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Debt Shifting and Transfer Pricing in a Volatile World

Abstract

In this article we introduce a stochastic model with a multinational company (MNC) that exploits tax avoidance practices. We focus on both transfer pricing (TP) and debt shifting (DS) activities and show how their optimal level is chosen by the shareholders. In addition, we perform an extensive numerical simulation, fine-tuned on empirical data, to measure the impact of tax avoidance practices on the MNC's value and to study their sensitivity to exogenous variables. We will show that: an increase in risk sharply reduces leverage and slightly decreases a MNC's value; the cost of TP leads to a sharp reduction in the MNC's value, whereas it does not affect leverage; the impact on MNC's decisions is increasing in the tax rate differential; finally, the cost of DS has always a relevant impact on both MNC's value and leverage.

JEL-Codes: H250, G330, G380.

Keywords: capital structure, default risk, business taxation and welfare.

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1 Introduction

Debt shifting (DS) and transfer pricing (TS) activities are a worldwide phenomenon and have been studied for a long time.[1]

To our knowledge, despite the existence of several empirical articles, only Schenkelberg (2020) studies both TP and DS and finds that TP is on average 85% of the increase in pre-tax earnings while less than 15% is attributable to DS. Again, only Schindler and Schjelderup (2016) provide a theoretical model where both TP and DS are studied together. These authors assume that a higher leverage may reduce marginal concealment costs of transfer pricing (and vice versa). Moreover, they assume that the concealment costs related to TP may rise when debt shifting increases (and vice versa). In principle, this cross effect is interesting. However, there is no empirical evidence that supports such an hypothesis. For this reason, we disentangle the concealment costs of DS and TP by assuming standard quadratic cost functions. Moreover, Schindler and Schjelderup (2016) apply a deterministic model. Since we believe that risk dramatically affects firms' decisions, we will depart from their assumptions and focus on a representative multina-

[1]The empirical literature on both debt shifting (see, e.g., the pioneering articles by Collins and Shackelford (1992) and Froot and Hines (1995)) and transfer pricing (see, e.g., Grubert and Slemrod (1998)) began in America. Subsequently it spread up around the world. In Europe, for instance, Ramb and Weichenrieder (2005) showed that the tax rates of the parent companies have no statistically significant effect on their subsidiaries' leverage, whereas Overesch and Wamser (2014) studied the effects of parent companies' tax rates on their own capital structure. Moreover, using the effective cross-border tax rates Huizinga et al. (2008) estimated a negative impact of parent company taxation. As shown by Miniaci et al. (2014) however, the effects of a change in parent company tax rate are much more complex, because taxes affect both a MNC's borrowing decision and the distribution of debt among its entities. Accordingly, the meta-analysis of the empirical literature on corporate capital structure by Feld et al. (2013) emphasized the complexity of tax effects at a multinational level. Based on 48 studies, they estimate a marginal tax effect on the debt ratio of about 0.27, that is, the debt-to-assets ratio rises by 2.7% if the marginal tax rate increases by 10%. When, however, they focus on the capital structure of foreign subsidiaries, taxation has a more complex impact, as the tax sensitivity of inter-company debt financing is particularly strong. Overall, their meta-analysis does not support the idea that the international tax system affects the financing decisions of multinational firms. These results show that there is room for further research aimed at focusing on firms' heterogeneity. As regards TP, MNCs shift income to low-tax subsidiaries in order to minimize their overall tax expenses around the world (see, e.g., Dischinger et al. (2014); Dischinger (2010); Devereux and Maffini (2007); Hines and Rice (1994)).

tional company (MNC) facing risk. Such a phenomenon has a twofold effect. Firstly, it makes a MNC's profitability volatile, thereby affecting the amount of shifted profit. Secondly, it may lead to default: the probability of this event can affect both financial choices and DS activities.

Our aim is therefore to show that, using a stochastic Earning Before Interests and Taxes (EBIT), the MNC's choices crucially depend on risk. In particular, we will show that: (i) an increase in risk leads to a dramatic drop of leverage and a slight decrease in MNC's value, (ii) the cost of TP leads to a sharp reduction in the MNC's value, whereas it does not affect leverage, (iii): the impact on MNC's decisions is increasing in the tax rate differential and (iv) the cost of DS always has a relevant impact on both MNC's value and leverage.

Of course, using ad hoc parameter value we will able to show that our results are similar to Schenkelberg (2020). In other terms, TP activities lead to a more relevant tax saving than DS.

The remaining part of this article is structured as follows. Section 2 introduces the model describing the behavior of a representative MNC. Section 3 provides a numerical analysis. A set of sensitivity analyses is also added to show the robustness our results. Section 4 summarizes our findings and discusses policy implications.

2 The model

The savings arising from tax avoiding activities crucially depend on the characteristics of concealment costs. Since there is no evidence about the characteristics of these cost functions, we will let them be separate and convex. Moreover, we will let shareholders make both TP and DS optimal as well as choose the optimal threshold level of EBIT, below which default takes place (this assumption is in line with Leland (1994) and Goldstein et al. (2001)). Moreover, the optimal debt level will be obtained by maximizing the levered value of a representative MNC. In doing so, we will allow lenders and shareholders to decide the leverage ratio together.[2]

[2]This assumption entails that there are no informational symmetries and that lenders and creditors decide together the optimal leverage ratio. Of course, this simplifying assumption allows us to find a closed-form solution. Asymmetric information will be left for further research.

2.1 EBIT's dynamics

In this section we use a continuous-time model based on Goldstein et al. (2001). We will focus on a representative MNC's EBIT, that is characterized by volatility and hence default risk. Accordingly, EBIT, as Π, is assumed to follow a Geometric Brownian Motion (GBM):

$$\frac{d\Pi_t}{\Pi_t} = \mu dt + \sigma dz_t, \tag{1}$$

where $\Pi_0 > 0$ is its initial value, μ and σ are the drift and the instantaneous standard deviation, respectively. Moreover, dz_t is the increment of a Weiner process. In line with Dixit and Pindyck (1994), we let $\delta = r - \mu$ be positive.[3] In this framework we also assume that the firm can borrow from a perfectly competitive credit sector, where the discount factor is the risk-free interest rate r. Moreover, we introduce the following:

Assumption 1 *At time 0, shareholders maximize the value of equity with respect to the threshold $\overline{\Pi}$ below which the default occurs, as well as with respect to the optimal transfer pricing and debt shifting strategies.*

Assumption 2 *Still at time 0, the MNC can borrow resources thereby paying a non-renegotiable coupon C. The optimal value of C is such that the levered value of the MNC is maximized.*

Assumption 3 *If the MNC does not meet its obligations, default occurs and hence the firm is expropriated by the lender and looses access to credit market.*

Assumption 4 *After default, the lender becomes shareholder and can exploit transfer price activities to reduce its tax bills.*

Assumption 1 implies that shareholders behave as if they own a put option, whose exercise leads to default.[4] Moreover, it entails that the MNC can reduce its tax burden by means of DS and TP activities. Assumption 2 means that the firm sets a coupon and then computes the debt market value.

[3] In this framework where the GMB is written in the risk neutral probability $\mathbb{Q}$, the positive dividend yield δ allows the possibility of an early exercise and smooth pasting, according to Shackleton and Sødal (2005).

[4] For further details on the characteristics of default conditions see, e.g., Leland (1994) and Panteghini (2007a).

