Excessive Risk Taking and the Maturity Structure of Debt*

Bertrand Djembissi †

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Abstract

This paper analyses the effect of short-term debt on equityholders risk taking decisions. We show that if short-term debt limits the expropriation of debtholders by equityholders, it does not however reduce the loss in tax shields associated to a low leverage. We then examine the incentive for equityholders to increase the firm risk when debtholders rather hold the option to swap their perpetual coupon bond with short-term debt. We find that, compared to standard short-term debt, this restructuring option dramatically limits debtholders expropriation, increases leverage and reduces the loss in tax shields due of asset substitution.

Keywords: Asset Substitution, Restructuring, Debt Maturity, Agency Costs.

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† CEFAB, CNAM PARIS, 40 Rue des Jeûneurs, 75002 Paris, France. Email: djembisb@cnam.fr. Tel:+33(0)158808345. Fax:+33(0)140272736.

1. Introduction

Asset substitution is one of the means by which equityholders can transfer wealth from creditors to themselves. Indeed, as Jensen and Meckling (1976) illustrated, in the presence of debt, limited liability introduces convexity in the equity function and therefore gives incentives to equityholders to alter the firm risk profile. Several tools have been proposed as a solution to this problem. Smith and Warner (1979) suggest that debt should be secured, whereas Green (1984) point out that convertible bonds can resolve the asset substitution problem. Diamond (1984) analyses the moral hazard counterpart of asset substitution, and shows that it may be reduced by firms using private/banks debt instead of public debt, due to the monitoring aspect of private debt. For Myers (1977), short term debt gives flexibility to future debt arrangement and therefore prevents firms with more growth opportunities from adopting suboptimal investment policies. However, a recent controversy has been raised against the conventional wisdom on the role of short-term debt in mitigating the asset substitution problem. For example, based on empirical evidence, Graham and Harvey (2001) conclude that "few executives feel that short-term borrowing reduce the chance that shareholders will want to take on risky projects". In the same vein, the analysis of Billett et al. (2007) supports the prediction that firms rather use restrictive covenants to control stockholder-bondholder conflicts over the exercise of growth options, and that short-term debt and restrictive covenants acts as substitutes in controlling such conflicts. On top of that, there are recent examples of corporate debt including a covenant that specifies a certain repayment policy. Bhanot and Mello (2005) investigate whether a rating trigger clause can reduce equityholder-debtholder conflict due to asset substitution. They conclude that, more than the trigger per se, the form of financing associated with the rating trigger is essential in reducing the cost of asset substitution.

In this paper we analyse how a trigger that reduces debt maturity may alter the incentive of equityholders to increase the firm risk after debt is in place. This *restructuring* decision is triggered by debtholders when the value of the cash flows falls to a certain level. When this cash flow level is reached, the consol bond is replaced by debt with finite average maturity. Hence, we may see the initial debt structure like a consol bond to which is attached an exchanged option.

To capture the essential elements of asset substitution we follow the framework of Décamps and Djembissi (2007). We consider a levered firm in which equityholders have the opportunity to alter the firm risk profile. Precisely, equityholders can switch to a riskier cash flows generating activity. This riskier activity is characterised by a lower risk-adjusted growth rate and a larger volatility for the cash flows process. The existence of this risk shifting option results in an inefficient transfer of wealth from debtholders to equityholders. However, rational debtholders anticipate such inefficient behaviour with the ex-ante consequence of lower leverage. The resulting equilibrium gives an insight into the impact of the maturity structure of debt on optimal capital structure and asset substitution costs. It also gives insight on the timing of debt restructuring with respect to the risk shifting time.

An ex-ante short term debt implies earlier repayment of debt principal. The first effect is a transfer of wealth from equityholders to debtholders in a short time horizon. This transfer increases the cost of debt for equityholders, and has a pervasive effect on risk shifting incentives. As illustrated by Leland (1998) and Ericsson (2000), this also increases the risk of default on debt at a given time horizon. This reduces the value of the risk shifting option for equityholders, and therefore attenuates their incentive to increase the firm's cash flows volatility. The interaction between these effects yields a marginal positive effect of short-term debt on both optimal capital structure and costs of asset substitution.

A trigger that reduces ex-post the maturity of debt imposes ex-post costs on equityholders, without requiring a wealth transfer from equityholders to debtholders in a short time horizon. Hence, in order to minimise the probability of reaching the restructuring trigger, equityholders optimally postpone high risk decisions. Consequently, by indexing debt refinancing decision on the risk shifting decision, debtholders can better control the incentive of equityholders to alter the firm risk profile. The existence of the restructuring trigger thus increases the firm's leverage close to that of a firm with no risk flexibility and significantly reduces the cost of asset substitution.

This paper ties on the strand of literature that analyses the role of debt restructuring on capital structure. Childs et al. (2005) examine numerically the interaction between financing and investment decisions in the presence of stockholder-bondholder conflicts. They find that with a dynamic debt policy, short-term debt significantly reduces the agency costs of investment distortions. Ju and Ou-Yang (2006) analyse the impact of a dynamic repricing of debt on asset substitution show that this arrangement significantly mitigate the asset substitution problem. Décamps and Djembissi (2007) find that secured debt reduces the cost of asset substitution, but only when the problem is severe. Hege and Mella-Barral (2000, 2005) focus on the renegotiation of debt service when default does not lead to the liquidation of the firm. They conclude, in particular, that flexibility in debt structure reduces the cost of default on debt.

The remainder of the paper is organised as follows. Section 2 presents a model of the levered firm with tax shields and default costs, and extends it with the risk shifting problem. Section 3 enrichs the previous section by allowing for short-term debt and debt restructuring . Section 4 discusses the impact of the restructuring trigger on equityholders risk shifting incentive. Closed form expressions for debt and equity are derived and the optimal restructuring trigger is characterised. Numerical implementation of the optimal capital structure is available in table 1 and table 2. These tables are used in section 5 to discuss the effect of finite maturity debt and the restructuring trigger on the costs of asset substitution. Section 6 concludes.

