{(1-\tau_A)\Psi_A}{r} & \text{after default,}\\ \\ \frac{(1-\tau_A)\Psi_A}{r}+\frac{(1-\tau_B)\Pi_B-(1-\widetilde{\tau})C_B^j}{r+\lambda}+f^j\left(\overline{\Pi}_B^j\right) & \text{before default,}\end{cases}\tag{8}$$

where $f^p\left(\overline{\Pi}_B^p\right)=0$ and $f^u\left(\overline{\Pi}_B^u\right)=\left(\frac{1}{1-\beta_2}\right)\left[\frac{(1-\widetilde{\tau})C_B^u}{r+\lambda}\right]\left(\frac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2}$.

The term $\frac{(1-\tau_B)\Pi_B-(1-\widetilde{\tau})C_B^j}{r+\lambda}$ measures the net benefit arising from the ownership of the subsidiary. As can be seen, this term is equal to the present value of the net cash flow with discount rate $(r+\lambda)$. The term $f^u\left(\overline{\Pi}_B^u\right)$ measures the value of financial flexibility under unprotected debt financing. As we pointed out, the MNC has opportunity to inject equity (or, equivalently, convert intra-debt into equity) in order to delay default and exploit future tax avoidance benefits, as well as any recovery in the subsidiary's profitability.

We can now compute the default threshold points under protected and unprotected debt financing. According to Definition 1, protected debt financing means that the default threshold point $\overline{\Pi}_B^p$ is exogenously given. We assume that $\overline{\Pi}_B^p$ is such that the MNC's overall profit is nil, i.e.[23]

$$Y_A^N\left(\overline{\Pi}_B^p\right)=(1-\tau_A)\Psi_A+(1-\tau_B)\overline{\Pi}_B^p-(1-\widetilde{\tau})C_B^j=(1-\tau_A)\Psi_A,$$

thereby obtaining

$$\overline{\Pi}_B^p\equiv\frac{(1-\widetilde{\tau})}{(1-\tau_B)}C_B^p.\tag{9}$$

Let us next compute the threshold value under unprotected debt financing. Following Leland (1994), $\overline{\Pi}_B^u$ is obtained by maximizing the value of equity, i.e.

$$\max_{\overline{\Pi}_B^u}E_A^u\left(\Pi_B\right).\tag{10}$$

Substituting (8) into (10) we can compute the MNC's default trigger point (see Appendix B)

$$\overline{\Pi}_B^u=\frac{\beta_2}{\beta_2-1}\frac{(1-\widetilde{\tau})}{(1-\tau_B)}C_B^u.\tag{11}$$

As can be seen, the threshold points $\overline{\Pi}_B^p$ and $\overline{\Pi}_B^u$ are proportional to the coupon paid, and are instead independent of the current EBIT.

[23]The quality of results does not change if we assume a different threshold value.

Comparing (9) with (11) it is straightforward to show that, *coeteris paribus*, the inequality $\overline{\Pi}_B^u < \overline{\Pi}_B^p$ holds. Under unprotected debt financing, the MNC can inject equity in order to meet the subsidiary's debt obligations. This means that, relative to the protected case, the MNC postpones default.

Moreover, it is easy to show that $E_A^u(\Pi_B) > E_A^p(\Pi_B)$. Such a difference is due to the fact that under unprotected debt financing, the MNC is endowed with a put option (i.e. the option to default). This makes the claim more valuable.[24]

Let us analyze the effects on tax avoidance on the default threshold points. It is straightforward to show that whenever tax avoidance is allowed we have $\widetilde{\tau} > \tau_B$, and the inequality $\frac{1-\widetilde{\tau}}{1-\tau_B} < 1$ thus holds. Given (9) and (11), therefore, we can write the following:

Lemma 1 *Tax avoidance leads to a postponement of delay.*

3.3 The optimal coupon

Substituting (7) and (8) into (6) we obtain the overall value of the MNC

$$V_A^j(\Pi_B) = \frac{(1-\tau_A)\Psi_A}{r} + \frac{(1-\tau_B)\Pi_B + \widetilde{\tau} C_B^j}{r+\lambda} - \left(\frac{\widetilde{\tau}}{r+\lambda} + \upsilon\right) C_B^j \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}. \tag{12}$$

Using (12) we can now find the optimal coupon. As shown by Leland (1994), the optimal coupon is the solution of the following problem:[25]

$$\max_{C_B^j} V_A^j(\Pi_B). \tag{13}$$

Solving (13) we obtain the optimal coupon (Appendix C)

[24] Given the inequality $E_A^u(\Pi_B) > E_A^p(\Pi_B)$ we might wonder why firms use protected debt as well. In fact unprotected debt would be preferable for shareholders. As pointed out by Leland (1994), protected debt may be preferred if agency costs are assumed. In particular protected debt may induce shareholders not to increase firm risk at the expense of the lender. However this point is beyond the scope of our article.

[25] The maximization of the MNC's overall value (including debt) implicitly rules out any agency conflict between shareholders and the lender. As pointed out in the previous footnote, strategic interactions, à la Myers (1977), are not deal with in this article.

$$\frac{C_B^j}{\Pi_B} = \left(m^j\right)^{-1} \frac{1-\tau_B}{1-\widetilde{\tau}} \left[\frac{1}{1-\beta_2} \frac{\widetilde{\tau}}{\widetilde{\tau} + (r+\lambda)\,\upsilon}\right]^{-\frac{1}{\beta_2}}, \tag{14}$$

with $m^p = 1$ and $m^u = \frac{\beta_2}{\beta_2 - 1}$.

It is straightforward to show that $\left(\frac{C_B^u}{\Pi_B}\right) > \left(\frac{C_B^p}{\Pi_B}\right)$. Under unprotected debt financing the MNC can decide when to default. Its higher flexibility thus allows the MNC to raise leverage.

As shown in (14), C_B^j is proportional to the current EBIT, Π_B, and is also affected by taxation. It is easy to ascertain that $\frac{\partial C_B^j}{\partial \widetilde{\tau}} > 0$. This means that the greater is the benefit arising from borrowing, i.e. $\widetilde{\tau}$, the higher the optimal coupon is. Not surprisingly an increase in $\widetilde{\tau}$ stimulates borrowing. On the other hand, we have $\frac{\partial C_B^j}{\partial \upsilon} < 0$. This means that an increase in the sunk cost of default (i.e. in υ) reduces the propensity to borrow.[26]

Let us next analyze the impact of income shifting on the capital structure. We can prove the following:

Lemma 2 *If $\tau_A \neq \tau_B$ a decrease in n raises the optimal coupon C_B.*

Proof- See Appendix D.

The intuition behind Lemma 2 is straightforward: a reduction in the cost of income shifting encourages tax avoidance, and thus raises the tax benefit of debt financing. Such an increase stimulates the issue of debt and thus induces the MNC to pay a higher coupon.

Let us next analyze the effects of risk on the MNC's debt strategy. Given the above results we can write the following

Lemma 3 *If υ is low enough, then* $\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \sigma^2} > 0$ *and* $\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \lambda} < 0$.

Proof- See Appendix E.