Without arbitrage, this is equivalent to first setting the debt value and then calculating the effective interest rate. For simplicity, we assume that debt cannot be renegotiated: this means that we apply a *static* trade-off approach where the firm's financial policy cannot be reviewed later.[5]

Assumption 3 introduces the risk of default, which occurs if the firm's EBIT falls below a given threshold value $\overline{\Pi}$. In this case, the MNC is expropriated by the lender who bears the cost of default and then becomes shareholder: our firm's operations keep generating further EBIT. In this case the ex-lender, who has become shareholder, can exploit TP activities to reduce its tax liabilities.

It is worth noting that tax saving due to debt-finance arises as long as the business tax rate is higher than the lender's rate (see, e.g., Panteghini (2007b)). For simplicity and without loss of generality, we let the lender's pre-default tax rate be nil. When, however, default takes place, the lender becomes shareholder and is therefore subject to corporate taxation.

2.2 Net profit of the multinational company

Let us assume, for simplicity, that our representative MNC holds two branches: A and B, located in two different countries, where relevant tax rates are respectively τ_A and τ_B,. Both subsidiaries are operating and allow the MNC to yield the EBIT Π. Accordingly, we assume that a portion $\theta \in (0,1)$ of EBIT is produced by the subsidiary located in A. The remaining portion $(1-\theta)$ is produced in country B.

In line with the empirical literature, we let the MNC shift a share $\alpha \in [0,1]$ of Π from the high-tax country to the low-tax one. Likewise, a share $\gamma \in [0,1]$ of C (if any) can be shifted from the low-tax country to the high-tax one, under the assumption that interest expenses are fully deductible.[6] It is worth noting that shifting both EBIT and debt is costly. For this reason, we introduce an ad hoc cost function, i.e., the TP cost function denoted as $\phi(\alpha)$, and the function of debt shifting, i.e, $\nu(\gamma)$. For simplicity we assume that both the cost functions are quadratic, namely:[7]

[5] The analysis of a dynamic trade-off model, where firms can subsequently adjust their capital structure, is left for future research.

[6] The quality of results does not change under partial deductibility of interest expenses.

[7] This choice is motivated by the lack of empirical evidence about the (hidden) cost of such operations. However, despite its simplicity, the functional form we propose introduces a penalty which is more than proportional to the shifted share α or γ, implicitly setting a

$$\phi(\alpha) = \frac{m}{2}\alpha^2 \quad \text{and} \quad \nu(\gamma) = \frac{n}{2}\gamma^2, \tag{2}$$

where m and n are scale parameters. Given these assumptions, our MNC's overall net profit Π^N is equal to:

$$\begin{aligned}\Pi^N = &(1-\widetilde{\tau})(\Pi - C) + [(\tau_B - \tau_A)\alpha - \phi(\alpha)]\Pi \\ &+ [(\tau_A - \tau_B)\gamma - \nu(\gamma)]C.\end{aligned} \tag{3}$$

where $\widetilde{\tau} \equiv \tau_A\theta + (1-\theta)\tau_B$ is the effective tax rate without tax avoidance.[8]

In addition, we notice that when DS is feasible, the effective tax rate is higher than in the other case, as $(\tau_A - \tau_B)\gamma - \nu(\gamma) > 0$.[9]

2.3 The value of equity

A MNC's value coincides with the value of equity, $E(\Pi)$, if debt is nil. When, however, the MNC is debt financed and default occurs, $E(\Pi)$ goes to zero. Using the notation of Dixit and Pindyck (1994), we can therefore write:

$$E(\Pi) = \begin{cases} 0 & \text{a.d.} \\ \Pi^N dt + e^{-rdt}\mathbb{E}[E(\Pi + d\Pi)] & \text{b.d.,} \end{cases} \tag{4}$$

limit to the exploitation of these techniques.

[8]Let A be the branch toward which both transfer pricing and debt shifting are carried out. Its shares of MNC's profit and coupon, equal to $\theta\Pi$ and θC without transfer pricing or debt shifting, thanks to these practices are increased to $(\theta+\alpha)\Pi$ and $(\theta+\gamma)C$ respectively. In reverse, the same shares of branch B become $(1-\theta-\alpha)\Pi$ and $(1-\theta-\gamma)C$. As the cost of these operations, as from equation (2), are respectively $\phi(\alpha)\Pi$ and $\nu(\gamma)C$, Π^N is defined as:

$$\begin{aligned}\Pi^N = &(1-\tau_A)[(\theta+\alpha)\Pi - (\theta+\gamma)C] \\ &+ (1-\tau_B)[(1-\theta-\alpha)\Pi - (1-\theta-\gamma)C] - \phi(\alpha)\Pi - \nu(\gamma)C.\end{aligned}$$

The effective tax-rate without transfer pricing or debt shifting $\tilde{\tau}$, as a function of τ_A, τ_B and θ, is obtained by solving the following equation:

$$1 - \widetilde{\tau} \equiv (1-\tau_A)\theta + (1-\tau_B)(1-\theta).$$

Finally, by rewriting Π^N as a function of $\tilde{\tau}$ and rearranging, the equation (3) follows.

[9]The after-tax cost of debt, as from equation (3), is $1 - \widetilde{\tau} + (\tau_A - \tau_B)\gamma + \nu(\gamma)$. Thanks to the definition of γ^* later derived, the last two addends can be rewritten as $(\tau_A - \tau_B)^2(2n)^{-1}$, which is always positive, given the existence of a tax differential.

where $\mathbb{E}$ is the expected value operator. Labels "a.d." and "b.d." stand respectively for "after default" and "before default". As proven in Appendix A.1.1, equation (4) can be rewritten as:

$$E(\Pi) = \begin{cases} 0 & \text{a.d.} \\ (1-\widetilde{\tau})\left(\frac{\Pi}{\delta} - \frac{C}{r}\right) + \left[(\tau_B - \tau_A)\alpha - \phi(\alpha)\right]\frac{\Pi}{\delta} & \\ \quad + \left[(\tau_A - \tau_B)\gamma - \nu(\gamma)\right]\frac{C}{r} + \sum_{i=1}^{2} A_i \Pi^{\beta_i} & \text{b.d.} \end{cases} \tag{5}$$

As shown in Appendix A.1.2, in the absence of financial bubbles, we have $A_1 = 0$. Moreover, solving the equation for A_2 at point $\Pi = \overline{\Pi}$ we obtain:

$$\begin{aligned} E(\Pi) = & (1-\widetilde{\tau})\left(\frac{\Pi}{\delta} - \frac{C}{r}\right) + (\tau_B - \tau_A)\left(\alpha\frac{\Pi}{\delta} - \gamma\frac{C}{r}\right) - \phi(\alpha)\frac{\Pi}{\delta} - \nu(\gamma)\frac{C}{r} \\ & - \left[(1-\widetilde{\tau})\left(\frac{\overline{\Pi}}{\delta} - \frac{C}{r}\right) + (\tau_B - \tau_A)\left(\alpha\frac{\overline{\Pi}}{\delta} - \gamma\frac{C}{r}\right) - \phi(\alpha)\frac{\overline{\Pi}}{\delta} - \nu(\gamma)\frac{C}{r}\right]\left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_2}. \end{aligned} \tag{6}$$

According to Goldstein et al. (2001), shareholders are assumed to choose the optimal default timing. Moreover, we also let them choose the optimal tax avoiding strategy. Their problem is therefore the following:

$$\max_{\overline{\Pi},\alpha,\gamma} E(\Pi). \tag{7}$$

As shown in Appendix A.1.3, the solution of this problem leads to the optimal controls for α and γ:

$$\alpha^* = \frac{\tau_B - \tau_A}{m} \quad \text{and} \quad \gamma^* = \frac{\tau_A - \tau_B}{n}. \tag{8}$$