2. The model

The ideas presented in this subsection are adapted from Goldstein, Ju and Leland (2001) and more recently Leland (2007). The underlying state variable X is the cash flows generated by the firm's activity (that is the firm's earnings before interest and taxes (EBIT)). The cash flows process $(X_{t,A})_{t\geq 0}$ is defined by the following stochastic differential equation:

$$\frac{dX_{t,A}}{X_{t,A}} = \mu_A dt + \sigma_A dW_t, \tag{1}$$

where dW is the increment of a Wiener process, μ_A is the instantaneous risk-adjusted expected growth rate of the cash flows and σ_A the volatility of the growth rate. $(X^x_{t,A})$

represents the cash flows process $(X_{t,A})$ with initial value $X_{0,A} = x$. Because of the lognormal dynamics in equation (1), earnings are always positive. Modelling EBIT as the underlying state variable allows for example, to the treatment debt and equity consistently as claims on the future EBIT flows. We denote by θ the tax rate on corporate income. Investors are risk neutral and discount the future at rate[1] $r > \mu_A$. An unlevered firm entity enjoys no tax shields and faces no default risk. Hence, its value is equal to the expected discounted value of the future after tax cash flows:

$$\mathbb{E}\left[\int_0^\infty e^{-rt}(1-\theta)X^x_{t,A}dt\right] = \frac{(1-\theta)x}{r-\mu_A}, \tag{2}$$

where x is the initial value of the cash flows.

In order to analyse the impact on asset substitution of a trigger that reduces the maturity of debt, the value of the firm is evaluated under three different debt structures. (i) In the first structure, the firm issues a perpetual coupon bond and and faces the asset substitution problem. The capital structure is characterised by a coupon rate. (ii) In the second structure, the firm uses short-term debt as a potential solution to the asset substitution problem. The capital structure is then characterised by debt maturity and a coupon rate. (iii) In the third structure, debtholders hold the option to trigger the conversion of debt from a consol bond to debt with a finite maturity. In this case, the capital structure is characterised not only by debt maturity and a coupon rate, but also by the *restructuring time*, when debtholders exercise their option.

2.1. Capital Structure

The firm issues debt in order to take advantage of the tax shields offered for interest expenses. Tax benefits are received at rate θc until default on debt. We assume *cash flows based covenants*. Precisely, the failure of the cash flows to cover the coupon payment result in an immediate liquidation of the firm and the firm is taken over by debtholders. At liquidation, a fraction γ of the future cash flows is lost as liquidation costs. We assume the absolute priority rule. Hence, at liquidation, only the residual value of the firm is transferred to former debtholders.

[1] We assume that the present value of the cash flows is finite and therefore that $r - \mu_A > 0$.

2.2. Benchmark: A simple model for the levered firm

In this section the firm faces no asset substitution problem, and debt is a perpetual coupon bond. The value of cash flows at liquidation is $x_L \equiv x_L(c) = c$. The liquidation value of debt is then equal to

$$D(x_L(c)) = (1-\gamma)\frac{(1-\theta)x_L}{r-\mu_A} \equiv (1-\gamma)(1-\theta)\nu_A x_L. \tag{3}$$

Debt and equity are claims on the firm's cash flows. The value of debt is discounted value of coupons received up to default, plus the residual value of the firm at default, after incurring the liquidation cost. It writes

$$D_A(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_A x_L\right)\left(\frac{x}{x_L}\right)^{\alpha_A} \text{ for } x \geq x_L, \tag{4}$$

with $\alpha_A = -\frac{\mu_A}{\sigma^2} + \frac{1}{2} - \sqrt{(\frac{\mu_A}{\sigma^2} - \frac{1}{2})^2 + \frac{2r}{\sigma_A^2}}$ and $\nu_A = \frac{1}{r-\mu_A}$. Since $r > 0$ we have $\alpha_A < 0$. The value of equity, denoted E_A, is the discounted value of after taxes cash flows net of debt service, plus the net savings of not paying future coupons after default:

$$E_A(x) = (1-\theta)\left[\nu_A x - \frac{c}{r} + \left(\frac{c}{r} - \nu_A x_L\right)\left(\frac{x}{x_L}\right)^{\alpha_A}\right], \tag{5}$$

The value of equity is a convex function of the state variable if and only if the liquidation trigger is lower than the zero-net present value trigger. This implies that the asset substitution problem is relevant only for firms in which the cash flows' expected growth rate is very low compared to its volatility. Hence, without loss of generality, we consider firms characterised by a negative cash flows growth rate. This implies that the value of equity in equation (5) is increasing with the volatility of the cash flows, from which it follows that declining firms are those in which equityholders have an incentive to increase risk. At last, the value of the firm is given by

$$v_A(x) \equiv D_A(x) + E_A(x) = (1-\theta)\nu_A x + \frac{\theta c}{r} - \left(\gamma(1-\theta)\nu_A x_L + \frac{\theta c}{r}\right)\left(\frac{x}{x_L}\right)^{\alpha_A}. \tag{6}$$

Equation (6) shows that the value of the firm is equal to the present value of the cash flows, plus the present value of the tax benefit ,net of the opportunity cost of default. Equation (6) also shows that the value of the firm is concave in x and decreasing with the volatility. This implies that it is never socially optimal to increase risk. Therefore, the framework in which the firm has no risk flexibility will use as benchmark. The optimal capital structure is obtained from the coupon rate c that maximises the initial firm value.

