Underinvestment, Capital Structure and Strategic Debt Restructuring

Grzegorz Pawlina*

September 2007

Abstract

This paper shows that shareholders' option to renegotiate debt in a period of financial distress *exacerbates* Myers' (1977) underinvestment problem at the time of the firm's expansion. This result is a consequence of a higher wealth transfer from shareholders to creditors occurring upon investment in the presence of the option to renegotiate. This additional underinvestment is eliminated by granting the creditors the entire bargaining power. In such a case, renegotiation commences at the shareholders' bankruptcy trigger so no additional wealth transfer occurs. It is also shown that the presence of a positive NPV investment opportunity combined with high shareholders' bargaining power may increase the likelihood of strategic default. Finally, the interaction of the growth and debt renegotiation options reduces the optimal leverage, which contributes to explaining the empirically observed low leverage ratios.

Keywords: underinvestment, debt financing, Nash bargaining solution, endogenous bankruptcy, capital structure puzzle

JEL classification: C61, D81, G31

---

*Department of Accounting and Finance, Lancaster University Management School, LA1 4YX, United Kingdom, email: g.pawlina@lancaster.ac.uk. I am grateful to Thomas Dangl, Avinash Dixit, Ulrich Hege, Peter Kort, Bart Lambrecht, Antonio Mello, Lukasz Pomorski, Luc Renneboog, Mark Shackleton, Grzegorz Trojanowski, and seminar participants at CERGE-EI at Prague, Erasmus University Rotterdam, Free University Brussels (ECARES), Lancaster University, Norwegian School of Management, and Tilburg University for valuable comments and suggestions. All remaining errors are mine.

1 Introduction

One of the consequences of debt financing is its influence on the firm's expansion policy. As it is known from Myers (1977), the presence of outstanding (risky) debt leads to underinvestment, that is, a situation in which some positive net present value (NPV) projects are foregone. Although the impact of debt on the firm's investment policy has been widely discussed in the literature, the existing contributions yield differing predictions concerning the effect of the renegotiability of outstanding debt on investment (see Myers (1977), Mella-Barral and Perraudin (1997), and Mauer and Ott (2000)). In a unified dynamic model of a levered firm, I explicitly analyze how the possibility of debt renegotiation upon financial distress (before or after investment) affects the optimal exercise policy of the growth option. Hence, I aim at reconciling a number of contributions investigating the impact of debt renegotiability on (dis)investment decisions.

In the paper it is shown that the possibility of renegotiating the debt contract upon financial distress exacerbates the underinvestment problem at the times of the firm's expansion. This result is based on the observation that upon investment a wealth transfer occurs from the firm's shareholders to its creditors. This wealth transfer is higher if shareholders have an option to renegotiate the original debt contract upon financial distress. Without the option to renegotiate, the wealth transfer from shareholders to creditors corresponds to the reduction in the value of the shareholders' option to go bankrupt.[1] When future renegotiation is possible, the wealth transfer equals the reduction in the option value to default strategically. As the reduction in the latter value is higher than the reduction in the value of the bankruptcy option, shareholders wait longer with investment (that is, until their growth option is deeper in-the-money) in the presence of the renegotiation option. This additional source of inefficiency in the investment policy has a magnifying effect on the agency cost of debt and directly affects the valuation of corporate securities. Furthermore, the interaction between the investment and strategic default options is shown to negatively affect the optimal leverage ratio, which is a step towards explaining the empirically observed low levels of leverage.

The additional underinvestment attributable to the renegotiability of debt does not occur if the entire bargaining power accrues to creditors. In such a case, creditors

[1] For literature on debt overhang, see, for example, Myers (1977), Mello and Parsons (1992), Parrino and Weisbach (1999), and Mauer and Ott (2000).

collect the whole surplus from bargaining and shareholders realize their outside option, which is equal to zero. Since this equals their payoff from bankruptcy, the option to renegotiate is worth exactly the value of the option to go bankrupt. As a consequence, the magnitudes of the wealth transfer with and without the option to renegotiate are the same and so are the expansion policies.

As it is known from the literature, the presence of the option to renegotiate depends on the structure of debt. In particular, renegotiation is expected to be feasible if the number of the firm's creditors is low (see Bolton and Scharfstein (1996), and Hege and Mella-Barral (2005)). The limiting case of a single issue of private debt (a bank loan) is associated with the least costly renegotiation. On the opposite side of the spectrum lies diffusely held public debt, which can make renegotiation prohibitively expensive (Hackbarth, Hennessy, and Leland (2007)). This is due to the co-ordination among the creditors being hardly feasible as a result of a free-rider problem and, possibly, of different seniority classes (Hege and Mella-Barral (2005)). Such a view is supported by the existing empirical evidence. The ratio of public to private debt and the number of bond issues are shown to reduce the probability of successful out-of-court debt restructuring (Asquith and Scharfstein (1994)) and to be negatively correlated with the deviations from the absolute priority rule (APR) (Franks and Torous (1994)).

The outcome of renegotiation is determined by the distribution of bargaining power between the firm's owners and its creditors. Usually, the bargaining power of the firm vis-à-vis its bank would be limited when the firm is relatively young and small and when it uses a portfolio of the bank's services. Consequently, the share of the renegotiation surplus received by the bank is substantial. The opposite holds for large corporations, especially those with legal departments specialized in debt restructuring. Higher bargaining power of the shareholders is also expected if the management owns a large fraction of the firm's equity. In such a situation, the alignment of managerial interests with shareholders' objectives is higher and so is the effort exerted in the renegotiation process (Davydenko and Strebulaev (2007)). Finally, when corporate debt is held by multiple creditors, their bargaining power may be relatively small, again, due to arising coordination problems (see Hege and Mella-Barral (2005)).

Subsequently, I analyze the effect of the firm's growth option on its optimal debt restructuring policy. I find that the presence of a positive NPV project, in combination with high debtors' bargaining power, is likely to result in an *earlier* timing of debt renegotiation.

Finally, I show that the possibility of renegotiating the debt contract can reduce the problem of premature liquidation. This is due to the fact that after default the firm remains in the hands of the original shareholders, who can run it more efficiently.[2] However, early liquidation cannot be fully avoided, which results from the adverse impact of the suboptimal investment policy on the going-concern value of the firm.

The model is based on the following assumptions. The firm has an investment opportunity to scale up its activities upon incurring an irreversible cost. The cash flow of the firm follows a random process and the firm has to pay an instantaneous coupon on its outstanding debt. Failure to pay the coupon triggers bankruptcy. Following Mella-Barral and Perraudin (1997) and Fan and Sundaresan (2000), I allow for the possibility of renegotiating the coupon payment so that bankruptcy can be avoided and the surplus be split among the equityholders and creditors.[3]

A number of existing contributions can be nested in this paper's framework. Setting the coupon level equal to zero leads to the basic model of Dixit and Pindyck (1994) with the firm scaling up its activities. Excluding the renegotiation possibility reduces my model to Mauer and Ott (2000). By setting the investment cost to infinity and liquidation value to zero, one arrives at Fan and Sundaresan (2000), whereas imposing a prohibitively high investment cost in combination with take-it or leave-it offers and no taxes reduces the model to Mella-Barral and Perraudin (1997).

Consequently, this paper builds upon Mauer and Ott (2000), who analyze the interaction between leverage and the investment option when renegotiation is not allowed for, and both Mella-Barral and Perraudin (1997), and Fan and Sundaresan (2000), who focus on strategic debt service.[4] Following these contributions, I restrict the cost of

[2]These results show the limitations of the static model of Myers (1977). In his case, the investment and liquidation decisions are made simultaneously so that the possibility of renegotiation enhances investment and reduces (inefficient) liquidation. In the present dynamic model, renegotiation reduces liquidation in bad states of nature but (anticipated by the shareholders in good states of nature) also impairs the investment activity.

[3]The possibility of debt renegotiation at the exercise boundary of the growth option is precluded. This assumption can be motivated in the following way: suppose that there is a positive fixed cost of renegotiation and the scale of a single expansion is not too large. In such a case, the benefits of renegotiation at an expansion threshold will not compensate for this cost. At the same time, (costly) renegotiation at the lower boundary may still be optimal as its (positive) effect on the value of the firm is likely to be substantial. Consequently, ruling out renegotiation at the investment threshold is aimed to reflect a common situation in which a typical capital investment decision, and its potential departure from the first-best policy, is associated with much less significant valuation implications than a decision to default.

[4]In a related work, Mauer and Sarkar (2004) and Sundaresan and Wang (2007) analyze the effect of

debt restructuring to be a binary variable and do not limit its duration (see Hackbarth *et al.* (2002) and François and Morellec (2004) for the relevant extensions).[5]

The remainder of the paper is organized as follows. In Section 2 the model of the firm is described. Numerical results and comparative statics are presented in Section 3. The summary and conclusions are provided in Section 4. Proofs of propositions are relegated to the Appendix.