As can be seen, an increase in m and n reduces the absolute value of α^* and γ^*. Moreover, the trigger point below which default takes place will then be:

$$\overline{\Pi}^* = \frac{\beta_2}{\beta_2 - 1}\frac{1 - \widetilde{\tau} - \frac{(\tau_A - \tau_B)^2}{2n}}{1 - \widetilde{\tau} + \frac{(\tau_B - \tau_A)^2}{2m}}\frac{\delta}{r}C \equiv \Delta C, \tag{9}$$

where $\Delta < 1$. It is worth noting that, *coeteris paribus*, m and n affect not only the absolute value of α^* and γ^*, but also the optimal threshold in $\overline{\Pi}^*$. In particular, an increase (decrease) in either m or n raises (reduces) $\overline{\Pi}^*$, thereby increasing (decreasing) the probability that Π hits $\overline{\Pi}^*$. In other terms, an increase (decrease) in either m or n raises (reduces) the default risk. A sensitivity analysis about the effects of parameter changes will be provided in section 3.3.

Given these results, we can rewrite 6 as:

$$\begin{aligned} E(\Pi) = & \left(\tfrac{\Pi}{\delta} - \tfrac{C}{r}\right) + \tfrac{(\tau_B - \tau_A)^2}{2m}\tfrac{\Pi}{\delta} + \tfrac{(\tau_A - \tau_B)^2}{2n}\tfrac{C}{r} \\ & - \left[(1-\widetilde{\tau})\left(\tfrac{\overline{\Pi}}{\delta} - \tfrac{C}{r}\right) + \tfrac{(\tau_B - \tau_A)^2}{2m}\tfrac{\overline{\Pi}}{\delta} + \tfrac{(\tau_A - \tau_B)^2}{2n}\tfrac{C}{r}\right]\left(\tfrac{\Pi}{\overline{\Pi}}\right)^{\beta_2}. \end{aligned} \tag{10}$$

2.4 The value of debt

In order to calculate the value of debt, $D(\Pi)$, we account for the fact that, before default, debt is equal to the sum between the coupon C (over the short period dt) and its expected change in the future. It is worth noting that, after default, the value of $D(\Pi)$ does not fall to zero.[10] As pointed out by assumption 3, the MNC keeps producing: in this case, the lender will benefit from the future net profit flow.[11] Thus, the value of debt after default is equal to a portion $\Omega \in (0,1)$ of the discounted perpetual rent of future net profit:

$$D(\Pi) = \begin{cases} \Omega \frac{[(1-\tau_A)(\theta+\alpha)+(1-\tau_B)(1-\theta-\alpha)-\phi(\alpha)]\Pi}{\delta} & \text{a.d.} \\ C dt + e^{-rdt}\mathbb{E}\left[D(\Pi + d\Pi)\right] & \text{b.d.} \end{cases} \tag{11}$$

As proven in Appendix A.2.1, the equation (11) can be rewritten as:

$$D(\Pi) = \begin{cases} \Omega \frac{[(1-\tau_A)(\theta+\alpha)+(1-\tau_B)(1-\theta-\alpha)-\phi(\alpha)]\Pi}{\delta} & \text{a.d.} \\ \frac{C}{r} + \sum_{i=1}^{2} B_i \Pi^{\beta_i} & \text{b.d.} \end{cases} \tag{12}$$

Moreover, as shown in Appendix A.2.2, assuming the absence of financial bubbles (i.e.,$B_1 = 0$) and solving for B_2 at point $\Pi = \overline{\Pi}$ gives:

$$D(\Pi) = \begin{cases} \Omega \frac{[1-\widetilde{\tau}+(\tau_B-\tau_A)\alpha-\phi(\alpha)]\Pi}{\delta} & \text{a.d.,} \\ \frac{C}{r} + \left[\Omega \frac{[1-\widetilde{\tau}+(\tau_B-\tau_A)\alpha-\phi(\alpha)]\overline{\Pi}}{\delta} - \frac{C}{r}\right]\left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_2} & \text{b.d.} \end{cases} \tag{13}$$

[10] As proven in Chapter 1, a second default cannot occur.

[11] After default, the MNC looses access to credit market and in this case debt shifting is not possible anymore. For this reason, after default the net profit defined in equation (3) becomes:

$$\Pi^N = [(1-\tau_A)(\theta+\alpha) + (1-\tau_B)(1-\theta-\alpha) - \phi(\alpha)]\,\Pi.$$

After default, the lender chooses the optimal level of transfer pricing (see Appendix A.2.3):

$$\max_{\alpha} D\left(\Pi\right) \quad \text{a.d.} \tag{14}$$

which coincides with the result shown in the equation (8), i.e., $\alpha^{*} = \frac{\tau_B - \tau_A}{m}$. Hence, solving (14), we obtain the following result:

$$D\left(\Pi\right) = \begin{cases} \Omega \frac{1-\widetilde{\tau}+\frac{(\tau_B-\tau_A)^2}{2m}}{\delta} \Pi & \text{a.d.,} \\ \frac{C}{r} + \left[\Omega \frac{1-\widetilde{\tau}+\frac{(\tau_B-\tau_A)^2}{2m}}{\delta} \overline{\Pi} - \frac{C}{r}\right] \left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_2} & \text{b.d.} \end{cases} \tag{15}$$

2.5 The value of multinational company

The overall value of the MNC is given by the sum between equity and debt, i.e.,

$$V\left(\Pi\right) = E(\Pi) + D(\Pi). \tag{16}$$

Substituting (10) and (15) into (16) we obtain:

$$\begin{aligned} V\left(\Pi\right) =& (1-\widetilde{\tau})\left(\frac{\Pi}{\delta} - \frac{C}{r}\right) + \frac{(\tau_B-\tau_A)^2}{2m}\frac{\Pi}{\delta} + \frac{(\tau_A-\tau_B)^2}{2n}\frac{C}{r} \\ & - \left\{(1-\widetilde{\tau})\left(\frac{\Delta C}{\delta} - \frac{C}{r}\right) + \frac{(\tau_B-\tau_A)^2}{2m}\frac{\Delta C}{\delta} + \frac{(\tau_A-\tau_B)^2}{2n}\frac{C}{r}\right\}\left(\frac{\Pi}{\Delta C}\right)^{\beta_2} \\ & + \frac{C}{r} + \left\{\Omega\left[1-\widetilde{\tau}+\frac{(\tau_B-\tau_A)^2}{2m}\right]\frac{\Delta C}{\delta} - \frac{C}{r}\right\}\left(\frac{\Pi}{\Delta C}\right)^{\beta_2}. \end{aligned} \tag{17}$$

As shown in Appendix A.3, we maximize (17) with respect to C and hence obtain:

$$C^{*} = \left[\frac{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}}{(1-\beta_2)\left[(1-\Omega)\left[1-\widetilde{\tau}+\frac{(\tau_B-\tau_A)^2}{2m}\right]\frac{\Delta}{\delta}+\left[\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}\right]\frac{1}{r}\right]}\frac{1}{r}\right]^{-\frac{1}{\beta_2}} \frac{\Pi}{\Delta}. \tag{18}$$

As can be seen, parameter values have a non-linear impact on endogenous variables. For this reason, we will run a numerical analysis. As shown in Appendix A.3, substituting (2) into (8) gives the optimal default threshold point as a function of C^{*}:

$$\overline{\Pi}^{*}\left(C^{*}\right) = \frac{\delta}{r}\left[\frac{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}}{(1-\beta_2)\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}+\left[1-(1-\Omega)\frac{\beta_2}{\beta_2-1}\right]\left[\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}\right]\right]}\right]^{-\frac{1}{\beta_2}} \Pi. \tag{19}$$

As can be seen, $\overline{\Pi}^{*}\left(C^{*}\right)$ is unaffected by m.