The intuition behind these results is straightforward. If the cost of default is low enough, an increase in σ reduces the ratio $\left(\frac{C_B^j}{\Pi_B}\right)$. In line with Leland (1994), indeed, an increase in volatility makes the costly event of default

[26] A detailed comparative statics analysis is provided by Leland (1994) and Goldstein et al. (2001).

more likely and thus discourages debt financing.[27] Moreover, an increase in λ rises $\left(\frac{C_B^j}{\Pi_B}\right)$. This is due to the fact that a rise in λ increases the discount rate $(r+\lambda)$. Thus the present value of 1 Euro contingent on the event of default is reduced. The decrease in the expected cost of default induces the MNC to borrow more resources (or, equivalently, to pay a higher coupon). As regards unprotected debt, the quality of results does not change.[28] We have thus provided a rationale for the positive effect of policy risk on debt financing, which has been found (but not explained) by Desai et al. (2004).

To have a better idea of the above effects we run a numerical simulation of $\left(\frac{C_B^j}{\Pi_B}\right)$ for different values of σ^2 and λ. As regards the tax rates, we follow Mills and Newberry (2004), and set the home corporate tax rate (τ_A) equal to the U.S. one, i.e. 0.35, and the foreign one (τ_B) equal to the average statutory rate levied on foreign income, which is about 0.32. We thus obtain $\tau_A - \tau_B = 0.03$. Moreover, we follow Goldstein et al. (2001), and set $\upsilon = 0.05$. It is worth noting that such a value is lower than those usually assumed in the relevant literature.[29] Setting $r = 0.045$ and focusing on protected debt we thus obtain the results depicted in Fig. 1.

Despite the use of a fairly low value of υ, results are in line with Lemma 3: both an increase in σ and a decrease in λ raise the ratio $\left(\frac{C_B^j}{\Pi_B}\right)$. The quality of results does not change if we assume unprotected debt.

4 The competitive equilibrium

In this section we model tax competition between two small open countries, called A and B. We assume that, in each country, there exists a MNC which owns a foreign subsidiary and chooses its optimal capital structure. We thus use the MNC studied in the previous section, defined as MNC A, and then add a second MNC, named MNC B, with headquarter in country B, and a

[27] As we pointed out in the introduction this result is in line with the empirical findings of Fan et al. (2003).

[28] In order for the derivative $\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \beta_2}$ to be positive, we need a lower value of υ.

[29] For instance Branch (2002) estimates a total default-related cost ranging between 12.7% and 20.5%. However, Goldstein et al. (2001) criticize the existing literature in that it usually assumes too high costs.

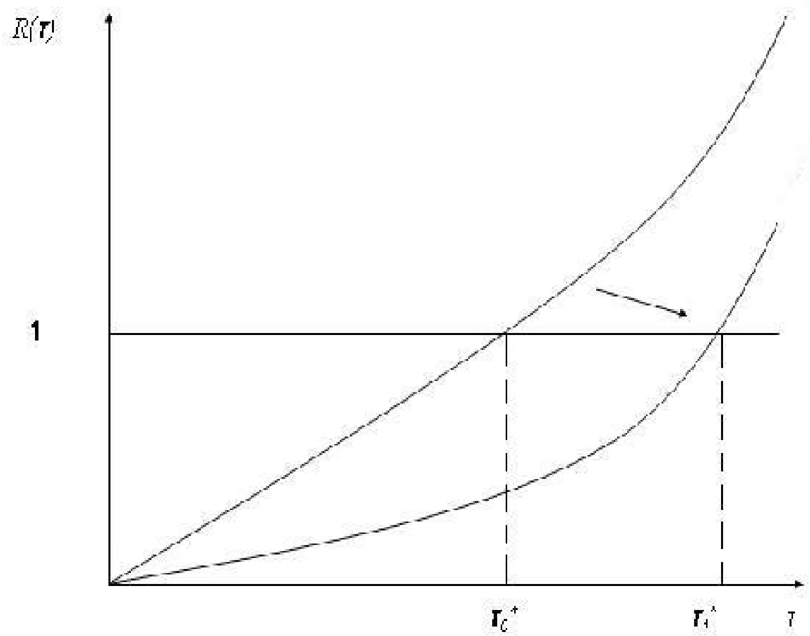

Figure 1: The effect of σ and λ on the ratio $\left(\frac{C_B^p}{\Pi_B}\right)$.

subsidiary operating in A. These MNCs face the same income shifting cost, i.e. $\nu(\gamma_k)$ with $k = A, B$.

Using the notation of Section 3, we define Ψ_B as the firm's operating profit earned in country B (i.e. in MNC B's home country), and C_A^j as the coupon paid to the lender. Moreover, Π_A is the stochastic EBIT faced by the subsidiary, which is driven by the geometric Brownian motion $\frac{d\Pi_A}{\Pi_A} = \sigma dz_A$, with $\Pi_A \geq 0$. The overall profit earned by MNC B is therefore

$$Y_B^N(t) = (1-\tau_A)\left[\Psi_B - \gamma_B C_A^j\right] + (1-\tau_B)\left[\Pi_A(t) - C_A^j + \gamma_B C_A^j\right] - \nu(\gamma_B) C_A^j, \tag{15}$$

Given the above assumptions, we have two country-specific shocks: namely the shock faced by MNC A when investing in country B and the one faced by MNC B when investing in country A.[30]

Let us next compute the governments' objective functions, under the assumption that 100% of the MNC resident in the home country is held by domestic households.[31] Moreover we assume that, despite MNCs' beliefs regarding policy risk, governments do not aim to expropriate foreign subsidiaries. Therefore the governments' objective functions do not embody the value of the foreign subsidiary, and are thus equal to the value of the resident MNC plus the present value of net tax revenues. The government A's objective function consists of five terms:

1. the value of equity of its resident MNC, i.e.[32]

$$E_A^j(\Pi_B) = \frac{(1-\tau_A)\Psi_A}{r} + \frac{(1-\tau_B)\Pi_B - (1-\widetilde{\tau})C_B^j}{r+\lambda} + f^j\left(\overline{\Pi}_B^j\right); \tag{16}$$

2. the present value of tax revenues gathered from the resident MNC, which is equal to the perpetual rent $\frac{\tau_A \Psi_A}{r}$;

3. the present value of taxes paid by the foreign subsidiary: since taxes are paid irrespective of the firm's ownership, they are not contingent

[30] The quality of results does not change if we assume that these two shocks are correlated.

[31] Such a home-bias is well documented in the literature. However some recent articles have shown that it has declined over the last decade (see e.g. Sørensen et al., 2005).

[32] By symmetry, the equity value of MNC B is $E_B^j(\Pi_A) = \frac{(1-\tau_B)\Psi_B}{r} + \frac{(1-\tau_A)\Pi_B - (1-\tau')C_A^j}{r} + f^j\left(\overline{\Pi}_A^j\right)$ with $\tau' \equiv \tau_A + \phi(\gamma_B)$.

on the event of default and are thus equal to a perpetual flow; given the initial income produced by the foreign subsidiary Π_A, the present value of tax revenues is $\frac{\tau_A \Pi_A}{r}$;

4. the net loss of revenues caused by income shifting from the parent company, placed in A, and its subsidiary operating in B $\left(-\tau_A \gamma_A^* C_B^j\right)$: as shown in Appendix F, its present value is

$$NB_B^j(\Pi_B) = -\tau_A \gamma_A \frac{C_B^j}{r} \left[1 - \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right]; \tag{17}$$

5. the net loss of revenues due to income shifting from the parent company placed in B and its subsidiary operating in A, $\left(\tau_A \gamma_B^* C_A^j\right)$; the present value of this net flow is (see Appendix F)

$$NB_A^j(\Pi_A) = \tau_A \gamma_B \frac{C_A^j}{r} \left[1 - \left(\frac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right]. \tag{18}$$

   As can be seen, both (17) and (18) are conditional on the event of default. This is due to the fact that, whenever default takes place, debt turns into equity. Since the lender becomes shareholder, any tax benefit due to debt financing vanishes.