2 Model of a Levered Firm

As a starting point, I provide basic characteristics of the firm and of the stochastic environment in which it operates. Subsequently, I develop a dynamic valuation model of the firm following the exercise of the growth option. Using this model, I calculate the values of the claims written on the firm's cash flows and derive the optimal debt restructuring and liquidation policies. These are used to derive results concerning the expansion policy of the firm.

Consider a firm that is run by a deep-pocket owner-manager (equityholders) maximizing the value of equity. The firm generates instantaneous cash flow x_t. The firm has an option to expand by incurring sunk cost I. After spending I, the firm is entitled to cash flow θx_t, with $\theta > 1$. Let indicator $i \in \{0, 1\}$ be equal to 0 if the growth option has not yet been exercised, and to 1 in the opposite case. The liquidation value of the firm is equal to γ_i.

All parties in the model are assumed to be risk-neutral and r is the instantaneous riskless interest rate.[6] The impact of economic uncertainty on the firm's cash flow is captured by letting x_t follow a geometric Brownian motion

$$\mathrm{d}x_t = \alpha x_t \mathrm{d}t + \sigma x_t \mathrm{d}w_t, \tag{1}$$

debt financing on the exercise policy of a growth option. However, neither of the papers allows for the firm to be active prior to the option exercise. As a consequence, there is no initial debt outstanding and the debt overhang problem, which is the focus of the current paper, does not exist.

[5]A far from complete list of references includes Vercammen (2000), analyzing how bankruptcy, triggered by the assets value falling below the face value of the debt, influences investment, Leland and Toft (1996), considering a finite maturity debt with a stationary structure, Anderson and Sundaresan (1996), Mella-Barral (1999), Acharya *et al.* (2006), and Hackbarth *et al.* (2002, 2007), analyzing the impact of debt renegotiability. A related work presented by Fischer *et al.* (1989), Mauer and Triantis (1994), and Dangl and Zechner (2004), focuses on the optimal recapitalization policy.

[6]Alternatively, one could impose an assumption that the payout from the project is spanned by a portfolio of traded assets.

where α and σ correspond to the instantaneous growth rate and the volatility of the firm's cash flow, respectively, and dw_t denotes a Wiener increment. To obtain finite valuations it is assumed that $\alpha < r$. Denote the return shortfall, $r - \alpha$, by δ. Furthermore, define β_1 (β_2) as the positive (negative) root of the fundamental quadratic $\frac{1}{2}\sigma^2\beta(\beta - 1) + \alpha\beta - r = 0$.

Cash flow of the firm is subject to taxation and the corporate tax rate is τ. No other taxes are assumed. The firm has a perpetual debt with coupon b, which is tax deductible. Because of the limited liability, it is optimal for equityholders to restructure debt in some states of nature. Equityholders restructure debt at trigger level x_{r_i} of cash flow process (1), which is chosen to maximize the value of equity. This modelling approach is consistent with, for instance, Leland (1994), Mella-Barral and Perraudin (1997), and Acharya and Carpenter (2002). Two types of debt restructuring upon default are analyzed: bankruptcy and strategic debt restructuring (debt renegotiation).

In the situation where default triggers formal bankruptcy, the absolute priority rule (APR) is upheld and equityholders receive nothing.[7] Once the firm is declared bankrupt, creditors foreclose its assets and act as its managers. We adopt a standard assumption that creditors are less efficient than shareholders when running the firm and the level of cash flow they can generate equals $\rho\theta x$, with $\rho \in (0, 1)$. It is assumed that $\gamma_i r < \rho\theta^{i-1}b(1-\tau)$, so it is not optimal for creditors to liquidate the firm immediately upon bankruptcy.[8] Such a restriction on the liquidation value implies that the debt is risky. When cash flow process x reaches a sufficiently low level, it becomes optimal for creditors to shut down the firm and to realize the liquidation value, γ_i. Furthermore, the investment opportunity is assumed to be lost upon bankruptcy. This assumption follows the notion that creditors do not have human capital necessary for an economically viable execution of the investment project and that they face, as a group, a significant coordination problem in doing so. It is also assumed that creditors do not re-lever after foreclosing the firm's assets.[9]

[7]Evidence presented by Franks and Torous (1989) indicates significant departures from the absolute priority rule in many bankruptcy settlements. This assumption has been introduced for simplicity and without it bankruptcy would occur for higher realizations of cash flow.

[8]Note that this assumption rules out a situation in which equityholders prefer to liquidate the firm and repay b/r to creditors.

[9]This assumption is made only for an analytical convenience. For the results to hold, the firm run by creditors is assumed to satisfy at least *one* of the three following conditions: (i) it cannot re-lever instantaneously so (a fraction of) the tax shield is lost upon bankruptcy, (ii) if bankruptcy occurs prior to investment, the exercise price of growth option gets multiplied by a constant $\phi > 1$ (e.g.,

The divergence between the value of the firm managed by shareholders and its value in the hands of creditors implies that there is scope for debt renegotiation. Renegotiation allows for avoiding the following three components of the cost of financial distress. First, the investment opportunity is preserved under renegotiation but not upon bankruptcy. Second, the inefficiency resulting from creditors managing the firm (and generating reduced cash flow ρx) is avoided. Finally, the tax shield on debt is not irreversibly lost but only temporarily suspended.

The renegotiation process is formalized as Nash bargaining in which bargaining power is split between the two groups of the firm's stakeholders (Fan and Sundaresan (2000), Christensen *et al.* (2002)). The distribution of bargaining power is captured by parameter $\eta \in [0, 1]$. A high (low) value of η is associated with high bargaining power of equityholders (creditors). High bargaining power of equityholders is expected for large corporations, which are likely to be aggressive in negotiations and have specialized legal departments. In contrast, small and young firms that use a portfolio of the bank's services are likely to have a much weaker bargaining position. In addition, Davydenko and Strebulaev (2007) argue that the equityholders' incentives to exert effort in renegotiation increase with insider ownership. Their notion is supported by the empirical observation that deviations from the APR in Chapter 11 are significantly higher when managers have an equity stake in the firm (Betker (1995), LoPucki and Whitford (1990)). Finally, shareholders are expected to be more tough if institutional shareholdings are relatively high. This is due to the fact that coordinated and more sophisticated investors can bargain more effectively. Take-it or leave-it offers made by shareholders or by creditors, as in Mella-Barral and Perraudin (1997), are limiting cases of the Nash bargaining solution. They correspond to situations where $\eta = 1$ and $\eta = 0$, respectively.

As debt renegotiation has a form of a strategic debt service, it is associated with a lower than contractual coupon payment. I follow Mella-Barral and Perraudin (1997) and Fan and Sundaresan (2000) in assuming that the coupon is a function of the current cash flow.[10] Moreover, I impose the assumption made by Fan and Sundaresan (2000) that during the renegotiation process the tax shield is temporarily suspended. As soon

to reflect the coordination problems among creditors), with a special case $\phi \to \infty$ meaning that the growth option expires unexercised, (iii) debtholders will run the firm less efficiently, so that the cash flow generated by the firm in their hands equals $\rho\theta^i (1 - \tau) x$, where $\rho \in (0, 1)$.

[10]This approach allows for avoiding path-dependency leading to analytical intractability. Hege and Mella-Barral (2000) make an alternative assumption that a once-reduced coupon cannot be increased.

as the cash flow from operations recovers and debtholders start receiving coupon b again, the tax shield is restored.[11,12] Therefore, the value of the firm as the bargaining object is endogenous to the choice of the renegotiation trigger.

As a result of bargaining, each party receives a fraction of the total firm value. First, I calculate the value of the firm as a function of the equityholders' renegotiation trigger and determine the optimal sharing rule. Second, I simultaneously derive the values of debt and equity, and determine the optimal equityholders' renegotiation and investment policies as well as the firm's optimal liquidation rule.

Before presenting the valuation of claims and the optimal equityholders' policies, I present the solution to the bargaining game. Denote the value of the firm by $V_i(x)$ and let $\varphi_i^*(x)$ be the outcome of the Nash bargaining process being equal to the fraction of the firm received by shareholders at cash flow level x. Consequently, shareholders receive $\varphi_i^*(x)V_i(x)$ and the debtholders obtain $(1-\varphi_i^*(x))\,V_i(x)$. Fraction $\varphi_i^*(x)$ depends on the outside options of equityholders and debtholders, that is, the payoffs that both the parties would receive if they decided to quit renegotiation. The outside option of equityholders and creditors is zero and $R_i(x)$, respectively, where $R_i(x)$ is the value of the assets when the firm is managed by creditors. Therefore, the solution of the bargaining game can be written as[13]

$$\begin{aligned}\varphi_i^*(x) &= \underset{\varphi_i(x)}{\arg\max}\left[(\varphi_i(x)V_i(x))^{\eta}\left((1-\varphi_i(x))\,V_i(x)-R_i(x)\right)^{1-\eta}\right]\\ &= \eta\frac{V_i(x)-R_i(x)}{V_i(x)}.\end{aligned} \tag{2}$$

From (2) it can be concluded that the fraction of the firm received by equityholders in the renegotiation process critically depends on the creditors' outside option, $R_i(x)$. If $R_i(x)=0$ (that is, if $\gamma_i=\rho=0$), shareholders receive the fraction of the firm equal to their bargaining power coefficient. In the opposite case, that is, when the creditors'

[11] According to Fan and Sundaresan (2000), p. 1072, the temporary tax shield suspension in the renegotiation region "may be interpreted as debtholders agree to forgive some debt and the Internal Revenue Service (IRS) suspends tax benefits until contractual payments are resumed." An alternative approach is proposed by Hege and Mella-Barral (2000), and Hackbarth *et al.* (2007), who assume that the magnitude of the tax shield corresponds to the prevailing coupon payment.