2.6 Some comparative statics

Before introducing the numerical simulation of Section 3, we run some useful numerical comparative statics. Given our two-stage approach, we use equations (8), (9) and (18), and analyze the effects of TP's and DS's concealment costs. In doing so, we will focus on the effects of a change in either m or n on α^*, γ^*, $\overline{\Pi}^* (C^*)$ and C^*.

It is straightforward to find: $\partial\alpha^*/\partial m < 0$ when $\alpha \in (0,1)$, $\partial\alpha^*/\partial n = 0$, $\partial\gamma^*/\partial m = 0$ and $\partial\gamma^*/\partial n < 0$ if $\gamma \in (0,1)$. These results depend on the fact that, contrary to Schindler and Schjelderup (2016), we use additive concealment cost functions, regarding TP and DS, respectively.

As regards $\overline{\Pi}^* (C^*)$, we find that $\partial\overline{\Pi}^* (C^*) /\partial m = 0$. Given (19) this result is not surprising. The reasoning is as follows: TP activities are, by assumption, made both before and after default. As shown in 2 and 14, TP activities do not depend on the default event. Since, given m, TP strategies are the same, they do not affect default timing.[12] In addition, we find that $\partial\overline{\Pi} (C^*) /\partial n < 0$. This result states the negative influence of DS cost on optimal default trigger. Finally, it is easy to show that in either m or n the optimal coupon is reduced: $\partial C^*/\partial m < 0$ and $\partial C^*/\partial n < 0$. This is due to the fact that the more costly the tax avoidance, the lower the coupon (and hence the debt value) is. In other terms, an increase in concealment costs discourages borrowing because it reduces related tax savings.

3 A numerical analysis

3.1 Purpose and parameters

The effects of TP and DS on the capital structure of the MNC determinants are then investigated. To do so, we will use a numerical approach and focus on: the value of equity E, the value of debt D, the overall value V and the leverage ratio L, i.e., the ratio between D and V. The behavior of these indicators is studied with respect to both the relevant tax rate in country B, τ_B, and the drift coefficient μ, which determines the expected growth of EBIT.

The purpose of this exercise is twofold. Firstly, we evaluate if and how

[12] Notice that results would be different if we assumed that, after default, the value of m, and hence, TP choices changed. We leave this point for further research.

	Variable	Value
τ_A	Tax rate in country A	0.15
τ_B	Tax rate in country B	0.25
μ	GBM drift	0.02
σ	GMB diffusion	0.2
Π	Current profitability	2.5

	Variable	Value
r	Risk-free interest rate	0.025
m	Scale parameter of TP cost	0.05
n	Scale parameter of DS cost	0.1
θ	Relative weight of firm A	0.5
$1-\Omega$	Cost of default	0.2

Table 1: Benchmark values of parameters and variables used in the numerical simulations.

much the exploitation of TP and DP affects MNC's indicators. Section 3.2 contains our main results. Secondly, in Section 3.3 we perform a sensitivity analysis aimed at evaluating the impact of changes in exogenous parameters. More in detail, we study the effects of EBIT's drift and diffusion coefficients, namely μ and σ, the relevant tax rate τ_B – which, given τ_A constant, allows to control the tax differential between countries – as well as the costs of transfer pricing and debt shifting, represented respectively by m and n .[13]

The benchmark values of both parameters m and n, as well as those regarding variable,s are shown in table 1. The starting value of relevant tax rates in country A and B is respectively 0.15 and 0.25 : this differential would make TP and DS feasible. The drift μ and the diffusion σ of the GMB are equal to 0.02 and 0.2, respectively (in line with Dixit and Pindyck (1994)). In order to normalize our results, the current values of Π (2.5) and r (0.025) are such that perpetual rent Π/r is equal to 100. Unfortunately, the evidence on the concealment costs is poor. For this reason, we will arbitrarily set m and n respectively equal to 0.05 and 0.1 , although we will run some robustness check. Finally, with no loss of generality, we set $\theta = 0.5$ and $1 - \Omega = 0.2$.[14] For all the parameters not object of the sensitivity analysis, we verified that their change does not affect the quality of results.

3.2 Effects of tax avoidance practices

As pointed out, our numerical simulation is based on the parameter values of table 1. The only exception is represented by the scale parameters of TP and DS costs, that have been properly set to define the following scenarios: (i) both transfer pricing and debt shifting are exploited, (ii) only debt shifting

[13]For the sake of simplicity we omit the plots of equity and debt. Rather, we focus on the MNC's value. Omitted plots are available upon request.

[14]See the discussion about default costs in Chapter 1.

is feasible, (iii) only transfer pricing is allowed and (iv) tax avoidance is impossible (this may happen if both m and n are high enough).[15] In what follows we show both V and L as a function of μ and τ_B, respectively.

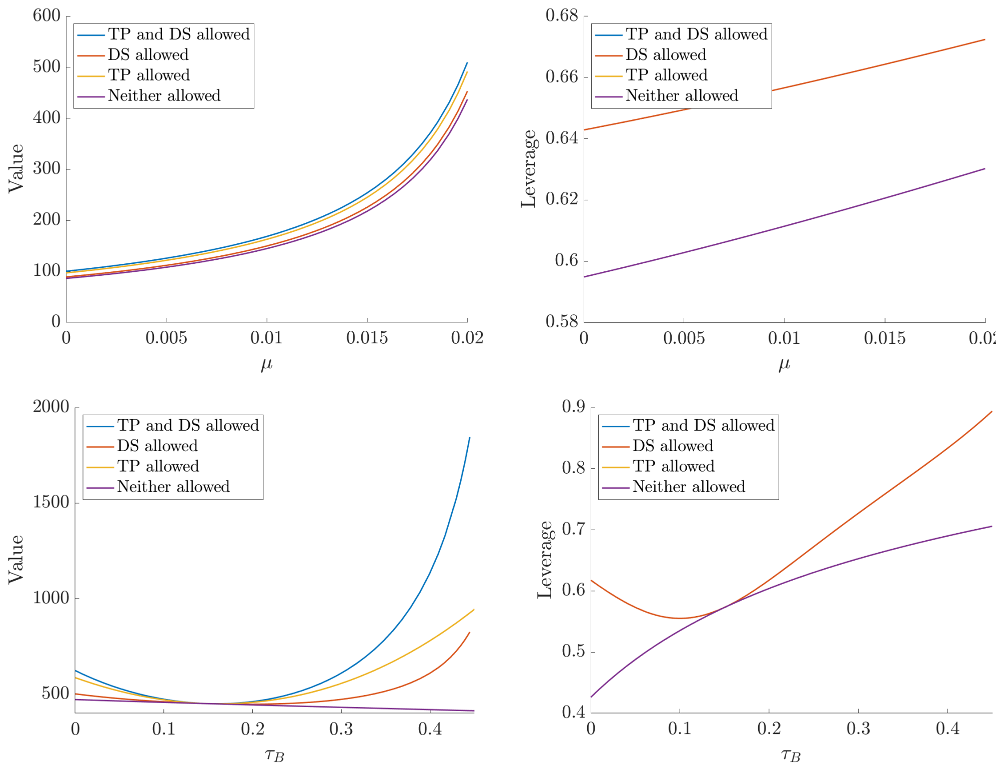

Figure 1: Effects on value function (left panels) and leverage (right panels), expressed as functions of future profitability μ (top panels) and of effective tax rate τ_B (bottom panels), of different availability of tax avoidance practices.