Adding the above terms, we obtain the government A's objective function[33]

$$\begin{gathered} W_A^j = \tfrac{\Psi_A}{r} + \tfrac{(1-\tau_B)\Pi_B - (1-\widetilde{\tau}) C_B^j}{r+\lambda} + f^j\left(\overline{\Pi}_B^j\right) + \\ -\tau_A \gamma_A^* \tfrac{C_B^j}{r} \left[1 - \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \tau_A \gamma_B^* \tfrac{C_A^j}{r} \left[1 - \left(\tfrac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] + \tau_A \tfrac{\Pi_A}{r} \text{ with } j = p, u. \end{gathered} \tag{19}$$

Following the same procedure we also obtain the government B's objective function.[34]

[33] Notice that the governments do not account for the costs of profit shifting.

[34] Using the same notation we obtain government B's welfare function:

$$\begin{gathered} W_B^j = \tfrac{\Psi_B}{r} + + \tfrac{(1-\tau_A)\Pi_A - \left(1-\tau'\right) C_A^j}{r} + f^j\left(\overline{\Pi}_A^j\right) + \\ -\tau_B \gamma_B^* \tfrac{C_A^j}{r} \left[1 - \left(\tfrac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] + \tau_B \gamma_A^* \tfrac{C_B^j}{r} \left[1 - \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \tau_B \tfrac{\Pi_B}{r}. \end{gathered}$$

Each government maximizes the welfare function,

$$\max_{\tau_k} W_k^j \qquad k = A, B. \tag{20}$$

The maximization of (20) is part of a sequential game, where at stage 1 the governments set the tax rates, and at stage 2 the two MNCs will decide both their debt-equity ratio and the percentage of income shifting. Solving (20) we can prove the following:

Proposition 1 *If n is low enough, a unique symmetric Nash equilibrium tax rate $\tau^* \in (0, 1]$ exists. The equilibrium tax rate under protected debt financing is higher than that obtained under unprotected debt financing.*

Proof See Appendix G.

The intuition behind Proposition 1 is straightforward. The equilibrium tax rate is $\tau^* \in (0, 1]$ on condition that n is low enough, i.e. income shifting is profitable enough.

The effect of default conditions on the equilibrium tax rates can be explained as follows. As we pointed out in Section 3, we have $C_B^u > C_B^p$. Since under unprotected debt financing the firm's leverage is higher, for any given percentage of income shifted γ_k^*, tax avoidance ensures a greater benefit. Relative to the protected-debt case, therefore, the governments are thus obliged to decrease tax rates in order to reduce such a tax benefit. As a consequence, the equilibrium tax rate under unprotected debt financing is lower.

Proposition 1 is obtained by assuming that the objective function does not account for all the firm's value but only for equity value. However, it is easy to prove the following:

Corollary 1 *The equilibrium tax rate is unchanged if the objective function also accounts for the value of debt.*

Proof See Appendix H.

Corollary 1 shows that the result of Proposition 1 is unaffected by the change in the governments' objective functions. The intuition behind Corollary 1 is straightforward: as the credit market is perfectly competitive, all profits accrue to shareholders. Therefore adding the value of debt to the objective function does not increase the relevant tax base. The equilibrium tax rate is thus unchanged.

Let us next provide some comparative statics regarding τ^*. We first analyze the impact of the default and the income shifting costs. We can prove the following:

Proposition 2 *An increase in either the cost of default (i.e. in υ) or the cost of shifting income (i.e. n) causes an increase in τ^*.*

Proof See Appendix I.

As shown in Proposition 2 both the distress and the income shifting cost have a positive impact on the equilibrium tax rates. An increase in υ raises the expected cost of default and thus discourages the use of debt. *Coeteris paribus*, a rise in υ reduces the optimal coupon and, given γ_k^*, the amount of income shifted from one country to the other. By discouraging income shifting, the increase in υ allows the competing governments to reach a higher equilibrium tax rate. This result has an interesting implication: both default procedures and debtors' protection rights (à la La Porta et al., 1997) can affect governments' fiscal strategies.

A similar reasoning holds for n. An increase in n makes income shifting more costly: this allows the governments to set a higher τ^*. This result has an interesting policy implication: as long as governments can affect the value of n, e.g. by means of more stringent anti-avoidance rules (such as thin capitalization and CFC rules), they can set a higher tax rate. This helps to explain the widespread introduction of these devices throughout the world. On the other hand, both the diffusion of sophisticated financial engineering activities and the decrease in tax consulting expenses may cause a reduction in n, and therefore lead to a decrease in τ^*.

Let us next analyze the impact of σ and λ on the equilibrium tax rate. Like in Fig. 1 we focus on the protected-debt case. Using the same parameter values of the case depicted in Fig. 1 (i.e. $\upsilon = 0.05$, $r = 0.045$, $n = 0.5$) we show that an increase in λ leads to a decrease in the equilibrium tax rate. The intuition behind this result is as follows: an increase in λ stimulates borrowing, and thus raises the ratio $\left(\frac{C_k^p}{\Pi_k}\right)$, with $k = A, B$. Given the optimal percentage γ_k^*, therefore, a greater amount of income can be shifted. In order to offset the increase in income shifting opportunities, governments are thus induced to set lower tax rates.

This result has an interesting policy implication: an increase in credibility, i.e. a lower value of λ, allows governments to set higher tax rates. In this

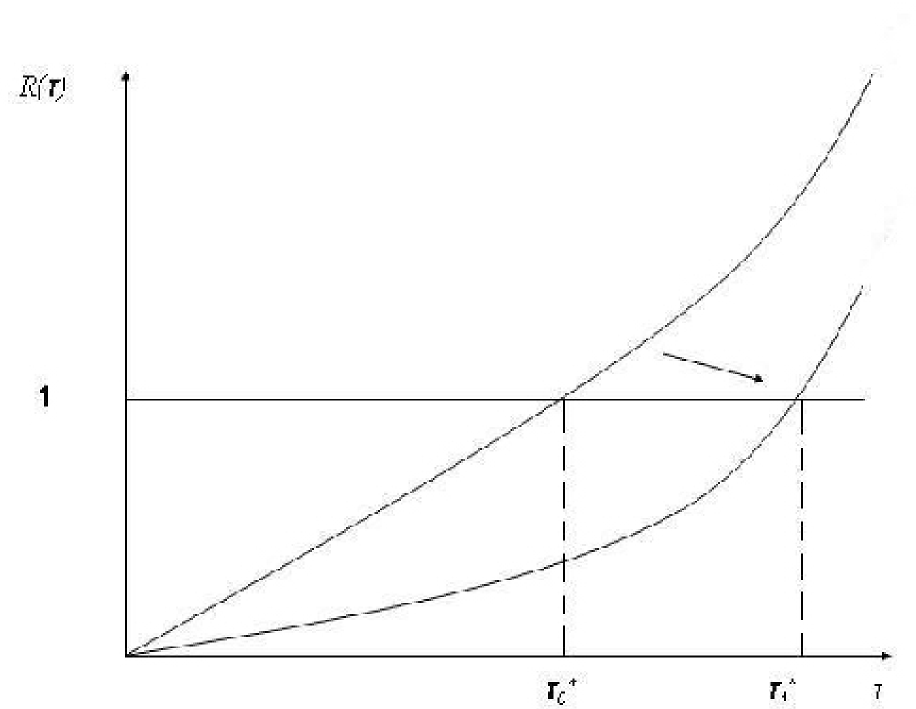

Figure 2: The effect of λ on the equilibrium tax rate τ^*.