[12] The optimal renegotiation trigger would be higher if the tax shield was not suspended during renegotiation. This is due to the fact that, in such a situation, the opportunity cost of commencing renegotiation would be lower. Consequently, my conservative assumption introduces (if anything) a bias towards the main findings.

[13] In fact, for $\eta = 0.5$ the game is the limit of Rubinstein (1982) with the length of the bargaining period tending to zero.

outside option equals the value of the firm ($\rho = 1$, $\tau = 0$, and $i = 1$), shareholders receive nothing.

The associated stream of coupon payments b_{r_i} is exactly equal to fraction $(1-\varphi_i^*(x))$ of the net cash flow in the renegotiation region or b outside that region:

$$b_{r_i} = \begin{cases} (1-\eta)\, x\theta^i (1-\tau) + \eta r \gamma_i & x \in \left(\underline{x}_{l_i}, \underline{x}_{lc_i}\right], \\ (1-\eta(1-\rho))\, x\theta^i (1-\tau) & x \in \left(\underline{x}_{lc_i}, \underline{x}_{r_i}\right], \\ b & x > \underline{x}_{r_i}. \end{cases} \tag{3}$$

The first regime of the strategic debt service corresponds to the earnings level remaining between the firm's optimal liquidation trigger, $\underline{x}_{l_i}$, and creditors' liquidation trigger, $\underline{x}_{lc_i}$. In this case, creditors receive a weighted average of cash flow from holding the collateral, $r\gamma_i$, and from operating the firm efficiently, $x\theta^i(1-\tau)$. These streams are weighted with shareholders' bargaining power coefficient, η. For the earnings level above $\underline{x}_{lc_i}$, but still in the renegotiation region, creditors receive a weighted average of cash flow from operating the company on their own, $x\rho\theta^i(1-\tau)$, and from serving as fully efficient managers, $x\theta^i(1-\tau)$. Outside the renegotiation region, the contractual coupon, b, is paid.

Note that for $\tau = 0$ and $\eta \in \{0, 1\}$, the coupon schedule corresponds to the outcome of the take-it or leave-it offers in Mella-Barral and Perraudin (1997), whereas setting γ_i to zero reduces the solution to the payment scheme of Fan and Sundaresan (2000). Furthermore, the presence of the growth opportunity does not change the coupon flow to the creditors within any of the three regimes. This results from the fact that the investment opportunity, which constitutes a part of the firm's value, is not associated with any payment stream.

To differentiate between the claims' values and policy triggers in the absence and in the presence of renegotiation, I introduce indicator k that assumes the value of 1 if renegotiation occurs upon default and 0 otherwise. For notational convenience, I assume that $\eta > 0$ implies $k = 1$ (when renegotiation is not allowed for, the distribution of bargaining power is irrelevant anyway).

By observing that equityholders maximize the value of their claim when selecting the debt restructuring policy and that the liquidation policy maximizes the (remaining) value of the firm and by solving the system of corresponding value-matching and smooth-pasting conditions, one can formulate the following proposition.[14]

[14] At the optimal equityholders' renegotiation trigger, the value of all claims remain differentiable. For the equity it is the result of the smooth-pasting condition that guarantees optimality of the trigger.

Proposition 1 *Under the assumptions given above, the values of the firm, $V_1^k(x)$, tax shield, $TS_1^k(x)$, bankruptcy costs, $BC_1^k(x)$, equity, $E_1^k(x)$, and debt, $D_1^k(x)$, after investment is made are equal to*

$$
\begin{aligned}
V_1^k(x) &= \tfrac{\theta x(1-\tau)}{\delta} + TS_1^k(x) - (1-k)\,BC_1(x) + L_1^k x^{\beta_2} && \textit{for } x > \underline{x}_{l_1}^k \\
&= \gamma_1 && \textit{for } x \leq \underline{x}_{l_1}^k \\
E_1^k(x) &= \tfrac{\theta x(1-\tau)}{\delta} - \tfrac{b(1-\tau)}{r} + B_1^k x^{\beta_2} && \textit{for } x > \underline{x}_{r_1}^k \\
&= \eta\left[V_1^1(x) - R_1(x)\right] && \textit{for } x \leq \underline{x}_{r_1}^k \\
D_1^k(x) &= V_1^k(x) - E_1^k(x) && \textit{for all } x,
\end{aligned}
$$

where

$$
\begin{aligned}
TS_i^k(x) &= \tfrac{b\tau}{r}\left[1 - \left(\tfrac{\beta_1}{\beta_1-\beta_2}\right)^k \left(\tfrac{x}{\underline{x}_{r_i}^k}\right)^{\beta_2}\right] && \textit{for } x > \underline{x}_{r_i}^k \\
&= k\left[\tfrac{b\tau}{r}\tfrac{-\beta_2}{\beta_1-\beta_2}\left(\tfrac{x}{\underline{x}_{r_i}^k}\right)^{\beta_1}\right] && \textit{for } x \leq \underline{x}_{r_i}^k \\
BC_i(x) &= \tfrac{(1-\rho)\theta^i x(1-\tau)}{\delta}\left(\tfrac{\max\left\{x,\underline{x}_{r_i}^0\right\}}{\underline{x}_{r_i}^0}\right)^{\beta_2-1} && \textit{for all } x.
\end{aligned}
$$

$R_i(x)$ denotes the value of the firm managed by creditors, which is equivalent to the value with immediate bankruptcy occurring upon default at x. The optimal debt restructuring and liquidation liquidation triggers, $\underline{x}_{r_1}$ and $\underline{x}_{l_1}$, are given by

$$
\underline{x}_{r_1}^k = \frac{-\beta_2}{1-\beta_2}\frac{b\delta\left(1-\tau+\eta\tau\right)}{\left(1-\eta\left(1-\rho\right)\right)\theta\left(1-\tau\right)r}, \tag{4}
$$

$$
\underline{x}_{l_1}^k = \frac{-\beta_2}{1-\beta_2}\frac{\delta}{\rho^{1-k}\theta\left(1-\tau\right)}\left[\gamma_1 - \frac{kb\tau}{r}\left(\frac{\underline{x}_{l_1}^1}{\underline{x}_{r_1}^1}\right)^{\beta_1}\right], \tag{5}
$$

respectively. Constants B_1^k, and L_1^k are defined by equations (A.6) and (A.15) in the Appendix.

According to Proposition 1, which is in line with Fan and Sundaresan (2000), the value of the firm, $V_1(x)$, is the sum of the present values of cash flows, tax shield, $TS_1^k(x)$, and of the liquidation option, $L_1 x^{\beta_2}$.[15] In a situation where bankruptcy occurs upon default, the value of the firm is reduced by the present value of bankruptcy costs, $BC_1(x)$. The value of equity is equal to the present value of cash flow from operations reduced by the present value of coupon payments and augmented with the debt restructuring option,

For the value of the firm and its debt it is a no-arbitrage condition. Since the renegotiation process is reversible, i.e., equityholders will restore the original coupon flow, b, as soon as the earnings process again exceeds the critical threshold, $\underline{x}_{r_1}$, the first-order derivative of the value of all the claims must be continuous.

[15] Superscript k is omitted as long as doing so does not introduce any ambiguity.

$B_1 x^{\beta_2}$. Following debt restructuring, the values of equity and debt are equal to the corresponding fractions of the firm value obtained according to the APR in case of bankruptcy upon default and to the optimal sharing rule (2) when renegotiation is allowed for. The value of debt can be simply calculated as the difference between the value of the firm and of its equity. The value of tax shield is a product of its present value if operated perpetually, $b\tau/r$, and the probability weighted discounted time of its operation (the value of which depends on the type of debt restructuring upon default). Finally, the value of the firm when managed by creditors, $R_1(x)$, is equivalent to $V_1^0(x)$ with bankruptcy having already occurred.