In the top-left panel of Figure 1, V is shown to be increasing in μ: the higher the drift, the higher the expected future profitability, the higher the MNC's value. Moreover, the MNC's is increasing in the tax avoidance opportunities (see the blue line): as can be seen, when both TP and DS are feasible, V is higher. Of course, when only one of these practices is available,

[15]Notice that when either m or n are higher than 3, tax avoidance is negligible, given $\tau_A = 0.15$ and $\tau_B = 0.25$.

V is lower for any μ. In the absence of tax avoiding practices (purple line) the MNC has the lowest value. Interestingly, we also see that the effect of TP is always more relevant than the DS one. This result is in line with Schenkelberg (2020), who estimated that about 85% of the tax avoidance benefit is due to TP. The remaining 15% is due to debt shifting activities. Here, we find similar values: with $\mu = .01$, the portion of benefit arising from TP (DS) is 78.1% (21.9%).

The top-right panel focuses on L. As can be seen, the leverage ratio is increasing in μ: this relationship is in line with static trade-off models. This behavior is in line with Dwenger and Steiner (2014), who show that the marginal tax rate has a statistically significant and relatively large positive effect on corporate leverage.[16] Moreover, we notice that cases (i) and (iii) are coincident and that so do cases (ii) and (iv). This means that the availability (unavailability) of DS alone implies L to be higher (lower). This happens because of the dynamics highlighted in section 2.6: as $\overline{\Pi}^* \left(C^*\right)$ is unaffected by m, the feasibility of TP does not matter. For this reason, E and D behave in the same way and the leverage ratio $L = \frac{D}{E+E}$ is unchanged.

In the bottom-left panel, we focus on the effects of τ_B, given $\tau_A = 0.15$. Of course, a change in τ_B affects the tax rate differential. Obviously, the higher the tax rate differential, the greater the tax benefit is. Of course, if the equality $\tau_A = \tau_B$ holds, no benefit is ensured. As can be seen,, V is higher when both TP and DS are feasible, for any tax rate differential. Not surprisingly, tax benefits vanish when $\tau_A = \tau_B$: in this case, all the lines are meeting at rate $\tau_B = 0.15$. Finally, in the bottom-right panel we show the leverage as a function of τ_B. Accordingly, DS has no effect on leverage and all the lines meet at point $\tau_B = 0.15$. Finally, we can see that the higher the tax differential, the higher the leverage ratio is.

3.3 Sensitivity analysis

To gain more insights on the previous results, we also run additional simulations regarding both different values of μ and τ_B.

In Figure 2 both top panels focus on the sensitivity analysis on μ. Not surprisingly, we see that V is increasing in both the tax differential[17] and

[16] However, when the trade-off model is dynamic, and hence the coupon may change over time, leverage is not necessarily increasing in μ: see, e.g., Strebulaev (2007).

[17] Notice that, when the tax differential is low enough, i.e., below 5%, the tax avoidance benefit is close to zero.

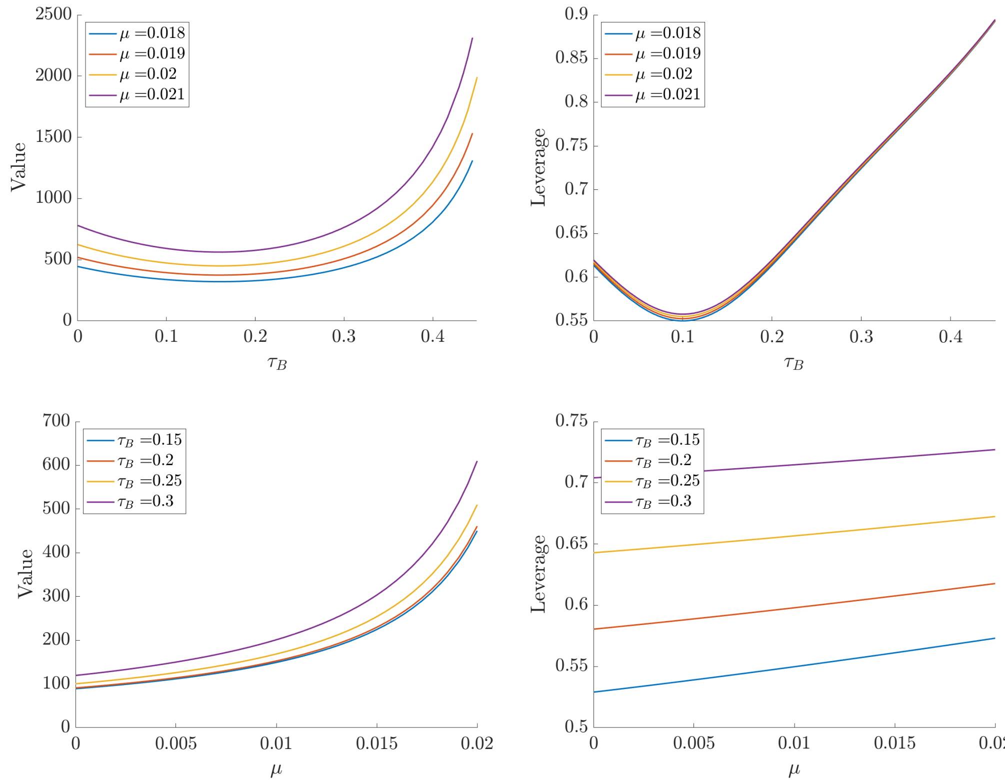

Figure 2: Effects on value function (left panels) and leverage (right panels), expressed as functions of effective tax rate τ_B (top panels) and of future profitability μ(bottom panels) of different values of the same variables.

μ. For example, given $\tau_B = 0.25$, an increase of μ from its benchmark value (0.02) to 0.021 leads to a dramatic increase in V (by 25.1%). In all cases, the minimum value is obtained when $\tau_A = \tau_B = 0.15$. Not surprisingly, L is also increasing in tax differential, although its sensitivity to changes in μ is almost negligible.

Bottom panels deal with the sensitivity analysis of τ_B. The left plot shows that, in line with our previous results, V is increasing in τ_B for any value of μ. Moreover, the higher the rate τ_B, the higher the MNC's value, given $\tau_A = 0.15$. For example, if $\mu = 0.01$, an increase of τ_B from its benchmark value (0.25) to 0.30 increases V by 19.3%. In addition, the right panel shows that L is also increasing in τ_B. In other terms, an increase in the tax differential reduces the tax burden and allows the MNC to retain more resources: coeteris paribus, the default risk decreases and encourages the MNC to borrow more.