model we have used an one-shot game and assumed the absence of any debt renegotiation. If we enriched the framework by assuming a repeated game between governments and by allowing MNCs to renegotiate debt, we then would expect a positive relationship between reputation and the level of tax rates.[35]

As shown in the previous Section, an increase in σ discourages borrowing, and thus reduces the ratio $\left(\frac{C_k^j}{\Pi_k}\right)$. *Coeteris paribus*, therefore, income shifting is discouraged, and the governments can set higher tax rates (see Fig. 3). The quality of results does not change if we focus on unprotected debt financing.

Let us finally compare the last result with Panteghini and Schjelderup (2006), who show that an increase in volatility discourages FDIs and thus reduces the overall number of multinational firms. In their case, the policy response is therefore to lower the tax rate in order to alleviate the negative impact of increased volatility. In this model, however, we analyze MNCs' strategies when FDI has *already* been undertaken and income can be shifted by means of debt financing. This explains the different results obtained.

5 Concluding remarks and policy implications

In this article we have studied the interactions between financial policies and income shifting activities of MNCs in a stochastic environment. In the first part we have shown that income shifting both 1) raises the tax benefit of debt financing, thereby stimulating debt financing, and 2) delays default.

In the second part of the article we have analyzed the impact of MNCs' strategies on the behavior of two competing governments. In line with Wilson and Wildasin's (2004), we have studied how the structure of financial markets and institutions may matter in terms of fiscal policies. We have therefore shown that the characteristics of debt financing can affect the governments' strategies. In particular the equilibrium tax rate is lower under unprotected debt financing than under protected debt financing.

Moreover, we have found that an increase in either the cost of default or the cost of income shifting raises the equilibrium tax rate. These results have some interesting policy implications. First of all, the cost of default may affect governments' tax strategies. In particular, both default procedures and

[35] This point has some similarities with Cherian and Perotti (2001), who show that a gradual increase in reputation allows governments to attract a greater amount of FDIs.

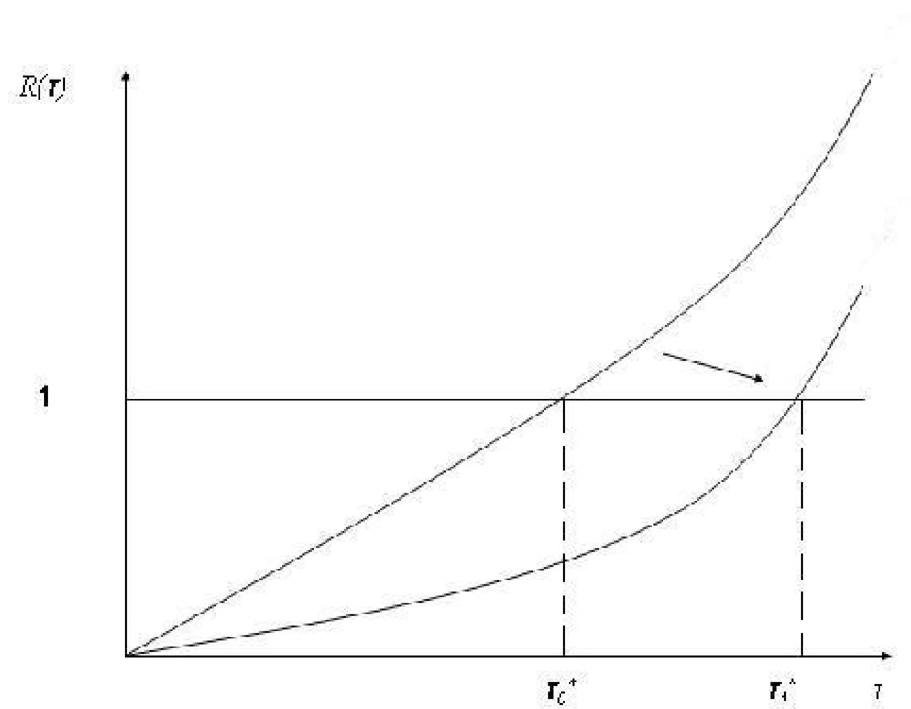

Figure 3: The effect of σ on the equilibrium tax rate τ^*.

debtors' protection rights are expected to affect governments' fiscal strategies. Also, more stringent anti-avoidance devices, such as thin capitalization and CFC rules, allow governments to set higher tax rates.

Finally, we have shown that risk has an ambiguous impact on governments' strategies. On the one hand, policy risk (related to MNCs' beliefs that governments may expropriate foreign activities) reduces the equilibrium tax rate. On the other hand, an increase in both business and default risk leads to higher tax rates.

There are at least two topics that still need to be looked at. First of all, here we have assumed that tax rates are the only policy tool in the hand of the two competing governments. A natural extension of the model would then be the introduction of a second policy tool regarding the tax base. Secondly, this article proposes some testable hypotheses regarding the interactions between MNCs' activities and governments' policies. These findings are left for future empirical investigation.

A Derivation of (7)

Using dynamic programming, debt can be written as

$$D_A^j(\Pi_B) = \begin{cases} (1-\tau_B)\,\Pi_B dt + (1-\lambda dt)\,e^{-rdt}\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] & \text{after default,} \\ \\ C_B^j dt + (1-\lambda dt)\,e^{-rdt}\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] & \text{before default,} \end{cases} \tag{21}$$

where $\xi[.]$ is the expectation operator. Function (21) can be rewritten as

$$D_A^j(\Pi_B) = \begin{cases} (1-\tau_B)\,\Pi_B dt + (1-\lambda dt)\,(1-rdt)\,\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] & \text{after default,} \\ \\ C_B^j dt + (1-\lambda dt)\,(1-rdt)\,\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] & \text{before default.} \end{cases} \tag{22}$$

Applying Itô's Lemma to (22), one obtains

$$(r+\lambda)\,rD_A^j(\Pi_B) = L + \frac{\sigma^2}{2}\Pi_B^2 D^j_{A_{\Pi_B\Pi_B}}(\Pi_B), \tag{23}$$

where $L = (1-\tau_B)\,\Pi_B, C_B^j$, and $D^j_{A_{\Pi_B\Pi_B}}(\Pi_B) = \frac{\partial^2 D_A^j(\Pi_B)}{\partial \Pi_B^2}$. The general closed-form solution of function (23) is

$$D_A^j(\Pi_B) = \begin{cases} \frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} + \sum_{i=1}^2 B_i^j \Pi_B^{\beta_i} & \text{after default,} \\ \\ \frac{C_B^j}{r+\lambda} + \sum_{i=1}^2 D_i^j \Pi_B^{\beta_i} & \text{before default,} \end{cases} \tag{24}$$

where β_1 and β_2 are, respectively, the positive and negative roots of the characteristic equation $\frac{\sigma^2}{2}\beta(\beta-1) - (r+\lambda) = 0$.[36]

To compute B_i^j and D_i^j for $i = 1, 2$, we introduce three boundary conditions. First of all we assume that whenever Π_B goes to zero the lender's claim is nil, namely condition $D_A^j(0) = 0$ holds. This implies that $B_2^j = 0$. Secondly, we assume that financial bubbles do not exist. This means that $B_1^j = D_1^j = 0$.[37] Thirdly, we must consider that at point $\Pi_B = \overline{\Pi}_B^j$, the

[36] These roots are $\beta_1 = \frac{1}{2} + \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} > 1$, and $\beta_2 = \frac{1}{2} - \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} < 0$.