From (4) it follows that taxes influence the debt restructuring trigger only when renegotiation is allowed for and shareholders have at least some bargaining power (i.e., when $\eta > 0$). Shareholders prefer an earlier debt restructuring when the tax rate increases since they obtain a fraction η of the present value of the firm's tax shield.[16] When creditors have the entire bargaining power, optimal renegotiation threshold equals the bankruptcy trigger. In general, the optimal renegotiation trigger does not depend on liquidation value γ_1. This results from the fact that the change of the instantaneous payoff when the renegotiation commences is not influenced by the collateral.[17]

Equation (5) implies that, in the absence of taxes, the optimal liquidation trigger, $\underline{x}_{l_1}$, reduces to the exit threshold of an otherwise identical all-equity financed firm. For $\tau > 0$, $\underline{x}_{l_1}$ is lower than the all-equity threshold as the strictly positive present value of tax shield increases the opportunity cost of liquidation. Consequently, in the presence of taxes the liquidation option is exercised later when the firm is partially financed with debt and renegotiation is possible. In the absence of renegotiation, the firm is liquidated by creditors at a higher level of x (cf. (5) with $k = 0$).

Having derived the values of debt and equity after investment, I am able to determine the optimal policies and calculate the claims' values before the expansion is

[16] In Fan and Sundaresan (2000), the underlying variable is the after-tax value (see also Leland (1994)). Consequently, the optimal renegotiation trigger in their paper decreases with taxes since only the effect of the increasing tax shield is taken into account.

[17] If γ_1 was high enough so that $R_1(x_{r_1}) = \gamma_1$, then the renegotiation trigger would depend on γ_1. However, this is ruled out by assumption. This result also is due to the special structure of optimal stopping problems that also underlies the main conclusions of Leahy (1993) and Baldursson and Karatzas (1997), according to which an investor, who must take into account subsequent investments of the competitors, employs the same investment policy as a monopolist who is not threatened by such future events.

made. The derivation of the optimal investment threshold, $\overline{x}$, is done simultaneously with finding the optimal debt restructuring, $\underline{x}_{r_0}$, and liquidation, $\underline{x}_{l_0}$, triggers. The values of corporate securities before investment and the relevant policy triggers are found analogously as in Proposition 1, with additional value-matching and smooth-pasting conditions ensuring the continuity of the claim values at the investment threshold and reflecting the equityholders' choice of the expansion policy.

Proposition 2 *Under the assumptions given above, the values of the firm, $V_0^k(x)$, its equity, $E_0^k(x)$, and debt, $D_0^k(x)$, before investment is made are equal to*

$$\begin{aligned}
V_0^k(x) &= \tfrac{x(1-\tau)}{\delta} + TS_0^k(x) - (1-k)\,BC_0(x) \\
&\quad + G_v^k x^{\beta_1}\left[1-(1-k)\left(\frac{\max\{x,\underline{x}_{r0}^0\}}{\underline{x}_{r0}^0}\right)^{\beta_2-\beta_1}\right] + L_0^k x^{\beta_2} && \text{for } x > \underline{x}_{l_0} \\
&= \gamma_0 && \text{for } x \le \underline{x}_{l_0} \\
E_0^k(x) &= \tfrac{x(1-\tau)}{\delta} - \tfrac{b(1-\tau)}{r} + G^k x^{\beta_1} + B_0^k x^{\beta_2} && \text{for } x > \underline{x}_{r0} \\
&= \eta\left[V_0^1(x) - R_0(x)\right] && \text{for } x \le \underline{x}_{r0} \\
D_0^k(x) &= V_0^k(x) - E_0^k(x) && \text{for all } x.
\end{aligned}$$

The optimal investment threshold, $\overline{x}$, debt shareholders' restructuring trigger, $\underline{x}_{r0}$, and liquidation trigger, $\underline{x}_{l_0}$, are given by the following equations:

$$\overline{x}^k = \frac{\beta_1}{\beta_1-1}\frac{\delta I}{(\theta-1)(1-\tau)} + \frac{\beta_1-\beta_2}{\beta_1-1}\frac{\delta\left(B_0^k-B_1^k\right)(\overline{x}^k)^{\beta_2}}{(\theta-1)(1-\tau)}, \tag{6}$$

$$\underline{x}_{r0}^k = \frac{-\beta_2}{1-\beta_2}\frac{b\delta(1-\tau+\eta\tau)}{r(1-\tau)(1-\eta(1-\rho))} - \frac{\beta_1-\beta_2}{1-\beta_2}\frac{\delta\left(G^k-\eta G_v^k\right)(\underline{x}_{r0}^k)^{\beta_1}}{(1-\tau)(1-\eta(1-\rho))}, \tag{7}$$

$$\underline{x}_{l_0}^k = \frac{-\beta_2}{1-\beta_2}\frac{\delta}{1-\tau}\left[\gamma_0 - \frac{bk\tau}{r}\left(\frac{\underline{x}_{l_0}^1}{\underline{x}_{r0}^1}\right)^{\beta_1}\right] - \frac{\beta_1-\beta_2}{1-\beta_2}\frac{\delta G_v^k(\underline{x}_{l_0}^1)^{\beta_1}}{1-\tau}. \tag{8}$$

Constants B_0^k, G^k, G_v^k, and L_0^k are defined by equations (A.25), (A.29) and (A.31) in the Appendix.

[Please insert Figure 1 about here]

The values of equity, debt, and the total value of the firm for $k=1$ are depicted in Figure 1. In general, the value of the firm, $V_0(x)$, consists of five components: cash flow from operations, present value of tax shield, bankruptcy costs (positive for $k=0$) and the options to invest and to liquidate. The value of equity before debt restructuring is equal to the present value of cash flow from operations reduced by the value of riskless debt (net of the tax shield) and augmented by the options to expand and to renegotiate the debt contract. In the renegotiation region, the value of equity equals, again, the fraction of the firm value derived according to the sharing rule (2). The value of debt equals the difference between the total value of the firm and the value of equity.

From Proposition 2 it follows that investment, debt restructuring and liquidation triggers are affected by the the growth and bankruptcy options being interrelated. The first component of the expansion trigger (6) is simply equal to the optimal investment threshold of an all-equity firm (with no option to exit). The second component reflects the change in the value of the debt restructuring option upon the expansion ($B_1\overline{x}^{\beta_2} - B_0\overline{x}^{\beta_2}$). As long as B_1 is different from B_0, the latter component is different from zero and the expansion policy of a debt financed company differs from the policy of an otherwise identical all-equity financed firm.

The optimal debt restructuring trigger of the firm is given by (7). Its first component equals the default trigger of an otherwise identical firm but without the growth option (cf. (4)). Its second component reflects the impact of the growth option on the timing of debt restructuring. A similar decomposition can be made for the liquidation trigger (8). In this case, the intuition is very simple: the opportunity cost of liquidation is higher when the growth option is present.

Proposition 3 *Risky debt financing leads to underinvestment in the sense of the shareholders exhibiting excessive waiting.*

Proposition 3 is a direct implication of the debt restructuring option being worth less after the growth option is exercised than before the firm's expansion. In other words, equityholders not only incur the cost of expansion but also face a reduction of the value of their debt restructuring option (cf. Myers (1977)). The mechanism of the reduction in the option value to restructure debt can be explained using the following options analogy. Prior to investment, the debt restructuring option is equivalent (ignoring the interaction between options) to a put on the present value of perpetual cash flow x (or the fraction $(1-\varphi_i^*)$ thereof when renegotiation is possible) with a strike price equal to $b(1-\tau)/r$. After investment, the strike remains the same but the put is written on the present value of θx (or its corresponding fraction) received in perpetuity. Obviously, the value of the latter put option is lower.[18]

[18]In fact, the two options differ only with respect to the initial price of the underlying and the latter option is more out-of-the-money. The ratio of the option values (ignoring the interaction of the former with the growth option) is therefore equal to the discounted probability of cash flow falling from θx

The intuition behind Proposition 3 follows from equation (6). When the possibility of debt restructuring exits, the optimal investment rule requires that the present value of the expansion project must be equal to the two following components. First, it has to compensate for the sunk cost, I, multiplied by markup $\beta_1/(\beta_1 - 1)$ (> 1). Second, it has to compensate for the loss in option value to restructure debt, $(B_0 - B_1)\overline{x}^{\beta_2}$, multiplied by markup $(\beta_1 - \beta_2)/(\beta_1 - 1)$.[19] (In fact, a similar mechanism based on interacting options influences the timing of debt restructuring ((7)) and of corporate liquidation (8).)

The markups can have a significant effect on the decision timing. When model parameters of Section 4 ($r = 5\%$, $\delta = 4\%$ and $\sigma = 20\%$) are adopted, an incremental dollar of an investment cost requires an additional $1.85/0.85 \times \$1 = \$2.17$ of the present value of the investment project to make the expansion worthwhile. Furthermore, a one-dollar loss in the option value to restructure debt requires an extra $(1.85 - (-1.35))/0.85 \times \$1 = \$3.76$ of the project value. (Similarly, one extra dollar gained upon debt restructuring and liquidation is needed to compensate for every foregone \$0.57 of the present value of cash flow and for every \$0.42 of the option value to expand.)