2.3. A Model of Asset Substitution

We now extend the model of section 2.2 to allow for risk shifting. We assume that, at any time, equityholders hold the option to switch from a cash flows process (μ_A, σ_A) to another cash flows process (mu_B, σ_B), with a lower drift and a higher volatility. Formally, $\mu_B < \mu_A < 0$ and $(\sigma_A > \sigma_B > 0$. There is no monetary cost to switching, but the decision to switch is irreversible. Equityholders will switch to the riskier activity when the cash flows fall below a trigger x_S. This modelling of asset substitution is borrowed from Décamps and Djembissi (2007). Our main contribution is to extend the framework by allowing for finite maturity debt and debt restructuring. If we denote by τ_S the first time when the process $(X_{t,A})$ reaches the trigger x_S, then the dynamics of the cash flows process is given by the stochastic differential equation

$$\frac{dX_t}{X_t} = (\mu_A 1_{t<\tau_S} + \mu_B 1_{t>\tau_S})dt + (\sigma_A 1_{t<\tau_S} + \sigma_B 1_{t>\tau_S})dW_t \tag{7}$$

We post the notations: $\alpha_i \equiv -\frac{\mu_i}{\sigma^2} + \frac{1}{2} - \sqrt{(\frac{\mu_i}{\sigma^2} - \frac{1}{2})^2 + \frac{2r}{\sigma_i^2}}$ and $\nu_i = \frac{1}{r-\mu_i}$ where $i \in \{B, A\}$. Note that $\nu_B < \nu_A$. It also turns out that $\alpha_B > \alpha_A$. Before default, the firm is operating the riskier activity. Hence, the value of debt at default is $D(x_L) = (1-\gamma)(1-\theta)\nu_B x_L$, where the liquidation trigger is $x_L = c$. To ensure that risk shifting occurs before default, as we show in appendix, thanks to Décamps and Djembissi (2007), the following assumption is needed:

$$\frac{\alpha_A - \alpha_B}{\nu_A(1-\alpha_A) - \nu_B(1-\alpha_B)}\frac{1}{r} > 1 \tag{8}$$

For $x \geq x_S$, the value of debt is equal to the value of a perpetual coupon net of the opportunity cost of default:

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_L}\right)^{\alpha_B}. \tag{9}$$

Similarly, the value of equity is equal to the net present value of the cash flows net of the opportunity cost of risk shifting plus the savings from not paying coupons in the future:

$$\begin{aligned} E(x) = (1-\theta)\left(\nu_A x - \frac{c}{r}\right) - (1-\theta)(\nu_A - \nu_B)x_S\left(\frac{x}{x_S}\right)^{\alpha_A} \\ +(1-\theta)\left(\frac{c}{r} - \nu_B x_L\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_L}\right)^{\alpha_B} \end{aligned} \tag{10}$$

The value of the firm is equal to the present value of the cash flows plus the tax benefit net of both the opportunity cost of risk shifting and the cost of default.

$$\begin{aligned} v(x) = (1-\theta)\nu_A x + \frac{\theta c}{r} - (1-\theta)(\nu_A - \nu_B) x_S \left(\frac{x}{x_S}\right)^{\alpha_A} \\ - \left(\gamma(1-\theta)\nu_B x_L + \frac{\theta c}{r}\right) \left(\frac{x}{x_S}\right)^{\alpha_A} \left(\frac{x_S}{x_L}\right)^{\alpha_B} \end{aligned} \tag{11}$$

The expression for debt value $D(x)$ is decreasing with x_S, while the expression for equity value $E(x)$ is a hump shaped function of x_S. This illustrates the conflict within the firm on the choice of the risk policy. In addition, the expression for the firm value is also decreasing with x_S. Hence, the conflict between debtholders and equityholders on the risk policy induces a deadweight loss. It is easy and interesting to see that the value of equity can be written under the following form:

$$E(x) = E_A(x) + \mathbb{E}(e^{-r\tau_S}) \left[E_B(x_S) - E_A(x_S)\right]. \tag{12}$$

where E_A and E_B are the equity values functions, respectively under the low risk profile and the high risk profile, and the risk shifting time τ_S is the first passage time of the cash flows process at the trigger x_S. τ_S and thus x_S is in fact chosen to maximise the second part of the expression of $E(x)$, which corresponds to the value of the risk shifting option for equityholders.

When $x_L \leq x < x_S$, the firm is operating forever under the riskier activity. The expression for the claims is given by the formulae in section 2 with the appropriate subscript. For $x < x_L$, the firm is liquidated and the assets are transferred to the former creditors. The optimal capital structure is given by the coupon rate that maximises the initial firm value. Since equation (11) gives the value of the firm subject when there is a risk shifting problem, we can measure the agency costs of risk shifting by the difference between $v(x)$ and the value of the benchmark firm $v_A(x)$ given by equation (6). Precisely, the agency costs of asset substitution is

$$AC(x) = \frac{v_A(x) - v(x)}{v_A(x)} \tag{13}$$

The result $AC(x) > 0$ is the illustration of the excessive risk taking behavior of equityholders. Note that we can write $AC = \Delta d + \Delta e$ where Δd and Δe are respectively the variation in debt and equity values due to asset substitution. $\Delta d > 0$, $\Delta e < 0$ and $AC > 0$ summarises that asset substitution is a transfer of value from debtholders to equityholders with a deadweight loss. This deadweight loss in therefore a natural proxy for equityholders inefficient investment decisions.

3. Debt restructuring and Asset substitution

The objective of this section is to analyse the impact of a trigger that reduces the maturity of debt on both risk shifting incentives and agency costs of asset substitution. In section 3.1, we describe recall a modelling of short-term debt that accounts for a stationary capital structure. Section 3.2 presents a model where debtholders have the option to swap the consol bond for debt with finite maturity.

3.1. Modelling short-term debt

Short-term debt is modelled in the same spirit as Leland (1994b). At each point in time, the firm pays a constant coupon rate c and debt has a constant principal P. In addition, the firm continuously retires a fraction mP of outstanding debt. Such a refinancing policy may be achieved through the settlement of a sinking fund provision to retire debt principal. As suggested by Barnea et al. (1980), this strategy performs the same task as short-term debt in aligning the interests of stockholders with those of bondholders. For the convenience of a stationary debt policy, the fraction mP is replaced by debt with the same characteristics. New debt is sold at its market value. In this setting, debt structure has a finite average maturity $\frac{1}{m} = \int_0^\infty tme^{mt}dt$. The choice of debt principal offers an additional degree of freedom to the firm. However, the choice of debt principal does not directly affect the risk shifting policy. Hence, there is no loss of generality in assuming for simplicity that $P = \frac{c}{r}$. Contrary to Leland(1994b) where default is endogenously declared by equityholders, here, default on debt is triggered the first time at which cash flows from both operation and newly issued debt are not sufficient to cover debt service expenses. The net cost of debt refinancing is $m[\frac{c}{r} - D(x)]$. This cost is the retired fraction of debt principal (equal to $m\frac{c}{r}$) net of the proceeds obtained from issuing new debt (equal to $mD(x)$). In addition to the regular coupon c, this amount should be covered by the proceeds x: $x \geq m[\frac{c}{r} - D(x)] + c$. The default trigger is then the smallest cash flows level $x_L(c,m)$ that satisfies the previous inequality. Hence, $x_L(c,m) + mD(x_L(c,m)) = c + m\frac{c}{r}$. The value of debt after liquidation is equal to the present value of future cash flows, net of default costs: that is