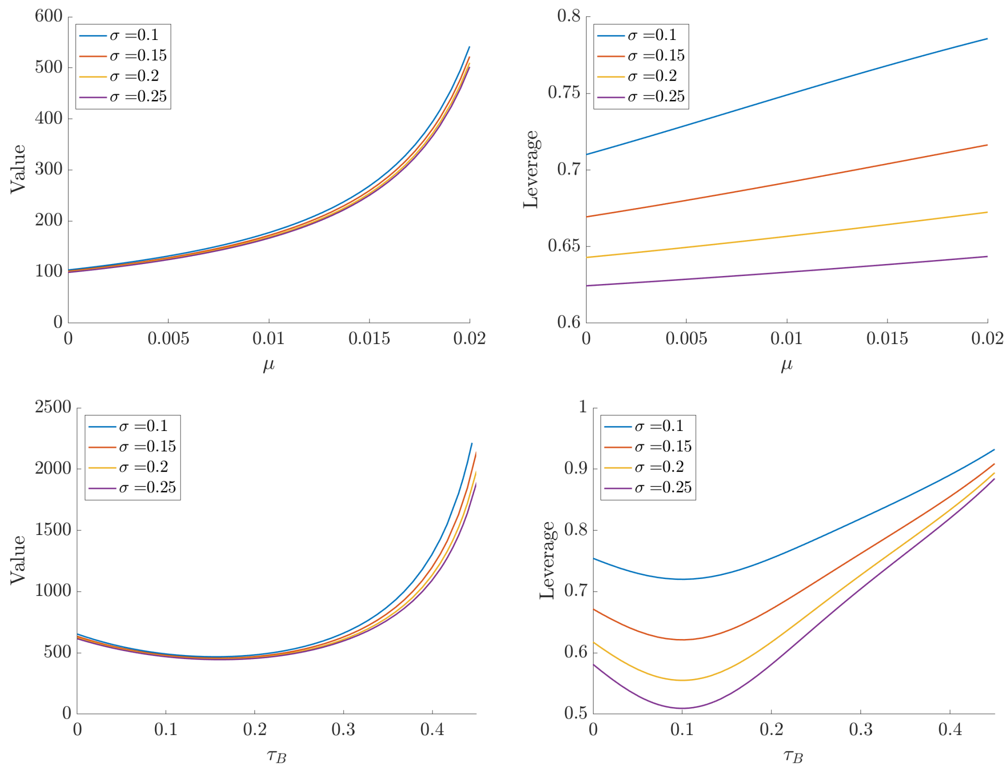

Figure 3: Effects on value function (left panels) and leverage (right panels), expressed as functions of future profitability μ (top panels) and of effective tax rate τ_B (bottom panels), of different values of EBIT's diffusion σ.

Figure 3 shows the effect of σ on V and L. Again, we set μ (upper panels) and τ_B (lower panels) on the horizontal axis. As can be seen, V is slightly decreasing in σ, since the higher the volatility of profit, the lower the value of E is. This effect dominates the negative one on D. For example, for $\mu = 0.01$, an increase in σ from its benchmark value (0.2) to 0.25 leads to a decrease in V and in L by -1.3% and -3.6%, respectively. Similarly, when τ_B is on the x-axis, the decrease in both V and L is respectively -1.6% and -4.3%.

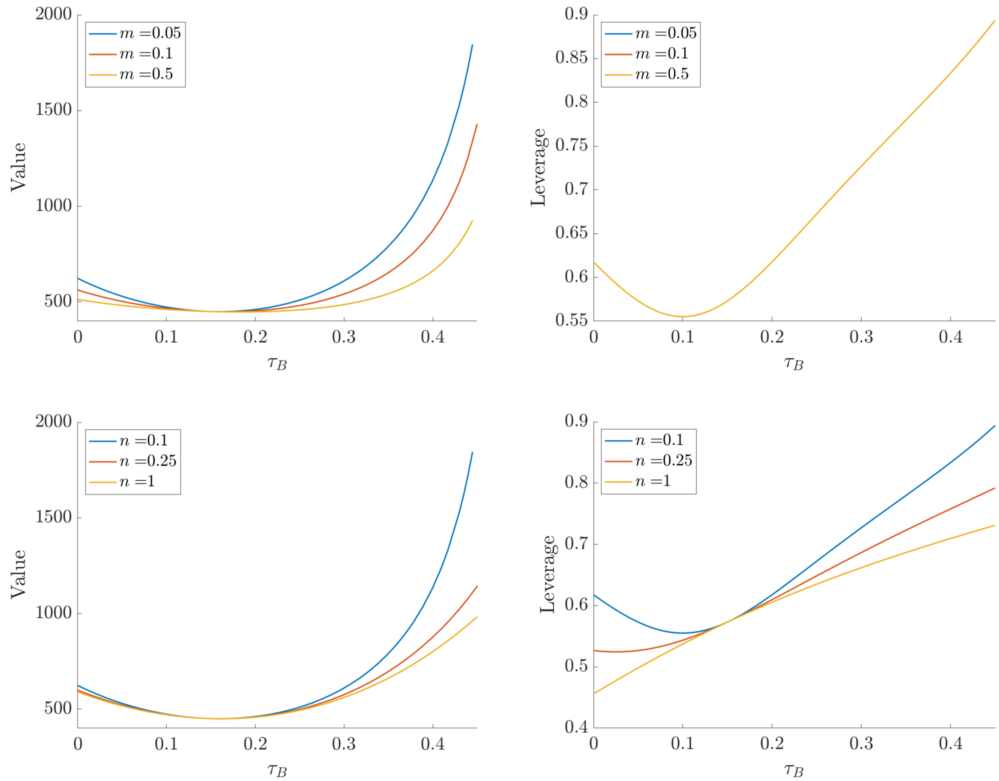

Figure 4: Effects on value function (left panels) and leverage (right panels), expressed as functions of effective tax rate τ_B, of different values of scale parameter cost of TP m (upper panels) and of DS n (bottom panels).

Figure 4 finally shows the effects of both m and n on V and L, for any given value of τ_B.[18] As can be seem, V is decreasing both in m and n. In other terms, the more costly the TP and DS activities, the lower the MNC's value is. For example, increasing m from its benchmark value (0.05) to 0.1 lowers V by -5.6%. Similarly, the reduction of V due to an increase in n from its benchmark value (0.1) to 0.25 is equal to -2.2%.

It is worth noting that L is unaffected by m since, given (19), the changes in both E and D are such that leverage remains unchanged. Moreover, L is decreasing in n: this is due to the fact that an increase in n raises E and

[18] We show only plots with τ_B set on the horizontal axis as it is more useful to see the combined effect of τ_B and one between m and n, since they are all determinants of the optimal shares of TP and DS, as from equation (8).

reduces D: this latter effect dominates the former one.

4 Conclusion

In this paper we have introduced a theoretical model aimed at describing a representative MNC's choices, under default risk. In particular, we have focused on tax avoidance strategies in a risky context.. The study shows that results dramatically differ from the ones obtained in a deterministic context. Unlike most literature, it has considered TP and DS together. In order to analyze the effects of volatility, we have run numerical simulations, where we show that results dramatically differ from deterministic ones.

More in detail, we have found a strong evidence of the existence of a positive effect on MNC's value due to the exploitation of tax avoidance practices. We have also observed the greater relevance of TP, compared to DS, finding a theoretical confirmation of the empirical evidence highlighted by Schenkelberg (2020). Then, we have studied how the riskiness of the environment impacts on the MNC's capital structure. We have in fact noticed that EBIT's variability, despite a minimal negative effect on the value function, dramatically reduces the leverage ratio. Finally, we have investigated the effects of the cost of tax avoidance practices. Despite the limit represented by separate quadratic concealment costs for TP and DS, we have studied the effects on MNC's indicators, highlighting how the dynamics of equity and debt lead to different effects on the leverage ratio. Our results have a clear policy implication: disregarding volatility leads to very simple models. However, the policy recommendations arising from such simplified frameworks are remarkably wrong.