In order to illustrate the mechanism of underinvestment in the model, I construct the following example. Assume that upon completing the investment project, the present value of the firm's cash flow will increase by \$16. The investment cost is \$10. The face value of debt is \$14 and it is assumed that equityholders declare bankruptcy if the present value of discounted future cash flow falls to \$8. The value of the option to default is \$3 (which is equal to the probability-weighted discount factor associated with the event of default, assumed to be 0.5, times the payoff on default, $\$14 - \$8 = \$6$). After investment, cash flow is higher, so the probability of hitting the equityholders' optimal default boundary is lower (and assumed to be equal to 0.17). This results in a new value of the bankruptcy option, \$1. Consequently, the NPV of the investment project that accrues to the shareholders equals (in \$) $16 - 10 - 3 + 1 = 4$. Now, assume that the threshold profitability of the project at which irreversible investment is optimally made equals 1.5. Since the profitability of the project is $16/10 = 1.6$, investment should be undertaken. However, the presence of risky debt financing will lead to underinvestment as the equityholders will not exercise the investment opportunity at the current profitability level (from their viewpoint, the profitability of the project is

to x, that is, to $\theta^{\beta_2} < 1$.

[19]The latter markup is greater that the markup on the investment cost since $\beta_2 < 0$.

only 1.4).

Now, the following proposition can be formulated.

Proposition 4 *Strategic debt restructuring under financial distress exacerbates the underinvestment problem in the sense of the expansion option being exercised later than in the presence of bankruptcy occurring upon default.*

In a situation where shareholders can renegotiate the debt contract, underinvestment is more severe than upon bankruptcy occurring upon default. This is a result of the fact that the option to strategically renegotiate debt generally has a higher value than an analogous option to go bankrupt. Since the value of the option to restructure debt (i.e., either to renegotiate or to go bankrupt) decreases upon the firm's expansion, and the proportional reduction is similar across the two types of options (and is of the order of $\theta^{-\beta_2}$), the absolute reduction in the value of the renegotiation option must be higher than in the option value to go bankrupt (in fact, this difference is of the order of $(1-\varphi^*)^{\beta_2}(1-\theta^{\beta_2})$ of the initial value of the bankruptcy option). To summarize, the higher magnitude of underinvestment with renegotiable debt is driven by a greater absolute loss in the option value to restructure debt occurring upon the firm's expansion.

Impact of Growth Opportunities on Liquidation and Strategic Default

The growth option affects, through its impact on the value of equity and the firm as a whole, the optimal liquidation and debt restructuring policies. As far as its impact on the timing of liquidation is concerned, it holds that

$$\frac{\underline{x}_{l_0}}{\underline{x}_{l_1}} \geq \frac{\theta\gamma_0}{\gamma_1}, \tag{9}$$

with the equality holding for $k=0$ (the growth option is lost upon bankruptcy so it does not affect the liquidation policy even with no expansion having been made). For $k=1$, the presence of the growth option raises the opportunity cost of liquidating the firm. As a consequence, the firm is liquidated optimally at a cash flow level lower than $\gamma_0\theta\underline{x}_{l_1}/\gamma_1$.

The relationship between $\underline{x}_{r0}$ and the debt restructuring trigger of an otherwise identical firm but without the growth option, $\theta\underline{x}_{r_1}$, is, in general, ambiguous. Before expansion, the value of equity contains an additional component reflecting the value of the growth option. Other things being equal, this makes debt restructuring less attractive (so it would call for $\underline{x}_{r0}$ being lower than $\theta\underline{x}_{r_1}$). In fact, this is exactly the outcome for $k = 0$. However, for $k = 1$, there is another opposing effect: it is possible that the value of the firm, as the object of bargaining, is higher when the investment opportunity is present. Therefore, from the perspective of equityholders the renegotiation can *ceteris paribus* become more attractive. Since these two effects work in opposite directions, the presence of the growth opportunity can, in general, either raise or lower the renegotiation trigger.

Proposition 5 *The optimal strategic debt restructuring trigger in the presence of the investment opportunity can either be lower or higher than the corresponding trigger in a situation where the growth option is absent. The condition $\eta > \eta^*$ such that*

$$\eta^* G_v = G \tag{10}$$

implicitly defines the range of parameter η in which the presence of the investment opportunity results in earlier debt restructuring.

From Proposition 5 it follows that in the presence of the growth option, renegotiation commences earlier than without the opportunity to expand if and only if the fraction of the growth option that accrues to shareholders under renegotiation, $\eta G_v x^{\beta_1}$, exceeds the current shareholders' value of the option to invest, Gx^{β_1}.[20] This means that if bargaining power parameter η is sufficiently high, it is optimal for shareholders holding the investment opportunity to begin renegotiation earlier than in the absence of the growth option. By doing so, shareholders forgo the component of the value of equity associated with the expansion option but they are more than compensated by receiving a fraction of the firm's value including the total value of the growth option (i.e., the sum of both the fractions of the investment opportunity that accrue to shareholders and creditors). If debt restructuring has a form of bankruptcy, the presence of the growth option always delays the equityholders' decision to default.

This finding has a direct implication for the credit risk analysis. Namely, the presence of an additional asset (here, the growth option) when its value in the first-best use (i.e., when held by equityholders) substantially exceeds its value in the second-best use (i.e., when held by creditors) can increase credit risk of the firm if strategic default is allowed for.

[20]Obviously, condition (10) never holds for bankruptcy occurring upon default (LHS is zero, as $k = 0$ implies $\eta = 0$, and its RHS is always positive).

3 Numerical Results

This section presents numerical results and comparative statics concerning the firm's optimal policies, the values of its claims, agency costs, capital structure decisions and the first-passage time probabilities. The set of input parameters used is as follows: risk-free rate $r = 5\%$, return shortfall $\delta = 4\%$, volatility of earnings $\sigma = 20\%$, tax rate $\tau = 35\%$, instantaneous coupon $b = 0.5$, efficiency of creditors as the users of the firm's assets $\rho = 50\%$, shareholders' bargaining power parameter $\eta = 0.5$, liquidation value before expansion $\gamma_0 = 1$, liquidation value after expansion $\gamma_1 = 2$, investment cost $I = 10$, expansion scale parameter $\theta = 2$. Unless stated otherwise, those parameter values will be used in all numerical examples.

Optimal Policies

The major finding concerning the impact of the renegotiability of debt on the expansion policy is that the option to restructure debt *exacerbates* Myers' (1977) underinvestment problem. A larger magnitude of underinvestment means in our context that the growth option is exercised later than in the absence of the option to renegotiate the debt contract (see Figure 2, Panels A–D). This is due to the fact that, upon undertaking the expansion project, shareholders of the firm not only incur the investment cost I but they also reduce the value of the option to renegotiate debt.

[Please insert Figure 2 about here.]

Recall that this additional delay in exercising the growth option results from the fact that the reduction in the value of the option to renegotiate exceeds the corresponding reduction in the value of the bankruptcy option.

The comparative statics for the optimal investment, debt restructuring, and liquidation policies are depicted in Table 1. Some of the results are consistent with those known from the real options literature (Dixit and Pindyck (1994), Ch. 6), structural valuation of corporate debt pricing (Leland (1994, 1998), Mella-Barral and Perraudin (1997), Fan and Sundaresan (2000)), and on investment under debt financing (Mauer and Ott (2000), Titman and Tsyplakov (2003), and Moyen (2007)). Therefore, in the remainder of the section, I focus on those results that are novel to this paper.

[Please insert Table 1 about here.]

(*i*) The magnitude of underinvestment increases with book leverage, measured as the instantaneous coupon flow b. This result holds for both the cases of bankruptcy and renegotiation occurring upon default (see Figure 2, Panel A).[21]

(*ii*) The magnitude of additional underinvestment following from the renegotiability of debt is positively related to the equityholders' bargaining power η (see Figure 2, Panel B). This is a direct implication of the negative changein the option value to renegotiate, which occurs upon investment, being larger (in absolute terms) for higher values of η. This latter relationship results from the fact that the renegotiation trigger is positively related to η and so is the adverse change in the probability of renegotiation.[22]

Obviously, shareholders' bargaining power has no impact on the investment policy of a firm whose debt is non-renegotiable (see $\overline{x}^0$ and $\overline{x}^{0,f}$ in Figure 2, Panel B).

(*iii*) The effect of debtholders' outside option, captured by their efficiency parameter ρ, is illustrated in Panel C of Figure 2. Higher efficiency of creditors as the potential owners-managers of the firm reduces the equityholders' value of renegotiation. As a consequence, the absolute difference in the values of the option to renegotiate before and after investment is smaller, which results in lower underinvestment.

Again, for non-renegotiable debt, ρ has no impact on the expansion policy pursued by equityholders.[23]

(*iv*) The effect of the growth option on the renegotiation trigger is, in general, ambiguous and crucially depends on the equityholders' bargaining power, η (see Proposition 5). For low to moderate values of η, the presence of the growth option

[21]To compare, the optimal threshold with the first-best investment policy (that is, the policy that maximizes the total value of the firm) *decreases* with leverage and is lower than that of the all-equity financed firm. The latter result is due to the fact that investment not only augments the firm's cash flow but also enhances the present value of tax shield and reduces the economic cost of default.