[37] For further details on these boundary conditions see e.g. Dixit and Pindyck (1994).

pre-default value of debt must be equal to the post-default one, net of the default cost. Using the two branches of (24) we thus obtain

$$\frac{(1-\tau_B)\,\overline{\Pi}_B^j}{r+\lambda}-\upsilon C_B^j=\frac{C_B^j}{r+\lambda}+D_2^j\overline{\Pi}_B^{j^{\beta_2}}.$$

Solving for D_2^j yields

$$D_2^j=\left[\frac{(1-\tau_B)\,\overline{\Pi}_B^j-C_B^j}{r+\lambda}-\upsilon C_B^j\right]\overline{\Pi}_B^{j^{-\beta_2}}.$$

Given the above results it is straightforward to obtain (7).

B Derivation of (8) and (11)

To derive the value of equity we must remember that default causes an expropriation of the subsidiary. This means that whenever we have $\Pi_B=\overline{\Pi}_B^j$, the value of equity reduces to

$$E_A^j\left(\overline{\Pi}_B^j\right)=\frac{(1-\tau_A)\,\Psi_A}{r}, \tag{25}$$

that is the fair value of the parent company when operating as a domestic firm.

Applying dynamic programming we next write the added value due to the ownership of a foreign subsidiary. Given the additional after-tax cash flow due to holding the subsidiary, i.e. $\left[Y_A^N(\Pi_B)-(1-\tau_A)\,\Psi_A\right]$, the added value is equal to

$$S_A^j(\Pi_B)=\begin{cases}0 & \text{after default,}\\ \left[Y_A^N(\Pi_B)-(1-\tau_A)\,\Psi_A\right]dt+(1-\lambda dt)\,e^{-rdt}\xi\left[E(\Pi_B+d\Pi_B)\right] & \text{before default.}\end{cases} \tag{26}$$

As can be seen (26) embodies the net benefit arising from income shifting, and accounts for the risk of expropriation (i.e. the MNC's fear that the government expropriates its subsidiary). Using Itô's Lemma, eliminating all the terms multiplied by $(dt)^2$ and dividing by dt, we can rewrite (26) as

$$(r+\lambda)\,S_A^j(\Pi_B)=\left[(1-\tau_B)\,\Pi_B-(1-\widetilde{\tau})\,C_B^j\right]+\frac{\sigma^2}{2}\Pi_B^2S^j_{A_{\Pi_B\Pi_B}}(\Pi_B), \tag{27}$$

where $S^j_{A_{\Pi_B \Pi_B}}(\Pi_B) = \frac{\partial^2 S^j_A(\Pi_B)}{\partial \Pi_B^2}$. Solving (27) we have

$$S^j_A(\Pi_B) = \begin{cases} 0 & \text{after default,} \\ \frac{(1-\tau_B)\Pi_B-(1-\widetilde{\tau})C^j_B}{r+\lambda} + \sum_{i=1}^2 A^j_i \Pi_B^{\beta_i} & \text{before default.} \end{cases} \tag{28}$$

Let us next compute A^j_i with $i = 1, 2$. In the absence of financial bubbles, we have $A^j_1 = 0$ for $j = p, u$. Moreover to compute A^j_2 we let the two branches of (28) meet at point $\Pi_B = \overline{\Pi}^j_B$ thereby obtaining

$$S^j_A\left(\overline{\Pi}^j_B\right) = \frac{(1-\tau_B)\,\overline{\Pi}^j_B - (1-\widetilde{\tau})\,C^j_B}{r+\lambda} + A^j_2 \overline{\Pi}^{j\,\beta_2}_B = 0.$$

Solving for A^j_2 thus yields

$$A^j_2 = -\frac{(1-\tau_B)\,\overline{\Pi}^j_B - (1-\widetilde{\tau})\,C^j_B}{r} \cdot \overline{\Pi}^{j\,-\beta_2}_B$$

The pre-default value of equity is thus equal to

$$\begin{gathered} E^j_A(\Pi_B) = \frac{(1-\tau_A)\Psi_A}{r} + S^j_A(\Pi_B) = \\ = \frac{(1-\tau_A)\Psi_A}{r} + \frac{(1-\tau_B)\Pi_B-(1-\widetilde{\tau})C^j_B}{r+\lambda} - \left[\frac{(1-\tau_B)\overline{\Pi}^j_B-(1-\widetilde{\tau})C^j_B}{r+\lambda}\right]\left(\frac{\Pi}{\overline{\Pi}^j_B}\right)^{\beta_2}, \end{gathered} \tag{29}$$

with $j = p, u$.

B.1 Equity value under protected debt

Recall that under full debt protection, we have $\overline{\Pi}^p_B = \frac{1-\widetilde{\tau}}{1-\tau_B} C^j_B$. In this case we have therefore $A^p_2 = 0$, and the value of equity reduces to

$$E^p_A(\Pi_B) = \frac{(1-\tau_A)\,\Psi_A}{r} + \frac{(1-\tau_B)\,\Pi_B - (1-\widetilde{\tau})\,C^j_B}{r+\lambda}. \tag{30}$$

B.2 Equity value under unprotected debt

Under unprotected debt, instead, the MNC must solve (10). Using (29) one obtains the following f.o.c.

$$\frac{\partial E_A^u(\Pi_B)}{\partial \overline{\Pi}_B^u} = -\frac{(1-\tau_B)}{r+\lambda}\left(\frac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2} + \beta_2\left(\frac{(1-\tau_B)\overline{\Pi}_B^u - (1-\widetilde{\tau})C_B^u}{r+\lambda}\right)\left(\frac{\Pi}{\overline{\Pi}_B^u}\right)^{\beta_2}\overline{\Pi}_B^{u^{-1}} = 0.$$

Solving for $\overline{\Pi}_B^u$ thus yields (11), i.e. $\overline{\Pi}_B^u = \frac{\beta_2}{\beta_2-1}\frac{(1-\widetilde{\tau})}{(1-\tau_B)}C_B^u$. Substituting (11) into (29) yields

$$E_A^u(\Pi_B) = \frac{(1-\tau_A)\Psi_A}{r} + \frac{(1-\tau_B)\Pi_B - (1-\widetilde{\tau})C_B^u}{r+\lambda} + \left(\frac{1}{1-\beta_2}\right)\left[\frac{(1-\widetilde{\tau})C_B^u}{r+\lambda}\right]\left(\frac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2}. \tag{31}$$

Finally, using (30) and (31) one easily obtains (8).