$$D(x_L(c,m)) = (1-\gamma)(1-\theta)\nu_B x_L(c,m). \tag{14}$$

The expression of the default trigger is thus given by

$$x_L(c,m) = \frac{r+m}{1+m(1-\gamma)(1-\theta)\nu_B}\frac{c}{r} \tag{15}$$

The function $m \mapsto x_L(c,m)$ is increasing and

$$\lim_{m \to 0} x_L(c,m) = c. \tag{16}$$

This is consistent with section 2.2 where debt is a consol and the default trigger is $x_L = c$. As long as as debt is risky, the function $m \mapsto x_L(c,m)$ is increasing. This implies that in absence of the asset substitution problem, the optimal debt retirement rate is $m = 0$. A shorter maturity debt is associated to a higher likelihood of default. As shown by Décamps and Djembissi (2007), the risk shifting trigger chosen by equityholders is decreasing with the default trigger. In other words, a decrease in the maturity of debt induces a decrease in the risk shifting trigger. In the following, we discuss the tradeoff between these opposite effects of short-term debt.

3.2. Strategic debt restructuring

Because short-term debt increases the likelihood of default at a given point of time, the incentives of equityholders' to alter the firm risk profile is significantly affected when debt maturity is shortened. In the presence of asset substitution, rational debtholders could ex-ante require a short maturity for their claim. Anticipating this, equityholders would be willing to commit themselves not to alter the firm's risk profile. However, this effect is not internalised ex-ante, when issuing short-term debt. In this section, we propose a less restrictive refinancing policy in which, in addition to the consol bond, debtholders are given the option to exchange their claim for another with shorter maturity. This option is exercised whenever the cash flows drop to a very low level. By increasing the firm's risk profile, equityholders increase the probability of reaching the restructuring trigger. In this sense, the restructuring option threatens equityholders for a heavier debt structure, should they increase the cash flows' volatility. The incentive of equityholders to switch to riskier activities is thus considerably altered. The initial debt contract is the following. The firm chooses the capital structure that consists of the coupon rate c and the average maturity $\frac{1}{m}$ for the new debt, in the event of exercise of the restructuring option. When the restructuring process is triggered, that is at the first time when the cash flows process reaches a predefined trigger x_m, debtholders swaps the consol bond for a finite maturity debt . In the following we analyse the interaction between debt restructuring and risk shifting decisions. The pair (c, m) is chosen to maximise the firm's value, conditional to the strategic behaviour of both debtholders and equityholders.

4. Optimal debt structure and restructuring decision

Because older debt is replaced by debt with the same characteristics, the capital structure is stationary. In particular the total coupon and total principal remains constant through time. This implies that the firm value has an expression similar to the one in equation (11).

$$\begin{aligned} v(x, c, m, x_S) = (1-\theta)\nu_A x + \frac{\theta c}{r} - (1-\theta)(\nu_A - \nu_B) x_S \left(\frac{x}{x_S}\right)^{\alpha_A} \\ - \left(\gamma(1-\theta)\nu_B x_L(c,m) + \frac{\theta c}{r}\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_L(c,m)}\right)^{\alpha_B}. \end{aligned} \tag{17}$$

Not surprisingly, the firm value $v(x, c, m, x_S)$ is decreasing with the risk shifting trigger x_S. However, the firm value does not depend directly on the restructuring trigger[2] x_m. Hence, the effect of debt restructuring on the firm value is derived from its potential impact on the risk shifting trigger.

[2]Note however that at the optimal capital structure, the coupon rate and debt retirement rate will depend on the restructuring trigger, so that the optimal firm value depends on the restructuring trigger.

4.1. The optimal restructuring decision

At the restructuring time, the maturity of debt is reduced. This implies a higher default trigger ($x_L(c,m)$ is increasing with m) and a higher likelihood of default on debt. Two situations need to be considered, with respect to the ranking of the risk shifting trigger x_S and the restructuring trigger x_m.

(i) When $x_m \geq x_S$, the timing of the model is the following. Once debt is issued, debtholders receive coupon at rate c. Whenever the cash flows reach the trigger x_m, debtholders require the reduction of debt maturity. Then, when the cash flows drop to the trigger x_S, equityholders exercise their risk shifting option and, at the cash flows level $x_L \equiv x_L(c,m)$ the firm is liquidated. In this setting, debtholders, anticipating the strategic behaviour of equityholders, ex-ante protect themselves by reducing the maturity of their claim before the risk shifting option is exercised. The value of debt is then