A Appendix

A.1 The value of equity

A.1.1 The derivation of (5)

In order to derive the value of equity, it is first necessary to rearrange the net profit defined in equation (3) as:

$$\Pi^N = [-1 + \tilde{\tau} + (\tau_B - \tau_A)\gamma - \nu(\gamma)]\, C + [1 - \tilde{\tau} + (\tau_B - \tau_A)\alpha - \phi(\alpha)]\, \Pi,$$

that is as the sum of two terms: one constant in Π, namely $a \equiv [-1 + \tilde{\tau} + (\tau_B - \tau_A)\gamma - \nu(\gamma)]\, C$, and one proportional to the same variable, namely $b\Pi$, with $b \equiv [1 - \tilde{\tau} + (\tau_B - \tau_A)\alpha - \phi(\alpha)]$. Applying Itô's lemma to equation (4) the following second order differential equation is:[19]

$$\frac{\sigma^2}{2}\Pi^2 E_{\Pi\Pi} + \mu\Pi E_\Pi - rE = -a - b\Pi. \tag{20}$$

The general solution of equation (20) is:

$$E = H_0 + H_1\Pi + A\Pi^\beta,$$

Substituting it into (20) thus leads to:

$$\frac{\sigma^2}{2}\Pi^2\beta(\beta-1)A\Pi^{\beta-2} + \mu\Pi\left(H_1 + \beta A\Pi^{\beta-1}\right) - r\left(H_0 + H_1\Pi + A\Pi^\beta\right) + a + b\Pi = 0,$$

which is satisfied if:

$$\begin{cases} \frac{\sigma^2}{2}\beta(\beta-1) + \mu\beta - r = 0 \\ \mu H_1 - rH_1 + b = 0 \\ -rH_0 + a = 0 \end{cases} .$$

From the second and the third equations it easily follows that $H_0 = ar^{-1}$ and $H_1 = b(r-\mu)^{-1}$, respectively. Moreover, the solution of the first equation leads to:

$$\beta_{1,2} = \frac{1}{2} - \frac{\mu}{\sigma^2} \pm \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}}, \tag{21}$$

[19] The dependency of E on Π is omitted to lighten the notation. Moreover, we denote the two first derivatives of E with respect to Π as E' and E'' respectively.

where $\beta_1 > 1$ and $\beta_2 < 0$. It follows that the general solution of equation (20) is:

$$E(\Pi) = \left[-1 + \tilde{\tau} + (\tau_B - \tau_A)\gamma - \nu(\gamma)\right]\frac{C}{r} + \left[1 - \tilde{\tau} + (\tau_B - \tau_A)\alpha - \phi(\alpha)\right]\frac{\Pi}{r-\mu} + \sum_{i=1}^{2} A_i \Pi^{\beta_i}.$$

After some rearrangements, we therefore obtain (5).

A.1.2 The derivation of (6)

Under the assumption that financial bubbles do not exist, we set $A_1 = 0$. Since, given $\overline{\Pi}$, the value of equity b.d. and a.d. must be equal, it holds that:

$$E\left(\overline{\Pi}\right) = (1 - \widetilde{\tau})\left(\frac{\overline{\Pi}}{\delta} - \frac{C}{r}\right) + (\tau_B - \tau_A)\left[\alpha\frac{\overline{\Pi}}{\delta} - \gamma\frac{C}{r}\right] - \phi(\alpha)\frac{\overline{\Pi}}{\delta} - \nu(\gamma)\frac{C}{r} + A_2\overline{\Pi}^{\beta_2} = 0,$$

Solving for A_2 gives:

$$A_2 = -\left[(1 - \widetilde{\tau})\left(\frac{\overline{\Pi}}{\delta} - \frac{C}{r}\right) + (\tau_B - \tau_A)\left(\alpha\frac{\overline{\Pi}}{\delta} - \gamma\frac{C}{r}\right) - \phi(\alpha)\frac{\overline{\Pi}}{\delta} - \nu(\gamma)\frac{C}{r}\right]\overline{\Pi}^{-\beta_2}, \quad (22)$$

Using (5) and (22) allows us to obtain (6).

A.1.3 The derivation of (8), (9) and (10)

To find the optimal controls of $\overline{\Pi}$, α and γ that solve problem (7) maximizing the value of equity shown in equation (6), it is necessary to set all its partials equal to zero. With regard to the optimal default $\overline{\Pi}$,we find that:

$$\begin{aligned}\frac{\partial E(\Pi)}{\partial \overline{\Pi}} &= -\frac{1}{\delta}\left[1 - \widetilde{\tau} + (\tau_B - \tau_A)\alpha - \phi(\alpha)\right]\left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_2} \\ &\quad + \left[(1 - \widetilde{\tau})\left(\frac{\overline{\Pi}}{\delta} - \frac{C}{r}\right) + (\tau_B - \tau_A)\left(\alpha\frac{\overline{\Pi}}{\delta} - \gamma\frac{C}{r}\right) - \phi(\alpha)\frac{\overline{\Pi}}{\delta} - \nu(\gamma)\frac{C}{r}\right]\frac{\beta_2}{\overline{\Pi}}\left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_2} = 0,\end{aligned}$$

from which it easily follows that:

$$\overline{\Pi}^* = \frac{\beta_2}{\beta_2 - 1}\frac{\left[1 - \widetilde{\tau} + (\tau_B - \tau_A)\gamma + \nu(\gamma)\right]}{\left[1 - \widetilde{\tau} + (\tau_B - \tau_A)\alpha - \phi(\alpha)\right]}\frac{\delta}{r}C. \quad (23)$$

Let us next focus on the optimal tax avoidance choices. Differentiating $E(\Pi)$ with respect to α and γ gives:

$$\frac{\partial E(\Pi)}{\partial \alpha} = \left[(\tau_B - \tau_A) - m\alpha\right]\left[\frac{\Pi}{\delta} - \frac{\overline{\Pi}}{\delta}\left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_2}\right] = 0$$

$$\frac{\partial E(\Pi)}{\partial \gamma} = -\left[(\tau_B - \tau_A) + n\gamma\right]\left[1 + \left(\frac{\Pi}{\overline{\overline{\Pi}}}\right)^{\beta_2}\right] = 0,$$

respectively. Their solutions easily lead to equation(8). Substituting into equation (23) the optimal controls for α and γ, we obtain (9). Finally, by substituting the values of α^* and γ^* into equation (6) the value of $E(\Pi)$, of equation (10), finally follows.

A.2 The value of debt

A.2.1 The derivation of (12)

Applying Ito's lemma to the increment $dD(\Pi)$, the value of debt before default in equation (11) can be rewritten as follows:[20]

$$\frac{\sigma^2}{2}\Pi^2 D_{\Pi\Pi} + \mu\Pi D_\Pi - rD = -C. \tag{24}$$

The general solution of (24) is:

$$D = K + B\Pi^\beta.$$

Rearranging therefore gives:

$$\left[\frac{\sigma^2}{2}\beta(\beta-1) + \mu\beta - r\right]B\Pi^\beta - rK + C = 0,$$

which holds if:

$$\begin{cases} \frac{\sigma^2}{2}\beta(\beta-1) + \mu\beta - r = 0 \\ -rK + C = 0 \end{cases}.$$

From the second equation, it easily follows that $K = Cr^{-1}$, while the first one is equal to the one in the case of equity and then leads to the same β_1 and β_2. It finally follows the general solution of equation (24) , that immediately leads to the value of debt before default in equation (12).