[22]If the timing of investment was chosen so as to maximize the value of the firm financed with renegotiable debt, the optimal investment threshold would decrease with η (see $\overline{x}^{1,f}$) due to the higher value of the tax shield.

[23]Creditors' efficiency ρ positively influences the optimal investment threshold when the expansion policy is chosen so to maximize the total value of the firm. When debt renegotiation becomes more remote, the present value of additional tax shield due to investment becomes smaller. Consequently, other things being equal, investment becomes less attractive. Since higher ρ reduces the probability of renegotiation, it also raises the investment threshold.

negatively influences the equityholders' willingness to engage in debt renegotiation. However, if shareholders expect to extract a high fraction of the bargaining proceeds (high η), they commence renegotiation earlier since the growth option enhances the value of the firm as the bargaining object.

Recall that under all-equity financing the investment threshold is increasing with riskless rate r (Dixit and Pindyck (1994), Ch. 6). Debt financing introduces another effect, which works in the opposite direction: given coupon b, a higher r is associated with a lower debt value, and thus with a lower magnitude of underinvestment. The latter effect can be a dominant one if both cash flow uncertainty and interest rate are low (Figure 2, Panel D).

Valuation of Securities

As long as shareholders' bargaining power parameter η is strictly positive, the option to renegotiate enhances the value of equity. This is due to the fact that shareholders can do in the process of renegotiation at least as well as in the case of bankruptcy occurring upon financial distress.

Equityholders' option to renegotiate may adversely affect the value of debt. This occurs when the renegotiation trigger is considerably higher than the bankruptcy threshold of an otherwise identical firm but financed with non-renegotiable debt and the financial position of the firm (measured by x) is sound. On the other hand, for x close enough to the bankruptcy trigger, allowing for renegotiation increases the value of debt since creditors' share of the firm received upon renegotiation is worth more than their claim upon bankruptcy.

Table 2 depicts the direction of the effects of model parameters on the valuation of equity, debt and the firm as a whole.

[Please insert Table 2 about here.]

(v) The interaction between the options to invest and to renegotiate can influence the value of debt in both directions. If the equityholders' bargaining power is so high that renegotiation commences earlier when the growth option is present (see Proposition 5), then the growth option can *reduce* the value of debt. Nevertheless, for most parameter configurations, the value of debt is augmented by the presence of the growth option, due to a lower probability of strategic default.

Agency Cost of Debt

The change in the investment policy of a firm due to risky debt financing results in the agency cost of debt. In other words, the *ex post* departure from the first-best investment policy results in a higher cost of debt at the time of its issuance. This, in turn, leads to a lower *ex ante* value of the firm. The presence of the option to renegotiate the debt contract can exacerbate the agency cost of debt.[24]

The agency cost of debt, $AC(x)$, is measured as the ratio of the difference between the values of the firm with the first-best and the equity value-maximizing investment policies and the value of debt. Such a measure is interpreted as the reduction in the firm value per $1 of debt issued due to the departure from the firm value-maximizing investment policy. In the absence of taxes and bankruptcy costs, the agency cost simply equals the reduction of the value of the firm per $1 of debt issued in relation to the all-equity financed firm.

Since the main focus of this subsection is to investigate the magnitude of the agency cost of debt related to the underinvestment problem, I use the default trigger of the firm pursuing the optimal investment policy as the default trigger of the firm's investment policy that maximizes the equity value. This allows me to isolate the effect of differing first- and second-best investment policies from the effect of differing debt restructuring policies, as in Mauer and Ott (2000).[25]

Table 3 illustrates the signs of sensitivities of the agency cost of debt to changes in model parameters. The bottom row of Table 3 describes changes in the agency cost of renegotiable debt in relation to analogous changes associated with a debt contract that cannot be renegotiated.

[Please insert Table 3 about here.]

An increase in leverage raises the agency cost of debt since the magnitude of the deviation from the firm value-maximizing investment policy increases with a higher

[24]The agency costs of debt have been analyzed in the literature in the context of investment decisions for the case of shareholders' propensity to change riskiness of the firm's assets (Leland (1998), Ericsson (2001), and Subramanian (2007)), and the timing of investment (Mauer and Ott (2000)), and considered non-renegotiable debt.

[25]In fact, this restriction potentially induces a bias against finding the agency cost. This is due to the fact that the equityholders' default options are not exercised optimally in the second-best case, which in principle reduces the equityholders' opportunity cost of expansion and, as a consequence, their optimal investment threshold.

proportion of debt. Moreover, changes in coupon rate b have a similar first-order effect on the agency cost of both renegotiable and non-renegotiable debt.

Shareholders' bargaining power coefficient η influences the agency cost of renegotiable debt through its positive impact on the renegotiation trigger. Consequently, the agency cost of debt due to underinvestment increases since equityholders become more reluctant to forego a fraction of the (higher) option value to renegotiate. With non-renegotiable debt, the bargaining power coefficient does not play any role since it does not affect the optimal investment trigger.

Creditors' ability to manage the firm's assets, ρ, reduces the agency cost of both kinds of debt. For non-renegotiable debt, higher ρ reduces the present value of inefficiencies arising when the firm becomes managed by the creditors. For renegotiable debt, in addition, an increase in ρ negatively influences the probability of strategic default. Therefore, the reduction in the agency costs which results from higher ρ is greater for renegotiable debt.

The moneyness of growth options, measured by both θ and the inverse of I, exacerbates the agency cost of debt. This is due to larger differences in the present values of cash flows before and after investment under first- and second-best policies. This effect is stronger for renegotiable debt since (*i*) the growth option contains not only the right to acquire higher cash flows but also a right to reduce the possibility of debt restructuring, and (*ii*) for strategic default, the latter possibility has a much higher value.[26]

I use our basic set of parameter values to illustrate the potential magnitude of the agency cost of debt that can be attributed to underinvestment. I show that the renegotiability of the debt contract can substantially increase this cost. Figure 3 illustrates the agency cost of renegotiable and non-renegotiable debt as a function of the cash flow variable x for $\alpha = 0.01$ (Panel A) and $\alpha = -0.06$ (Panel B).

[Please insert Figure 3 about here.]

The agency cost of debt induced by the underinvestment problem highly depend

[26] In addition, the agency cost of debt decreases with cash flow volatility as a result of the investment threshold being higher (which is associated with a lower discounted probability of investment) for both kinds of debt. Furthermore, the agency cost of debt due to underinvestment is positively related to the return shortfall, δ, and negatively related to the riskless rate, r. This is due to the fact that the probability of debt restructuring increases with δ (decreases with r) so timely investment becomes more (less) important for reducing the expected cost of default. The presence of the renegotiation option generally increases the sensitivity of the agency costs to the changes of the three parameters.

on equityholders' bargaining power. If equityholders can extract the majority of the surplus from bargaining, the agency cost is relatively high (see Figure 3, case of $\eta = 0.8$). Conversely, the agency cost of debt with creditors having more bargaining power is relatively low ($\eta = 0.2$). In fact, if the creditors can make take-it or leave-it offers, the agency cost is the lowest and *always* below the level corresponding to non-renegotiable debt. The latter result is due to the fact that an identical investment policy has the same impact on cash flows but a differing impact on the change in the present value of tax shield and bankruptcy costs (the latter are not present when renegotiation is allowed for). Consequently, reducing shareholders' bargaining power if the growth option is present appears to be an obvious way of mitigating the agency cost of debt.

An observation that is immediately made upon comparing both panels Figure 3 is that the agency cost of debt is much more severe when the dynamics of the firm's operating cash flow exhibits a relatively low drift rate (a large return shortfall). This is due to the fact that the optimal investment threshold is lower when α decreases (δ increases), which implies that the suboptimal investment policy has a stronger impact on the firm value.

The results of our analysis indicate that the higher flexibility of renegotiable debt does have its cost. Shareholders' inability to pre-commit to the optimal investment policy, or (at least) to the policy pursued with non-renegotiable debt financing, results in a higher *ex ante* cost of debt. This higher cost results from the fact that the agency cost of debt will ultimately be borne by debtholders, who rationally anticipate it when pricing the initial debt contract.

Optimal Capital Structure and Debt Capacity

The presence of the renegotiation option affects the optimal capital structure in two opposite ways (see Fan and Sundaresan (2000)). On the one hand, the possibility of avoiding bankruptcy costs works towards increasing optimal leverage. On the other hand, the loss of the tax shield in the region of strategic debt service impairs the firm's ability to increase its value through further increases in the debt level. The trade-off between these two effects is strongly influenced by the presence of the growth opportunity.

A higher proportion of the growth option component in the firm's total value reduces the optimal market leverage (defined as the ratio of the value of debt and the total value of the firm). This is due to the fact that the debt capacity of growth options (measured as the incremental optimal debt associated with an additional asset, see

Barclay *et al.* (2006)) is lower than the debt capacity of assets in place. Consequently, market leverage of the firm with the growth option is lower than the optimal leverage of its counterpart with the assets-in-place only. Introducing the option to renegotiate the debt contract amplifies the negative impact of the growth option on the optimal leverage level (see Table 4).