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L\right)\left(\frac{x}{x_m}\right)^{\alpha_A}\left(\frac{x_m}{x_S}\right)^{\alpha_A(m)}\left(\frac{x_S}{x_L}\right)^{\alpha_B(m)} \tag{18}$$

where $\alpha_i(m) \equiv -\frac{\mu_i}{\sigma^2} + \frac{1}{2} - \sqrt{(\frac{\mu_i}{\sigma^2} - \frac{1}{2})^2 + \frac{2(r+m)}{\sigma_i^2}}$ and $\alpha_i = \alpha_i(0)$ for $i \in \{B, A\}$. The parameters $\alpha_i(m)$ satisfy $\alpha_i \geq \alpha_i(m)$ and $\alpha_B(m) > \alpha_A(m)$, and $\alpha_i(m)$ is decreasing with m. Hence, the expression for debt value is increasing with x_m. The restructuring trigger chosen by debtholders is then $x_m^* = x$. This is to say that the initial debt is a standard short-term debt, in the vein of Leland (1998) and Ericsson (2000). The main results are obtained by making the comparison with the model of long term debt in section 2.1. At the optimal capital structure, the value of the firm is increased and equivalently, the agency cost of asset substitution is reduced. Precisely, the presence of finite maturity debt reduces the value of the risk shifting option and increases the tax shields. This translates into a larger coupon rate and a lower risk shifting trigger. The ability of the firm to reduce the cost of asset substitution is nevertheless limited through time by the lower maturity of debt. To see this, let write the value of debt and the value of the firm under the following form:

$$v(x) = v_A^m(x) + \mathbb{E}(e^{-r\tau_S})\left[v_B^m(x_S) - v_A^m(x_S)\right] \tag{19}$$

and

$$D(x) = D_A^m(x) + \mathbb{E}(e^{-(r+m)\tau_S})\left[D_B^m(x_S) - D_A^m(x_S)\right] \tag{20}$$

where v_A^m (resp. D_A^m) and v_B^m (resp. D_B^m) refer to the values of the firm (resp. debt), respectively under the low risk profile and the high risk profile, when debt has the average maturity $\frac{1}{m}$. The loss due to the risk shifting option is discounted by the firm at the rate r and by debtholders at the rate $r+m$. Because of this difference in discount factors, short-term debt has the side effect of transferring value from equityholders to debtholders, regardless the risk shifting time and the optimal capital structure. Then, for a given pair (c, x_S), the relative contribution of Δd and Δe (the variation in debt and equity values due to asset substitution) to the agency costs ($AC = \Delta d + \Delta e$) are modified by the shorter maturity, without any effect on the level of these agency costs. This artificial increase in leverage exacerbates the asset substitution problem. Hence, at the optimal capital structure, the firm will set too low maturity and coupon rate for debt. This property of short-term debt limits its effects on the risk shifting decision, and on the agency costs.

(ii) When $x_m \leq x_S$, the value of debt is

$$D(x,c,m,x_m,x_S) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L(c,m)\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_m}\right)^{\alpha_B}\left(\frac{x_m}{x_L(c,m)}\right)^{\alpha_B(m)}. \tag{21}$$

This expression for debt is also increasing with x_m. The optimal restructuring trigger x_m^* chosen by debtholders is therefore the larger trigger available. That is $x_m^* = x_S$. The value of debt and the value of the firm can then be expressed under the following form:

$$v(x) = v_A(x) + \mathbb{E}(e^{-r\tau_S})\left[v_B^m(x_S) - v_A^m(x_S)\right] \tag{22}$$

and

$$D(x) = D_A(x) + \mathbb{E}(e^{-r\tau_S})\left[D_B^m(x_S) - D_A^m(x_S)\right]. \tag{23}$$

By comparing these expressions with the expressions from equation (19) and equation (20), we observe that the side effect of short-term, induced by a difference in discount factors between debtholders and the whole firm, has disappeared. Now the effect of short-term debt on the firm value and leverage is incorporated into its the effect of short-term debt on the risk shifting trigger and on the coupon rate. This leads to the following characterisation of the optimal restructuring trigger x_m^*:

Proposition 4.1 *The optimal debt restructuring policy is to reduce debt maturity as soon as risk shifting is triggered:* $x_m^* = x_S$

This result points out the main feature of short-term debt. Debtholders have preference for short-term claims, because it covers themselves from premature default of equityholders. However, by transferring such value from equityholders to debtholders, short-term debt not completely play its role on equityholders incentives for risky projects. Proposition 4.1 tells that the restructuring option held by debtholders a threat towards equityholders, and has a more efficient effect on the agency costs of asset substitution.

4.2. Optimal risk shifting and capital structure

The value of equity is the difference between the value of the firm in equation (17) and the value of debt in equation (21), with the constraint $x_m = x_S$. Equityhdolders will choose a risk shifting trigger x_S that maximises the value of their claim:

$$x_S^* = Argmax_{x_S}\left[E(x,c,m,x_S) \equiv v(x,c,m,x_S) - D(x,c,m,x_S,x_S)\right]. \tag{24}$$

The first order condition to equation (24) is $\frac{\partial E(x,c,m,x_S)}{\partial x_S} = 0$, or equivalently $\frac{\partial D(x,c,m,x_S,x_S)}{\partial x_S} = \frac{\partial v(x,c,m,x_S)}{\partial x_S}$. Explicitly, x_S solves

$$\begin{aligned}
&-\frac{\alpha_B(m)-\alpha_A}{x_S}\Delta D(c,m))\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_L(c,m)}\right)^{\alpha_B(m)} \\
&= -(1-\alpha_A)(1-\theta)(\nu_A-\nu_B)\left(\frac{x}{x_S}\right)^{\alpha_A} - \frac{\alpha_B-\alpha_A}{x_L(c,m)}\Delta v(c,m))\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_L(c,m)}\right)^{\alpha_B-1}
\end{aligned} \tag{25}$$

where $\Delta D(c,m) \equiv \frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L(c,m)$ and $\Delta v(c,m) \equiv \gamma(1-\theta)\nu_B x_L(c,m) + \frac{\theta c}{r}$ are the costs of default, to debtholders and the firm respectively. The left hand side of equation(25) is the marginal change of debt in response to any marginal change in x_S whereas its right hand side is the corresponding marginal change in the firm value. It is easy to see that the first order condition is equivalent to the smooth pasting condition at the trigger x_S. Equation (25) can be rewritten as

$$\frac{\alpha_B(m) - \alpha_A}{\alpha_B - \alpha_A} \frac{\Delta D(c,m)}{x_S} \left(\frac{x_S}{x_L}\right)^{\alpha_B(m)} - \frac{\Delta v(c,m)}{x_S} \left(\frac{x_S}{x_L}\right)^{\alpha_B} = \frac{(1-\alpha_A)(1-\theta)(\nu_A - \nu_B)}{\alpha_B - \alpha_A}. \tag{26}$$

Let $\tilde{m}$ be the value of m for which $x_S = x_L$ is solution to equation (26). A debt average maturity lower than $\frac{1}{\tilde{m}}$ is typically value destroying. For $m \in (0, \tilde{m})$, equation (26) yields equityholders' optimal risk shifting trigger x_S^* as a function of (c, m). The optimal risk shifting trigger x_S^* is a linear function of the coupon rate. The value of the firm thus writes

$$v(c,m) \equiv v(c,x,x_S^*(c,m)). \tag{27}$$

The capital structure is then characterised by the pair (c, m) that maximises the firm value: $(c^*, m^*) = ArgMax_{(c,m)} v(c,m)$. Since no closed form value is available for $x_m^*(c,m)$, the next step is a numerical question.