C The optimal coupon

Let us solve problem (13). Using (12) and differentiating with respect to C_B^j, one easily obtains the f.o.c.

$$\frac{\partial V_A^j(\Pi_B)}{\partial C_B^j} = \frac{\widetilde{\tau}}{r+\lambda} - \left(\frac{\widetilde{\tau}}{r+\lambda}+\upsilon\right)\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2} + \beta_2\left(\frac{\widetilde{\tau}}{r+\lambda}+\upsilon\right)\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\frac{C_B^j}{\overline{\Pi}_B^j}\frac{\partial\overline{\Pi}_B^j}{\partial C_B^j} = 0, \tag{32}$$

with $\frac{C_B^j}{\overline{\Pi}_B^j}\frac{\partial\overline{\Pi}_B^j}{\partial C_B^j} = 1$. Manipulating (32) yields

$$\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2} = \frac{1}{1-\beta_2}\frac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\upsilon} \tag{33}$$

Substituting (9) and (11) into (33) yields (14).

D Proof of Lemma 2

To prove Lemma 1, let us apply a log-transform to (14)

$$\begin{aligned}\log\left(\frac{C_B^j}{\Pi_B}\right) &= -\log m^j + \log(1-\tau_B) - \log(1-\widetilde{\tau}) \\ &\quad -\frac{1}{\beta_2}\log\frac{1}{1-\beta_2} - \frac{1}{\beta_2}\log\left[\frac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\upsilon}\right].\end{aligned} \tag{34}$$

Differentiating (34) with respect to $\widetilde{\tau}$ yields

$$\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \widetilde{\tau}} = \frac{1}{1-\widetilde{\tau}} - \frac{1}{\beta_2}\frac{(r+\lambda)\,\upsilon}{\left[\widetilde{\tau}+(r+\lambda)\,\upsilon\right]\widetilde{\tau}} > 0.$$

Given $\frac{\partial \widetilde{\tau}}{\partial \phi(\gamma_A^*)} = 1$ and $\frac{\partial \phi(\gamma_A^*)}{\partial n} = -\frac{(\tau_A-\tau_B)^2}{2n^2} < 0$ for $\tau_A \neq \tau_B$, we thus have $\underbrace{\frac{\partial \log\left(\frac{C_B^u}{\Pi_B}\right)}{\partial \widetilde{\tau}} \frac{\partial \widetilde{\tau}}{\partial \phi\left(\gamma_A^*\right)}}_{>0} \cdot \frac{\partial \phi(\gamma_A^*)}{\partial n} < 0$. The Lemma is thus proven.■

E Proof of Lemma 3

Taking the log of (14) and differentiating with respect to σ^2 and λ we obtain

$$\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \sigma^2} = \frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \beta_2} \cdot \frac{\partial \beta_2}{\partial \sigma^2},$$

and

$$\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \lambda} = \frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \beta_2} \cdot \frac{\partial \beta_2}{\partial \lambda} + \frac{1}{\beta_2}\frac{\upsilon}{\widetilde{\tau}+(r+\lambda)\,\upsilon},$$

where

$$\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \beta_2} = \underbrace{\left(-\frac{1}{m^j}\frac{\partial m^j}{\partial \beta_2}\right)}_{\geq 0} + \underbrace{\left\{-\frac{1}{\beta_2}\left[\log\left(1-\beta_2\right) + \frac{1}{(1-\beta_2)}\right]\right\}}_{>0} + \underbrace{\frac{1}{\beta_2^2}\log\left[\frac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\,\upsilon}\right]}_{<0}, \tag{35}$$

with $\frac{\partial \beta_2}{\partial \sigma^2} > 0$, $\frac{\partial \beta_2}{\partial \lambda} < 0$, and $\frac{\partial m^u}{\partial \beta_2} < \frac{\partial m^p}{\partial \beta_2} = 0$. Given (35) we have $\frac{\partial \log\left(\frac{C_B}{\Pi_B}\right)}{\partial \beta_2} > 0$ if υ is high enough. This is sufficient to obtain $\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \sigma^2} > 0$ and $\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \lambda} < 0$.

As regards unprotected debt it is worth noting that the term $\left(-\frac{1}{m^u}\frac{\partial m^u}{\partial \beta_2}\right)$ is positive. Therefore we need a lower value of υ for the derivative $\frac{\partial \log\left(\frac{C_B^u}{\Pi_B}\right)}{\partial \beta_2}$ to be positive. This proves the Lemma.■

F Derivation of (17) and (18)

Let us compute the present value of the net loss of revenues due to income shifting from the parent company placed in A and its subsidiary operating in B. Given the current flow $\left(-\tau_A \gamma_A^* C_B^j\right)$, we can write its present value as[38]

$$NB_B^j\left(\Pi_B\right) = \begin{cases} 0 & \text{after default} \\ \\ -\left(\tau_A \gamma_A^* C_B^j\right) dt + e^{-rdt} \xi \left[NB_B^j(\Pi_B + d\Pi_B)\right] & \text{before default.} \end{cases} \tag{36}$$

Applying Itô's Lemma to (36), one obtains

$$rNB_B^j(\Pi_B) = -\tau_A \gamma_A^* C_B^j + \frac{\sigma^2}{2} \Pi_B^2 NB_{B_{\Pi_B \Pi_B}}^j(\Pi_B), \tag{37}$$

with $NB_{B_{\Pi_B \Pi_B}}^j(\Pi_B) = \frac{\partial^2 NB_B^j(\Pi_B)}{\partial \Pi_B^2}$. In the absence of financial bubbles the closed-form solution of (37) is

$$NB_B^j(\Pi_B) = -\frac{\tau_A \gamma_A^* C_B^j}{r} + N_2^j \Pi_i^{\beta_i}. \tag{38}$$

Let us next compute N_2^j. We know that when default occurs the net flow vanishes and, thus, the equality

$$NB_B^j(\overline{\Pi}_B^j) = 0 \tag{39}$$

holds. Substituting (38) into the condition (39) it is easy to obtain (17).

Following the same procedure we can compute the present value of the net loss of revenues due to profit shifting from the parent company placed in B and its subsidiary operating in A (18).

G Proof of Proposition 1

To prove Proposition 1 let us focus on the decision of the government A. Substituting (19) into (20) and differentiating the objective function with

[38]Remember that $NB_B^j\left(\Pi_B\right)$ is computed by the government, that by assumption does not aim to expropriate the foreign subsidiary.

respect to τ_A yields the following f.o.c.

$$\frac{\partial W_A^j}{\partial \tau_A} = \frac{\partial \widetilde{\tau}}{\partial \tau_A}\frac{C_B^j}{r+\lambda} + \frac{\partial f^j\left(\overline{\Pi}_B^j\right)}{\partial \tau_A} - \gamma_A^* \frac{C_B^j}{r}\left[1-\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \gamma_B^* \frac{C_A^j}{r}\left[1-\left(\frac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] +$$
$$-\tau_A \frac{\partial \gamma *_A}{\partial \tau_A}\frac{C_B^j}{r}\left[1-\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] - \tau_A \gamma_A^* \frac{1}{r}\frac{\partial C_B^j}{\partial \tau_A}\left[1-\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \tau_A \gamma_A^* \frac{C_B^j}{r}\left[\frac{\partial \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}}{\partial \tau_A}\right] +$$
$$+\tau_A \frac{\partial \gamma_B^*}{\partial \tau_A}\frac{C_A^j}{r}\left[1-\left(\frac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] + \tau_A \gamma_B^* \frac{1}{r}\frac{\partial C_A^j}{\partial \tau_A}\left[1-\left(\frac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] - \tau_A \gamma_B^* \frac{C_A^j}{r}\left[\frac{\partial \left(\frac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}}{\partial \tau_A}\right] + \frac{\Pi_A}{r} = 0 \tag{40}$$

with $\gamma_A^* = \frac{\tau_A - \tau_B}{n}$, $\gamma_B^* = \frac{\tau_B - \tau_A}{n}$, $\frac{\partial \gamma_A^*}{\partial \tau_A} = \frac{1}{n}$, and $\frac{\partial \gamma_B^*}{\partial \tau_A} = -\frac{1}{n}$.