[20]The dependency of D on Π is omitted to lighten the notation. Moreover, we denote the two first derivatives of D with respect to Π as D' and D'' respectively.

A.2.2 The derivation of (13)

For the same reason detailed in section A.1.2, B_1 must be set equal to 0, leaving only the constant B_2 to be computed. Since in correspondence of default trigger $\overline{\Pi}$ the value of debt before and after default must be equal and set to zero, it holds that:

$$D\left(\overline{\Pi}\right)=\frac{C}{r}+B_2\overline{\Pi}^{\beta_2}=\Omega\frac{\left[(1-\tau_A)(\theta+\alpha)+(1-\tau_B)(1-\theta-\alpha)-\phi(\alpha)\right]\overline{\Pi}}{\delta},$$

from which, also recalling the definition of effective tax rate shown in footnote 8, the value of B_2 easily follows:

$$B_2=\left[\Omega\frac{\left[1-\widetilde{\tau}+(\tau_B-\tau_A)\alpha-\phi(\alpha)\right]\overline{\Pi}}{\delta}-\frac{C}{r}\right]\overline{\Pi}^{-\beta_2},$$

which once substituted in the equation above leads to equation (13). The value of debt after default can be simplified, in the same way, by the definition of effective tax rate.

A.2.3 The derivation of (15)

The derivative with respect to α of the value of debt after default, defined in equation (13), is:

$$\frac{\partial D(\Pi)}{\partial\alpha}=\Omega\frac{\left[(1-\tau_A)-(1-\tau_B)-m\alpha\right]\Pi}{\delta},$$

which, once set equal to zero, leads to the same solution of shareholders' problem before default, shown in equation 8. By substituting this result into equation (13) and after some rearrangements, equation (15) easily follows.

A.3 The value of the MNC

The value of the MNC defined in equation (17) can be rearranged as:

$$\begin{aligned}V(\Pi)=&\left[1-\widetilde{\tau}+\tfrac{(\tau_B-\tau_A)^2}{2m}\right]\tfrac{\Pi}{\delta}+\left[\widetilde{\tau}+\tfrac{(\tau_A-\tau_B)^2}{2n}\right]\tfrac{C}{r}\\&-\left\{(1-\Omega)\left(1-\widetilde{\tau}+\tfrac{(\tau_B-\tau_A)^2}{2m}\right)\tfrac{\Delta C}{\delta}+\left[\widetilde{\tau}+\tfrac{(\tau_A-\tau_B)^2}{2n}\right]\tfrac{C}{r}\right\}\left(\tfrac{\Pi}{\Delta C}\right)^{\beta_2},\end{aligned}$$

whose derivative with respect to C is:

$$\frac{\partial V(\Pi)}{\partial C} = \left[\widetilde{\tau} + \frac{(\tau_A-\tau_B)^2}{2n}\right]\frac{1}{r} - (1-\beta_2)\left\{(1-\Omega)\left[1-\widetilde{\tau}+\frac{(\tau_B-\tau_A)^2}{2m}\right]\frac{\Delta}{\delta} + \left[\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}\right]\frac{1}{r}\right\}\left(\frac{\Pi}{\Delta C}\right)^{\beta_2}.$$

By setting it equal to zero and rearranging, equation (18) follows. In addition, thanks to this result, we can rewrite the definition of the optimal default trigger provided in equation (9) as:

$$\overline{\Pi}^{*}(C^{*}) = \frac{\delta}{r}\left[\frac{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}}{(1-\beta_2)\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}\left[1-\widetilde{\tau}-\frac{(\tau_A-\tau_B)^2}{2n}\right]+\left[\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}\right]\right]}\right]^{-\frac{1}{\beta_2}}\Pi,$$

from which, after some rearrangements, equation (19) easily follows.

A.4 Derivatives of optimal controls with respect to m and n

As regards $\overline{\Pi}^*(C^*)$, we notice that it is unaffected by m. Thus, we immediately conclude that $\partial\overline{\Pi}^*(C^*)/\partial m = 0$. Moreover, differentiating $\overline{\Pi}^*(C^*)$ with respect to n gives:

$$\frac{\partial\overline{\Pi}^*(C^*)}{\partial n} = \Pi\left[r(1-\beta_2)\right]^{\frac{1}{\beta_2}}\frac{1}{\beta_2}\left[\frac{\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}(1-\widetilde{\tau})+\widetilde{\tau}\right]+\left[1-(1-\Omega)\frac{\beta_2}{\beta_2-1}\right]\frac{(\tau_A-\tau_B)^2}{2}n^{-1}}{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2}n^{-1}}\right]^{\frac{1}{\beta_2}}\frac{\frac{(\tau_A-\tau_B)^2}{2}\left(\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}(1-\widetilde{\tau})+\widetilde{\tau}\right]-\left[1-(1-\Omega)\frac{\beta_2}{\beta_2-1}\right]\widetilde{\tau}\right)}{\left(\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2}n^{-1}\right)^2}n^{-2}.$$

Notice that all factors are positive, with the only exception of β_2^{-1}. This implies that, given (21), the derivative $\partial\overline{\Pi}^*(C^*)/\partial n$ is negative.

As regards C^*, we find that:

$$\frac{\partial C^*}{\partial m} = -\left[\frac{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}}{(1-\beta_2)\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}\left[1-\widetilde{\tau}-\frac{(\tau_A-\tau_B)^2}{2n}\right]+\left[\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2n}\right]\right]}\right]^{-\frac{1}{\beta_2}}\frac{\beta_2-1}{\beta_2}\frac{\Pi}{1-\widetilde{\tau}-\frac{(\tau_A-\tau_B)^2}{2n}}\frac{(\tau_B-\tau_A)^2}{2}m^{-2},$$

whose factors are all always positive. Given the initial minus, we conclude that $\partial C^*/\partial m < 0$. Differentiating with respect to n gives:

$$\begin{aligned}\frac{\partial C^*}{\partial n} = &\frac{\beta_2-1}{\beta_2}\left[1-\widetilde{\tau}+\frac{(\tau_B-\tau_A)^2}{2m}\right]\frac{r}{\delta}\Pi\left[\frac{(1-\beta_2)\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}-\widetilde{\tau}(1-\Omega)\frac{\beta_2}{\beta_2-1}+\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2}\left[1-(1-\Omega)\frac{\beta_2}{\beta_2-1}\right]n^{-1}\right]}{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2}n^{-1}}\right]^{\frac{1}{\beta_2}}\\ &\left[\frac{1}{\beta_2}\left[\frac{(1-\beta_2)\left[(1-\Omega)\frac{\beta_2}{\beta_2-1}-\widetilde{\tau}(1-\Omega)\frac{\beta_2}{\beta_2-1}+\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2}\left[1-(1-\Omega)\frac{\beta_2}{\beta_2-1}\right]n^{-1}\right]}{\widetilde{\tau}+\frac{(\tau_A-\tau_B)^2}{2}n^{-1}}\right]^{-1}\left(1-\widetilde{\tau}-\frac{(\tau_A-\tau_B)^2}{2}n^{-1}\right)^{-1}-\frac{\frac{(\tau_A-\tau_B)^2}{2}}{\left((1-\widetilde{\tau})n-\frac{(\tau_A-\tau_B)^2}{2}\right)^2}\right],\end{aligned}$$

whose factors of the first row are all positive. In the second row, we notice that both terms are negative (given $\beta_2^{-1} < 0$). It is straightforward to see that $\partial C^*/\partial n < 0$.

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