5. Numerical Illustration

In this section, we provide a numerical illustration of the impact of short term debt and debt restructuring on the firm's leverage and on the agency costs of asset substitution. The figures are summarised in table 1. For comparison, Table 2 describes a scenario where asset substitution is a pure risk shifting problem as in Leland (1998) and Ericsson (2000). The values of parameters are the default cost ratio $\gamma = 0.3$, the tax rate $\theta = 0.3$ and the risk-free interest rate $r = 0.06$. These values are within the range generally used in the literature. Their choice may affect quantitatively the results, but will not qualitatively affect our findings. For some interesting comparative statics of these parameters on the capital structure, we may refer to Leland (1994a). The tables show four rows. The first row (a) corresponds to the benchmark firm of section 2.2 where there is no risk flexibility. The second row (b) is the model of section 2.3 where debt is a consol, and equityholders have the option to switch to a riskier activity. The third row (c) corresponds to the model of short-term debt that is presented in section that 3.1. The last row (d) illustrates the model of debt restructuring developped in section 4. Leverage is the ratio of debt value over firm value, whereas agency costs are measured against the benchmark firm. Considering the scenario of table 1:

The benchmark firm (table 1, row (a)): In the scenario (a) of table 1, the cash flows process initially has the drift-volatility pair $(\mu_A, \sigma_A) = (-0.02, 0.1)$. Equityholders have no risk flexibility, and leverage accounts for 61.80% of the firm value.

Asset Substitution (table 1, row (b)): Asset substitution is illustrated by equityholders' option to switch to the drift-volatility pair $(\mu_B, \sigma_B) = (-0.021, 0.4)$. Equityholders risk flexibility reduces leverage to 17.45% of the firm value, which is far below the benchmark leverage ratio. This decrease in leverage corresponds partly to an increase in the value of equity, that is the value of the risk shifting option. Hence, risk shifting corresponds to a transfer of wealth from debtholders to equityholders. The value of the risk shifting option is the difference between the value of equity from rows (a) and (b) in the tables. The decrease in leverage is also associated to a shortfall in the firm value, corresponding to the loss in tax shields. This deadweight loss represents here 10.49% of the value of a firm with no risk flexibility.

Short-term debt (table 1, row (c)): When debt initially has a finite maturity, leverage increases to 27.21% and the agency cost drops to 9.19% (by less than 1%). Short-term debt weakly attenuates the impact of asset substitution on the firm. . Note that with an average maturity for debt of 4.5 years (compared to the long term debt of row (b)), debt value is increased by 58%, the value of equity is reduced by 10.5%, and the firm's value is increased by only 1.45% . Hence, short-term debt has the effect of transferring wealth from equityholders to debtholders but is not able to prevent wealth transfer outside the firm [3].

Debt Restructuring (table 1, row (d)): When debtholders can trigger debt restructuring, the agency costs are substantially reduced and leverage is dramatically increased. Indeed, agency costs are reduced, by about 5%, to 4.05% of the value of a firm with no risk flexibility. Accordingly, leverage increases, by about 30%, to 47.80% of the value of

[3] While asset substitution results in a wealth transfer from debtholders to equityholders, this is not a problem per se. The essential feature of asset substitution is that the wealth transfer occurs with a deadweight loss, known as the agency costs of asset substitution. An efficient solution to asset substitution should therefore minimise these agency costs.

a firm with no risk flexibility. We can also compare this situation with the case of long term debt of row (b). With an average maturity of 28 years, debt value is increased by 193%, the value of equity is reduced by 32.21%, and the firm's value is increased by 7.17%. This finding clearly departs from the model with short-term debt. A threat to ex-post reduction of debt maturity is thus more efficient and less costly that a simple ex-ante reduction of debt maturity.

Similar observations are made in table 2.This table also illustrates that the cost of asset substitution is almost eliminated by using the restructuring option. Because the restructuring option limits the incentive of equityholders to expropriate debtholders, the value of equity in this case is closer to the value of equity in the benchmark, where the firm has no risk flexibility.

Some comments can be made with respect to the variation in equityholders and debtholders' wealth when moving from one debt structure to another. After debt issuance, the optimal scenario for equityholders is the one in which they can exercise the risk shifting option, without constraint on debt maturity (row (b) in the tables). However, this is not only the worst scenario for debtholders, but also for the whole firm. This has several implications. First, asset substitution does not only pit equityholders against debtholders, but also prevents the firm from extracting full tax shields. In this sense, the increase in the riskiness of the firm assets is an excessive risk taking. The agency costs, that is the loss in tax shields, are thus a natural proxy for the cost of this inefficient investment decision. Second, with the restructuring trigger, there is a swap component attached to debt. The value of this restructuring option can be measured as the difference between the value of the consol (row (b) in the tables) and the value of debt with the restructuring option (row (d) in the tables). Note that this value can be extracted ex-ante by equityholders by initially charging an appropriate price for debt. Third, the value of the restructuring option (for debtholders) is larger than the value of the risk shifting option (for equityholders). Hence, even if their claim will have a lower value ex-post, it is in the interest of equityholders to issue debt with a restructuring option. This is true as long as, equityholders can ex-ante extract the value of this option. These results show that while short-term debt has a negligible effect on the costs of asset substitution, a restructuring option does not limit the wealth transfer from debtholders to equityholders, but also restores to the firm the loss in tax shields associated to the asset substitution problem.