Under symmetry we have $\tau_k = \widetilde{\tau} = \tau$, $\left.\frac{\partial \widetilde{\tau}}{\partial \tau_k}\right|_{\tau_A=\tau_B} = \gamma_k^* = 0$, $\Pi_k = \Pi$, $C_k^j = C^j$, and $\overline{\Pi}_k^j = \overline{\Pi}^j = m^j C_k^j$, with $k = A, B$, and $j = p, u$. The f.o.c. (40) thus reduces to

$$\left.\frac{\partial W_A^j}{\partial \tau_A}\right|_{\tau_A=\tau_B} = \left.\frac{\partial f^j\left(\overline{\Pi}_B^j\right)}{\partial \tau_A}\right|_{\tau_A=\tau_B} - \tau \frac{2}{n}\frac{C^j}{r}\left[1-\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}\right] + \frac{\Pi}{r} = 0. \tag{41}$$

G.1 Protected debt

If debt is protected we have $\left.\frac{\partial f^p\left(\overline{\Pi}_B^p\right)}{\partial \tau_A}\right|_{\tau_A=\tau_B} = f^p\left(\overline{\Pi}_B^p\right) = 0$, and equation (41) reduces to

$$\frac{\partial W_A^p}{\partial \tau_A} = -\tau \frac{2}{n}\frac{C^p}{r}\left[1-\left(\frac{\Pi}{\overline{\Pi}^p}\right)^{\beta_2}\right] + \frac{\Pi}{r} = 0 \tag{42}$$

Given $m^p = 1$ and $C^p = \Pi$, substituting (14) into (42) we have

$$1 = R^p(\tau) \equiv \frac{2}{n}\left(\frac{1}{1-\beta_2}\right)^{1-\frac{1}{\beta_2}}\left[\frac{\tau}{\tau + (r+\lambda)\upsilon}\right]^{1-\frac{1}{\beta_2}}\left[(1-\beta_2)(r+\lambda)\upsilon - \beta_2 \tau\right]. \tag{43}$$

Let us analyze the RHS of (43). It is easy to ascertain that $R^p(0) = 0$, $\frac{\partial R^p(\tau)}{\partial \tau} > 0$ for $\tau \geq 0$, and $\lim_{\tau \to \infty} R^p(\tau) = \infty$. As shown in Fig. 4 therefore there exists one point τ^* such that the equality (43) holds. If n is high enough we have $\tau^* \in (0, 1]$.

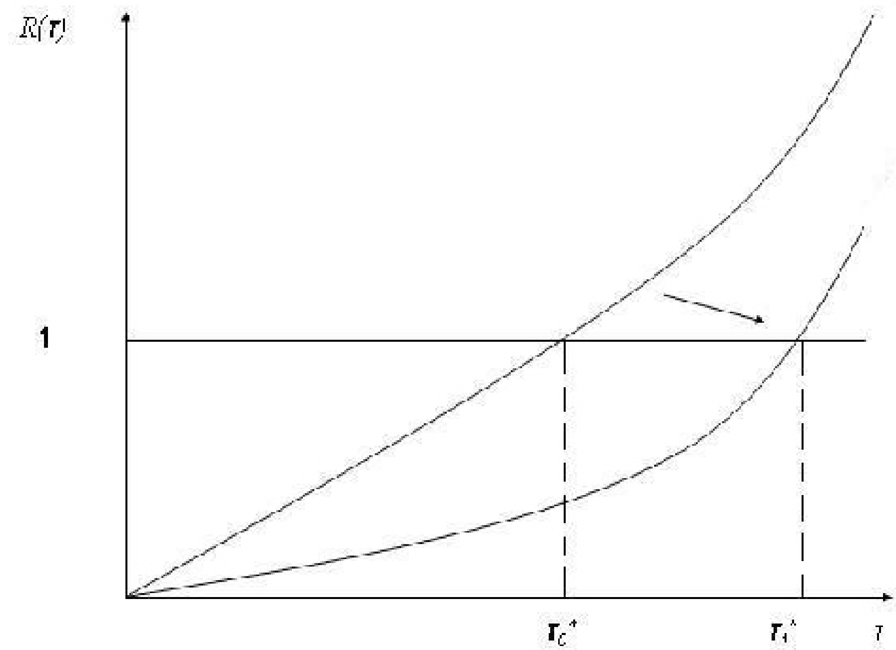

Figure 4: The equilibrium condition (43).

G.2 Unprotected debt

If debt is unprotected equation (41) reduces to

$$\left.\frac{\partial W_A^u}{\partial \tau_A}\right|_{\tau_A=\tau_B} = \left.\frac{\partial f^u\left(\overline{\Pi}_B^u\right)}{\partial \tau_A}\right|_{\tau_A=\tau_B} - \tau \frac{2}{n}\frac{C^u}{r}\left[1-\left(\frac{\Pi}{\overline{\overline{\Pi}}^u}\right)^{\beta_2}\right] + \frac{\Pi}{r} = 0. \tag{44}$$

Using (8) and (14) we thus have

$$\frac{\partial f^u\left(\overline{\Pi}_B^u\right)}{\partial \tau_A} = \left[-\frac{1}{\beta_2}\frac{1-\tau_B}{r+\lambda}\left(\frac{1}{1-\beta_2}\right)^{1-\frac{1}{\beta_2}}\Pi\right]\frac{\partial\left[\left(\frac{\tau}{\tau+(r+\lambda)\upsilon}\right)^{1-\frac{1}{\beta_2}}\right]}{\partial\widetilde{\tau}}\frac{\partial\widetilde{\tau}}{\partial \tau_A}.$$

Under symmetry we have $\frac{\partial\widetilde{\tau}}{\partial \tau_A}=0$, and hence $\left.\frac{\partial f^u\left(\overline{\Pi}_B^u\right)}{\partial \tau_A}\right|_{\tau_A=\tau_B}=0$. Therefore (44) reduces to

$$\frac{\partial W_A}{\partial \tau_A} = -\tau \frac{2}{n}\frac{C^u}{r}\left[1-\left(\frac{\Pi}{\overline{\overline{\Pi}}^u}\right)^{\beta_2}\right] + \frac{\Pi}{r} = 0, \tag{45}$$

with

$$C^u = \frac{\beta_2-1}{\beta_2}\left[\frac{1}{1-\beta_2}\frac{\tau}{\tau+(r+\lambda)\upsilon}\right]^{-\frac{1}{\beta_2}}\Pi,$$

and

$$\left(\frac{\Pi}{\overline{\overline{\Pi}}^u}\right)^{\beta_2} = \frac{1}{1-\beta_2}\frac{\tau}{\tau+(r+\lambda)\upsilon}.$$

Using (45) we thus obtain

$$1 = R^u(\tau) \equiv \left(\frac{\beta_2-1}{\beta_2}\right)R^p(\tau). \tag{46}$$