[Please insert Table 4 about here.]

Similarly as in Leland (1994), Fan and Sundaresan (2000), and Mauer and Ott (2000), the optimal leverage increases with the current value of the project, x, the riskless rate, r, the tax rate, τ, and the creditors' efficiency parameter, ρ. Moreover, it decreases with cash flow volatility, σ. As in Anderson and Sundaresan (1996), leverage increases with shortfall δ when equityholders' bargaining power is sufficiently high. Moreover, market leverage decreases with equityholders' bargaining power parameter itself.

Introducing the growth option reduces the leverage most dramatically for high levels of earnings x, high interest rate r, and low levels of taxes τ. The interaction between the growth and debt renegotiation options appears to be the main driving force of a lower optimal leverage when equityholders bargaining power is high. In contrast, when creditors have much say in the debt restructuring process (low η), the growth option does not seem to reduce market leverage in the optimum. In general, an increase in the option moneyness (lower I or higher θ) reduces more significantly the optimal leverage of *renegotiable* debt.

The results of this section provide therefore a complementary explanation to the existing capital structure puzzle as they help to reconcile the wedge between high theoretical levels of optimal leverage and much lower levels of corporate indebtness observed empirically. One of the determinants of low market leverage is the interaction of the growth option with the debt renegotiation option. The leverage of growth firms with renegotiable debt is shown to be lower than a simple superposition of the effects of the growth option and debt renegotiability would indicate. In other words, leverage is expected to be positively correlated with the interaction term of a proxy for growth opportunities (such as Tobin's q) and renegotiation frictions.

The presence of the investment option results in a higher face value of debt, b^*/r, at the optimal leverage level. The increment of a face value of debt due to the growth option is generally lower when debt is renegotiable. Again, the adverse effect of the growth option on the optimal coupon level is the highest when shareholders have substantial bargaining power.

Debt renegotiability and the presence of the growth option affect the firm's debt capacity, defined as the maximum market value of debt the firm is able to issue. In the absence of growth options, debt capacity is the highest when there is no option to renegotiate and bankruptcy occurs upon default. Moreover, in the presence of the renegotiation option, debt capacity falls with equityholders' bargaining power. These two results (see Table 4) are to a large extent consistent with Fan and Sundaresan (2000). In addition, the presence of the growth option generally results in a higher debt capacity since it is associated with a higher opportunity cost of default (i.e., a higher cash flow-generating ability of the firm and a positive cost of foregoing a growth option upon default). The presence of the growth option improves debt capacity irrespective of the debt restructuring procedure employed and of the distribution of bargaining power. However, the incremental debt capacity of the growth option is significantly reduced when debt is renegotiable. This is due to the fact that debt renegotiability adversely affects the value of the investment opportunity as it leads to a more severe underinvestment. Again, such a reduced incremental debt capacity is most apparent when equityholders' bargaining power η is high. In contrast, renegotiable debt combined with high creditors' ability to manage the firm, ρ, and equityholders' low bargaining power has a higher incremental capacity than non-renegotiable debt.

First-Passage Time Probabilities

The path-dependency of both the expansion and debt restructuring policies makes the knowledge of the optimal decision thresholds often insufficient to fully evaluate their implications. Consequently, we extend the analysis and calculate first-passage time probabilities associated with the expansion and debt restructuring.[27]

In order to evaluate the influence of a given option or a parameter on a policy, I calculate the probabilities of reaching the threshold triggering the policy within time interval T. For example, the probability of strategic debt restructuring is equivalent to the probability of the cash flow process hitting either renegotiation trigger $\underline{x}_{r_0}$, or, first, the investment threshold, $\overline{x}$, and then renegotiation trigger $\underline{x}_{r_1}$. On the other hand, the probability of investment equals the probability of hitting the investment threshold, $\overline{x}$,

[27]As a consequence of the fact that equityholders face in fact a double-barrier control problem, there is no one-to-one correspondence between the optimal thresholds and the first-passage time probabilities.

conditional on not hitting the liquidation trigger, $\underline{x}_{l_0}$. By examining these probabilities, it is possible to conclude in which situations a firm is, after all, more likely to invest if it uses renegotiable debt, despite a higher magnitude of the underinvestment problem.[28]

The presence of the growth option affects the probability of strategic debt restructuring. In most cases, renegotiation is less likely when the growth option is present due to the higher opportunity cost of strategic default. Nevertheless, in the presence of a positive NPV project, the probability of debt renegotiation can be *higher* than without the investment option. This situation can occur when shareholders' bargaining power parameter η is high so the actual renegotiation trigger $\underline{x}_{r_0}$ exceeds the analogous trigger in the absence of the investment opportunity (see Proposition 5) and the current cash flow is not excessively high.[29] This effect is amplified for low levels of uncertainty (high uncertainty increases the shareholders' value of the investment option which makes renegotiation less likely). The relationship between the equityholders' bargaining power parameter η and the ratio of the probabilities of renegotiation (within $T = 5$ years) in the absence and presence of the growth option is illustrated in Figure 4, Panel A.

[Please insert Figure 4 about here.]

Debt renegotiability affects the probability of expansion in two opposite ways. First, it raises the optimal investment threshold. Second, it allows preservation of the investment opportunity for the levels of cash flow lower than the bankruptcy trigger.[30] Panel B of Figure 4 illustrates how the ratio of the probabilities of investment with and without a renegotiation option changes with shareholders' bargaining power (again, $T = 5$). When the ratio is larger than one, the effect of a preserved investment opportunity (between $\underline{x}_{l_0}$ and $\underline{x}^0_{r_0}$) more than offsets the impact of delayed investment. For low values of η, both investment thresholds are close to each other so that the only significant factor affecting the probabilities of investment is the presence of the down-and-out barrier associated with bankruptcy. For higher shareholders' bargaining power, not only does hitting the liquidation trigger, $\underline{x}_{l_0}$, become more likely but also the divergence of investment thresholds starts playing an important role. Therefore, for sufficiently high η, the ratio of probabilities becomes strictly lower than one.

[28] The derivation of the relevant probabilities, based on an explicit finite difference method, is available from the author upon request.

[29] Since bankruptcy trigger $\underline{x}_{b_0}$ is always lower than $\theta\underline{x}_{b_1}$, the presence of the investment opportunity always reduces the default probability when there is no option to renegotiate.

[30] Recall that with renegotiable debt the growth option is lost only upon the liquidation of the firm.

The comparative statistics results concerning the probability of investment, debt renegotiation and bankruptcy are given in Table 5. The presented results have been obtained by numerical calculation of the relevant probabilities for an extensive range of input parameters.[31]

[Please insert Table 5 about here.]

4 Conclusions

It is known that the investment policy of a firm is affected by its capital structure. The presence of debt financing results in an inefficient delay in exercising corporate growth options. I show that the possibility of strategic debt restructuring at the times of financial distress exacerbates the underinvestment problem upon the firm's expansion. This is a consequence of the fact that the wealth transfer from equityholders to creditors which occurs upon investment is larger when the renegotiation option is present. The additional inefficiency in the investment policy is more severe when equityholders have a stronger bargaining position, and can be eliminated by granting the entire bargaining power to creditors. This result highlights the importance of the type of debt financing and of the bankruptcy code under which the firm operates on the way its investment decisions are made.

The debt restructuring policy itself is affected by the presence of the growth option. In most scenarios, the growth option reduces the probability of a strategic default due to a higher opportunity cost of doing so. However, the presence of the growth opportunity can make renegotiation more likely if shareholders' bargaining power is sufficiently high. In the opposite situation, that is, when the creditors possess substantial bargaining power, the renegotiation trigger is lower.

The model provides a number of empirical implications. In the framework applied in this paper, investment is triggered by a sufficiently high level of cash flow from

[31] Cash flow volatility, σ, affects the probability of investment through its impact on the investment threshold, $\overline{x}$, and, in the absence of renegotiation option, through the bankruptcy trigger, $\underline{x}^0_{r_0}$. For high cash flow levels, higher uncertainty results in a lower probability of investment due to higher $\overline{x}$. For lower levels of cash flow, uncertainty raises the probability of investment. This is due to two effects. First, the unconditional probability of hitting the investment threshold increases for sufficiently low cash flow levels. Second, bankruptcy becomes less likely since with high cash flow volatility, the shareholders find it optimal to service debt for longer, waiting for the improvement of their fortunes (the "junk bonds" effect in Leland (1994)).

operations. This implies that a higher magnitude of Myers (1977) underinvestment makes investment less likely to be triggered by an incremental cash flow increase for any initial cash flow level. As a consequence, the presence of the renegotiation option combined with high shareholders' bargaining power, which results in higher underinvestment, is likely to reduce the sensitivity of investment to the firm's cash flow.[32] Therefore, my model provides an alternative explanation of the empirical evidence that small and young firms (that is, those with low bargaining power) as well as companies financed with market debt, exhibit relatively higher investment-cash flow sensitivity (see Hubbard (1998) and Boyle and Guthrie (2003)).