6. Conclusion

Conventional wisdom states that short-term debt is an adapted tool to eliminate equityholders' risk shifting incentive in a levered firm. In this paper, we show that while short-term debt limits the wealth transfer from debtholders to equityholders, it is rather less efficient when it comes to avoiding the transfer of tax shields outside the firm. We also analyse the role, on equityholders risk shifting decisions and firm leverage, of a threat of debt restructuring. This restructuring threat is raised by debtholders, who hold the option to swap their consol bond for debt with a predefined finite maturity. We show that the optimal restructuring time is also that of risk shifting. In this sense equityholders decide on both the restructuring time and the risk shifting time. By setting an imminent risk shifting time, equityholders expose themselves to the risk of premature default and takeover on the firm by debtholders. Such an event that could be postponed by choosing a lower risk shifting trigger. At the optimal capital structure, which is set to minimise the costs of asset substitution, this flexibility offered to equityholders is shown to be more efficient that standard short-term debt. Indeed, we find that when the restructuring option is attached to a consol bond, the agency cost of asset substitution is substantially reduced and the firm can increase tax shields by increasing its leverage to a level close to that of a firm with no asset substitution problem.

7. Appendix

Debt, equity and firm values

We describe in this section the procedure used to derive the value of debt and equity throughout the paper. Consider, on a given interval, the following dynamics for the firm cash flows

$$\frac{dX_t}{X_t} = \mu_i dt + \sigma_i dW_t \tag{A-1}$$

with $X_0 = x$ and $i \in \{A, B\}$. Let f denote the value of debt, equity or the firm value and $CF(X_t)$ denotes the cash flows rate associated to f. It is well known that if agents discount the future ar rate r, then f is solution of the following partial differential equation (PDE)

$$\frac{\sigma_i^2}{2} x^2 f''(x) + \mu_i x f'(x) + CF(x) = rf(x). \tag{A-2}$$

Equation (A-2) stipulates that in a risk neutral environment, all financial claims yield the same return r. The general solution to equation (A-2) has the following form

$$f(x) = f_0(x) + \phi x^\alpha, \tag{A-3}$$

where $f_0(x) \sim_{x \to \infty} f(x)$, ϕ is a constant determined by a specific boundary condition and $\alpha \in \{\alpha_A, \alpha_B, \alpha_A(m), \alpha_B(m)\}$ with

$$\alpha_i(m) = -\frac{\mu_i}{\sigma_i^2} + \frac{1}{2} - \sqrt{\left(\frac{\mu_i}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2(r+m)}{\sigma_i^2}} \tag{A-4}$$

and $\alpha_i \equiv \alpha_i(0)$ for $i \in \{A, B\}$. The appropriate value for α is obtained by identifying the dynamics of the cash flows ((μ_A, σ_A) or (μ_B, σ_B)) and debt retirement rate (0 or m) with respect to the cash flows level and the capital structure. We apply this methodology to sections 2.2 section 2.3 and section 4.1 in order to obtain hereafter the expressions for the values of debt and equity.

Debt, equity and firm values in section 2.2. The PDE (A-2) is solved on the interval $[x_L, +\infty)$ where $x_L = c$ is the liquidation trigger. The cash flows rate to debtholders is $CF(x) = c$. The boundary condition is $D_A(c) = (1-\gamma)(1-\theta)\nu_A c$ with $\nu_A \equiv \frac{1}{r-\mu_A}$, and the face value of debt is $\lim_{x\to\infty} D_A(x) = \frac{c}{r}$. This leads to

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_A c\right)\left(\frac{x}{c}\right)^{\alpha_A} \text{ for } x \geq c. \tag{A-5}$$

The cash flows rate to equityholders is $CF(x) = (1-\theta)(x-c)$. The boundary condition is $E_A(c) = 0$ and the face value of equity is $\lim_{x\to\infty} E_A(x) = (1-\theta)(\nu x - \frac{c}{r})$ lead to

$$E_A(x) = (1-\theta)\left[\nu_A x - \frac{c}{r} + \left(\frac{c}{r} - \nu_A c\right)\left(\frac{x}{c}\right)^{\alpha_A}\right] \text{ for } x \geq c. \tag{A-6}$$

The value of the firm is $v_A(x) \equiv E_A(x) + D_A(x)$.

Debt, equity and firm values in section 2.3. For $x \leq x_S$, the firm is operated under the high risk activity. Hence, the value of debt D_B and the value of equity E_B are given by equations (A-5) and (A-6), adjusted with the appropriate subscript "B". It then remains to solve the PDE for $x \geq x_S$ with the boundaries conditions $D(x_S) = D_B(x_S)$ and $E(x_S) = E_B(x_S)$. We then have

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - D_B(x_S)\right)\left(\frac{x}{x_S}\right)^{\alpha_A} \tag{A-7}$$

and

$$E(x) = (1-\theta)\left(\nu_A x - \frac{c}{r}\right) + \left(E_B(x_S) - (1-\theta)\left(\nu_A x_S - \frac{c}{r}\right)\right)\left(\frac{x}{x_S}\right)^{\alpha_A}. \tag{A-8}$$

By substituting the expressions of $D_B(x_S)$ and $E_B(x_S)$ we have, for $x \geq x_S$

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B c\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{c}\right)^{\alpha_B} \tag{A-9}$$

and

$$E(x) = (1-\theta)\left[\nu_A x - \frac{c}{r} - (\nu_A - \nu_B)x_S\left(\frac{x}{x_S}\right)^{\alpha_A} + \left(\frac{c}{r} - \nu_A c\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{c}\right)^{\alpha_B}\right]. \tag{A-10}$$

The value of the firm is directly obtained as $v(x) \equiv D(x) + E(x)$.