It is thus easy to ascertain that $R^u(0)=0$, $\frac{\partial R^u(\tau)}{\partial\tau}>0$ for $\tau\geq 0$, and $\lim_{\tau\to\infty}R^u(\tau)=\infty$. Moreover we know from (46) that $R^u(\tau)>R^p(\tau)$. This entails that the equality $R^u(\tau)=1$ holds for a lower value of τ. As a consequence, the equilibrium tax rate is lower under unprotected debt financing. This concludes the proof.■

H Proof of Corollary 1

To prove Corollary 1 let us add the value of debt (i.e. (7)) to the objective function (19), so as to obtain the new objective function of government A[39]

$$\begin{aligned} \pounds_A^j = \tfrac{\Psi_A}{r} + \tfrac{(1-\tau_B)\Pi_B + \tilde{\tau} C_B^j}{r+\lambda} - \left(\tfrac{\tilde{\tau}}{r+\lambda} + \upsilon\right) C_B^j \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2} + \\ -\tau_A \gamma_A^* \tfrac{C_B^j}{r}\left[1 - \left(\tfrac{\Pi}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \tau_A \gamma_B^* \tfrac{C_A^j}{r}\left[1 - \left(\tfrac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] + \tau_A \tfrac{\Pi_A}{r}. \end{aligned} \tag{47}$$

Differentiating (47) with respect to τ_A we have

$$\begin{aligned} \tfrac{\partial \pounds_A^j}{\partial \tau_A} = \tfrac{\partial \tilde{\tau}}{\partial \tau_A}\tfrac{C_B^j}{r+\lambda} - \tfrac{\partial \tilde{\tau}}{\partial \tau_A} C_B^j \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2} - \left(\tfrac{\tilde{\tau}}{r+\lambda} + \upsilon\right)\tfrac{\partial C_B^j}{\partial \tau_A}\left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2} - \left(\tfrac{\tilde{\tau}}{r+\lambda} + \upsilon\right) C_B^j \left[\frac{\partial \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}}{\partial \tau_A}\right] + \\ -\gamma_A^* \tfrac{C_B^j}{r}\left[1 - \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \gamma_B^* \tfrac{C_A^j}{r}\left[1 - \left(\tfrac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] + \\ -\tau_A \tfrac{\partial \gamma_A^*}{\partial \tau_A}\tfrac{C_B^j}{r}\left[1 - \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] - \tau_A \gamma_A^* \tfrac{1}{r}\tfrac{\partial C_B^j}{\partial \tau_A}\left[1 - \left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}\right] + \tau_A \gamma_A^* \tfrac{C_B^j}{r}\left[\frac{\partial \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}}{\partial \tau_A}\right] + \\ +\tau_A \tfrac{\partial \gamma_B^*}{\partial \tau_A}\tfrac{C_A^j}{r}\left[1 - \left(\tfrac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] + \tau_A \gamma_B^* \tfrac{1}{r}\tfrac{\partial C_A^j}{\partial \tau_A}\left[1 - \left(\tfrac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}\right] - \tau_A \gamma_B^* \tfrac{C_A^j}{r}\left[\frac{\partial \left(\frac{\Pi_A}{\overline{\Pi}_A^j}\right)^{\beta_2}}{\partial \tau_A}\right] + \tfrac{\Pi_A}{r} = 0, \end{aligned} \tag{48}$$

where $\frac{\partial C_B^j}{\partial \tau_A} = \frac{\partial C_B^j}{\partial \tilde{\tau}}\frac{\partial \tilde{\tau}}{\partial \tau_A}$, and $\frac{\partial \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}}{\partial \tau_A} = \frac{\partial \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}}{\partial \tilde{\tau}}\frac{\partial \tilde{\tau}}{\partial \tau_A}$, with $\frac{\partial \tilde{\tau}}{\partial \tau_A} = \frac{(\tau_A - \tau_B)}{n}$.

Under symmetry we have $\frac{\partial \tilde{\tau}}{\partial \tau_A} = 0$, $\left.\frac{\partial C_B^j}{\partial \tau_A}\right|_{\tau_A = \tau_B} = 0$, and $\frac{\partial \left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2}}{\partial \tau_A} = 0$. Thus (48) reduces to

$$\left.\frac{\partial \pounds_A^j}{\partial \tau_A}\right|_{\tau_A = \tau_B} = -\tau \frac{2}{n}\frac{C^j}{r}\left[1 - \left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}\right] + \frac{\Pi}{r} = 0 \tag{49}$$

[39] Following the same procedure it is straightforward to obtain the objective function of government B.

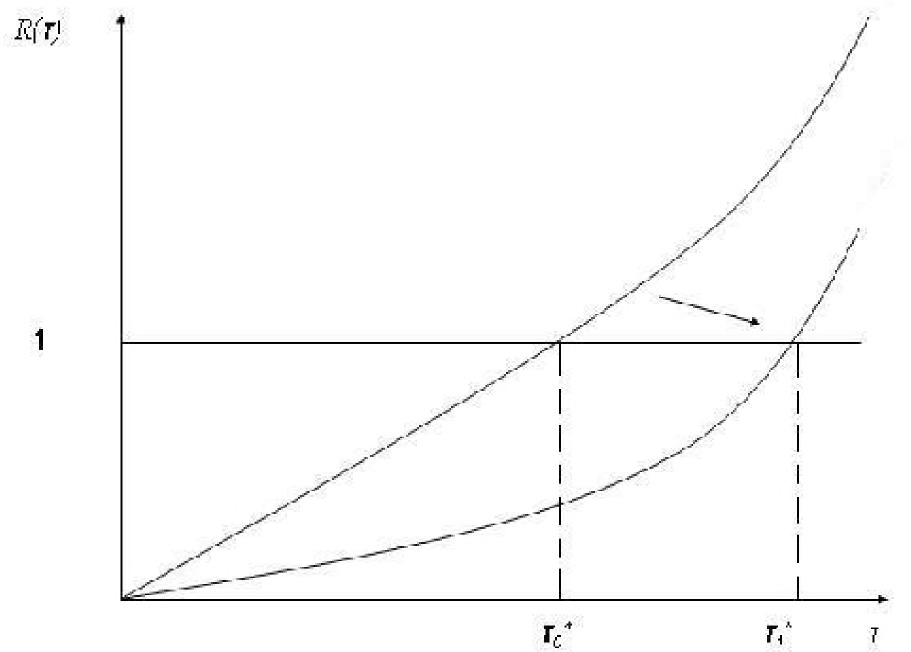

Figure 5: The effect of an increase in n and/or υ on the equilibrium tax rate τ^*.

As can be seen eq. (49) collapses to (41). This is sufficient to prove that the equilibrium tax rate is the same as that obtained in Proposition 1. The Corollary is thus proven.■.

I Proof of Proposition 2

To prove Proposition 2 let us recall (43). It is easy to show that $\frac{\partial R(\tau)}{\partial \upsilon} < 0$, and $\frac{\partial R(\tau)}{\partial n} < 0$. This effect is depicted in Fig. 5. As can be seen, an increase in either υ or n shifts curve $R(\tau)$ downwards.

Therefore the equilibrium tax rate increases from τ_0^* to τ_1^*.

A similar result can be obtained under unprotected debt financing. According to Proposition 1, however, the equilibrium tax rate is lower than that obtained in the protected-debt case. This concludes the proof.■

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