Debt, equity and firm values in section 4.1. Because cash flows received by equity-holders depend on debt value (due to the refinancing policy), the PDE followed by equity value depends on debt value as well. To keep things tractable, we first evaluate debt and firm values and then we deduce equity value. We provide in the following the details for obtaining the value of debt when debt restructuring is posterior to risk shifting. The reverse case is similarly obtained. Several regimes are possible:

For $x_L \leq x \leq x_m \leq x_S$, considering the net refunding cost $m(\frac{c}{r} - D(x))$, the cash flows accruing to total debtholders is $CF(x) = c + m(\frac{c}{r} - D(x))$. The value of debt therefore solves

$$\frac{\sigma_B^2}{2} x^2 D''(x) + \mu_B x D'(x) + c + m\frac{c}{r} = (r+m)D(x). \tag{A-11}$$

Here we have $\alpha = \alpha_B(m)$ with the boundary condition is $D(x_L) = (1-\gamma)(1-\theta)\nu_B x_L$. Hence,

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L\right)\left(\frac{x}{x_L}\right)^{\alpha_B(m)}. \tag{A-12}$$

For $x_L \leq x_m \leq x \leq x_S$, the value of debt solves

$$\frac{\sigma_B^2}{2} x^2 D''(x) + \mu_B x D'(x) + c = rD(x). \tag{A-13}$$

$\alpha = \alpha_B$ and a boundary condition is given by $D(x_m)$, deduced from equation (A-12). We obtain

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L\right)\left(\frac{x}{x_m}\right)^{\alpha_B}\left(\frac{x_m}{x_L}\right)^{\alpha_B(m)} \tag{A-14}$$

For $x_L \leq x_m \leq x_S \leq x$, the value of debt solves

$$\frac{\sigma_A^2}{2} x^2 D''(x) + \mu_A x D'(x) + c = rD(x). \tag{A-15}$$

With $\alpha = \alpha_A$ and the boundary condition given by $D(x_S)$ from equation (A-14), we have

$$D(x) = \frac{c}{r} - \left(\frac{c}{r} - (1-\gamma)(1-\theta)\nu_B x_L\right)\left(\frac{x}{x_S}\right)^{\alpha_A}\left(\frac{x_S}{x_m}\right)^{\alpha_B}\left(\frac{x_m}{x_L}\right)^{\alpha_B(m)}. \tag{A-16}$$

The value of the firm is $v(x) = v_B(x)$ for $x \leq x_S$. When $x \geq x_S$, The value of the firm solves

$$\frac{\sigma_A^2}{2} x^2 v''(x) + \mu_A x v'(x) + (1-\theta)x + \theta c = rv(x). \tag{A-17}$$

Straightforward computations then yield

$$
\begin{aligned}
v(x) = (1-\theta)\nu_A x + \frac{\theta c}{r} - (1-\theta)(\nu_A - \nu_B) x_S \left(\frac{x}{x_S}\right)^{\alpha_A} \\
- \left(\gamma(1-\theta)\nu_B x_L + \frac{\theta c}{r}\right) \left(\frac{x}{x_S}\right)^{\alpha_A} \left(\frac{x_S}{x_L}\right)^{\alpha_B}.
\end{aligned}
\tag{A-18}
$$

The expression for equity value is $E(x) = v(x) - D(x)$.

Table 1. Optimal capital structure and magnitude of the agency cost respectively for the benchmark where the firm has no risk flexibility (row (a)), for the basic model with risk flexibility (row (b)), for the model where debt is once and forever of finite maturity (row (c)) and finally for the framework where debt is optimally converted by debtholders from a long term to a short-term debt (row (d)). $v(x)$ is the optimal firm value. $c(x)$ is the optimal coupon rate. L (in percentage of the firm value) is the optimal leverage $(D(x)/v(x))$. AC (in percentage of the no risk flexibility firm value) is the magnitude of the agency cost, that is the shortfall in the firm value due to asset substitution. $\frac{1}{m}$ is the average maturity of debt. The parameters values are: the default cost ratio $\gamma = 0.3$, the tax rate $\theta = 0.3$, the fixed market interest rate $r = 0.06$ and the normalized initial cash flows value $x = 5$.

Table 1

$\mu_A = -0.02 \quad \Delta\mu = 0.1\%,\ \sigma_A = 0.1 \quad \Delta\mu = 30\%$						
	$v(x)$	E(x)	$c(x)$	$L(\%)$	$AC(\%)$	$\frac{1}{m}$(years)
(a) No risk flexibility	50.83	19.41	2.22	61.80	-	∞
(b) Basic model with risk shifting	45.50	37.56	0.57	17.45	10.49	∞
(c) Short-term debt	46.16	33.60	0.75	27.21	9.19	4.5
(d) Debt with restructuring option	48.77	25.46	1.57	47.80	4.05	28

Table 2. Optimal capital structure and magnitude of the agency cost respectively for the benchmark where the firm has no risk flexibility (row (a)), for the basic model with risk flexibility (row (b)), for the model where debt is once and forever of finite maturity (row (c)) and finally for the framework where debt is optimally converted by debtholders from a long term to a short-term debt (row (d)). $v(x)$ is the optimal firm value. $c(x)$ is the optimal coupon rate. L (in percentage of the firm value) is the optimal leverage $(D(x)/v(x))$. AC (in percentage of the no risk flexibility firm value) is the magnitude of the agency cost, that is the shortfall in the firm value due to asset substitution. $\frac{1}{m}$ is the average maturity of debt. The parameters values are: the default cost ratio $\gamma = 0.3$, the tax rate $\theta = 0.3$, the fixed market interest rate $r = 0.06$ and the normalized initial cash flows value $x = 5$.

Table 2

$\mu_A = -0.02 \quad \Delta\mu = 0,\ \sigma_A = 0.1 \quad \Delta\sigma = 30\%$						
	$v(x)$	$E(x)$	$c(x)$	$L(\%)$	$AC(\%)$	$\frac{1}{m}$(years)
(a) No risk flexibility	50.83	19.42	2.22	61.80	-	∞
(b) Basic model with risk shifting	45.04	35.04	0.84	22.22	11.80	∞
(c) Short-term debt	46.15	33.65	0.75	27.09	9.21	2.94
(d) Debt with restructuring option	50.44	19.85	2.10	60.65	0.77	10.2

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