The riskiness of debt reflected by its credit spread is highly influenced by the presence of both an investment and a renegotiation option. Mella-Barral and Perraudin (1997) show that allowing for the possibility of strategic debt service can significantly increase spreads. My model implies that the presence of investment opportunities will lead to a bigger reduction in a credit spread of debt for which renegotiation frictions are insignificant. Conversely, without the renegotiation option (i.e., in a case of a widely held debt and a large number of issues), the impact of the investment opportunity on credit spreads is expected to be the smallest.

The results of the model yield testable implications for the optimal capital structure. The presence of the growth option reduces the optimal leverage to a larger extent if debt is renegotiable and the bargaining power of the shareholders is high. The result provide therefore a complementary explanation of the capital structure puzzle following from the observed levels of leverage being generally lower than theoretically predicted. Empirically, the coefficient of the interaction term of the renegotiation frictions proxy with Tobin's q is expected to have a positive sign in the leverage regression.

Finally, the model generates testable implications for the optimal financing of growth options. When the firm is financed with private, that is renegotiable, debt, the optimal financing structure of a new project will entail a higher participation of the creditors. This is due to the fact that a higher leverage ratio of the new project is required to reduce an otherwise larger inefficiency of the shareholders' investment policy.

[32] In this simple setup, the endogenous investment variable would be binary.

A Appendix

Proof of Proposition 1. An arbitrary claim, $F(x)$, contingent on x, and yielding instantaneous cash flow $Bx + C$, where $B, C \in \mathbb{R}$, satisfies the ordinary differential equation (ODE)

$$rF(x) = (r-\delta)\, x \frac{\partial F(x)}{\partial x} + \frac{1}{2}\sigma^2 x^2 \frac{\partial^2 F(x)}{\partial x^2} + Bx + C. \tag{A.1}$$

Consequently, the value of the firm, $V_i(x)$, its equity, $E_i(x)$, debt, $D_i(x)$, and the value of the firm in the hands of the creditors, $R_i(x)$, all satisfy ODE (A.1). Constants B and C are equal, respectively, to $\theta^i(1-\tau)$ and $b\tau$ for the firm, to $\theta^i(1-\tau)$ and $-b(1-\tau)$ for the equity, to 0 and b for the debt, and to $\rho\theta^i(1-\tau)$ and 0 for the firm when run by the creditors. The solution to (A.1) is of the form

$$F(x) = \frac{B}{\delta} + \frac{C}{r} + M_1 x^{\beta_1} + M_2 x^{\beta_2}. \tag{A.2}$$

Constants M_1 and M_2 are determined from boundary conditions specific to each claim.[33]

The value of equity can therefore be expressed as

$$E_1(x) = \frac{\theta x(1-\tau)}{\delta} - \frac{b(1-\tau)}{r} + B_1 x^{\beta_2}, \tag{A.3}$$

where $B_1 x^{\beta_2}$ is the value of the debt restructuring option. B_1 and $\underline{x}_{r_1}$ are obtained from the following value-matching and smooth-pasting conditions:

$$\frac{\theta x(1-\tau)}{\delta} - \frac{b(1-\tau)}{r} + B_1 \underline{x}_{r_1}^{\beta_2} = \eta\left[V_1\left(\underline{x}_{r_1}\right) - R_1\left(\underline{x}_{r_1}\right)\right], \tag{A.4}$$

$$\frac{\theta(1-\tau)}{\delta} + \beta_2 B_1 \underline{x}_{r_1}^{\beta_2 - 1} = \eta \left.\frac{\partial\left[V_1(x) - R_1(x)\right]}{\partial x}\right|_{x=\underline{x}_{r_1}}. \tag{A.5}$$

This gives

$$B_1 = \left[\eta\left(V_1\left(\underline{x}_{r_1}\right) - R_1\left(\underline{x}_{r_1}\right)\right) + \frac{b(1-\tau)}{r} - \frac{\theta \underline{x}_{r_1}(1-\tau)}{\delta}\right] \underline{x}_{r_1}^{-\beta_2}, \tag{A.6}$$

and $\underline{x}_{r_1}$ is obtained by multiplying both sides of condition (A.4) by $\beta_2 \underline{x}_{r_1}^{-1}$ and subtracting it from (A.5).

The value of the tax shield, $TS_i(x)$, satisfies ODE (A.1), so its value can be expressed as

$$TS_i(x) = \begin{cases} N_1 x^{\beta_1} + N_2 x^{\beta_2} & x < \underline{x}_{r_i}, \\ \frac{b\tau}{r} + N_3 x^{\beta_1} + N_4 x^{\beta_2}. & x \geq \underline{x}_{r_i}. \end{cases} \tag{A.7}$$

[33] After investment, $M_2 = 0$ since there is no upper action trigger.

Since

$$\lim_{x\uparrow\infty} TS_i(x) = \frac{b\tau}{r}, \text{ and} \tag{A.8}$$

$$\lim_{x\downarrow 0} TS_i(x) = 0, \tag{A.9}$$

it holds that $N_2 = N_3 = 0$. The only remaining unknown constants are N_1 and N_4. Now, one needs to consider two cases. If renegotiation is not allowed ($k = 0$), $N_1 = 0$ as the tax shield is irreversibly lost upon default. Then, N_4 is calculated by applying the value-matching condition

$$\lim_{x\uparrow \underline{x}_{r_i}} TS_i(x) = \lim_{x\downarrow \underline{x}_{r_i}} TS_i(x), \tag{A.10}$$

which gives

$$N_4 = -\frac{b\tau}{r}\underline{x}_{r_i}^{-\beta_2}. \tag{A.11}$$

If renegotiation is allowed for ($k = 1$), there is no restriction on N_1, and it is determined simultaneously with N_4 using value-matching condition (A.10) and the following smooth-pasting condition[34]

$$\left.\frac{\partial TS_i(x)}{\partial x}\right|_{x\uparrow \underline{x}_{r_i}} = \left.\frac{\partial TS_i(x)}{\partial x}\right|_{x\downarrow \underline{x}_{r_i}}. \tag{A.12}$$

This results in

$$N_1 = \frac{b\tau}{r}\frac{-\beta_2}{\beta_1-\beta_2}\underline{x}_{r_i}^{-\beta_1}, \text{ and} \tag{A.13}$$

$$N_4 = \frac{b\tau}{r}\frac{-\beta_1}{\beta_1-\beta_2}\underline{x}_{r_i}^{-\beta_2}. \tag{A.14}$$

The optimal liquidation trigger can be found by applying the following value-matching and smooth-pasting conditions to the value of the firm:

$$\frac{\underline{x}_{l_1}\theta(1-\tau)}{\delta} + TS_1\left(\underline{x}_{l_1}\right) + (k-1)BC_1\left(\underline{x}_{l_1}\right) + L_1\underline{x}_{l_1}^{\beta_2} = \gamma_1, \tag{A.15}$$

$$\frac{\theta(1-\tau)}{\delta} + \frac{\beta_1}{\underline{x}_{l_1}}TS_1\left(\underline{x}_{l_1}\right) + (k-1)\left.\frac{\partial BC_1(x)}{\partial x}\right|_{x=\underline{x}_{l_1}} + \beta_2 L_1\underline{x}_{l_1}^{\beta_2-1} = 0. \tag{A.16}$$

Constant L_1 can be directly calculated from (A.15). Multiplying both sides of condition (A.15) by $\beta_2\underline{x}_{l_1}^{-1}$ and subtracting it from (A.16) yields the implicit formula for

[34] The smooth-pasting condition reflects the fact that renegotiation trigger $\underline{x}_{r_i}$ is a reversible switch point and does entail any optimization. Continuity of the first derivative of the value function at $\underline{x}_{r_i}$ is then required for no arbitrage (for details see Dumas (1991)).

$\underline{x}_{l_1}$. Obviously, if debt restructuring has the form of bankruptcy, it is creditors who ultimately shut down the firm.

■

Proof of Proposition 2. The value of the firm's securities and the level of optimal action triggers can be bound by solving ODE (A.1) for the firm and its equity subject to the following value-matching and smooth-pasting conditions:

$$
\begin{aligned}
V_0\left(\overline{x}\right) &= V_1\left(\overline{x}\right) - I, && \text{(A.17)}\\
E_0\left(\overline{x}\right) &= E_1\left(\overline{x}\right) - I, && \text{(A.18)}\\
\left.\frac{\partial E_0(x)}{\partial x}\right|_{x=\overline{x}} &= \left.\frac{\partial E_1(x)}{\partial x}\right|_{x=\overline{x}}, && \text{(A.19)}\\
E_0\left(\underline{x}_{r0}\right) &= \eta\left[V_0\left(\underline{x}_{r0}\right) - R_0\left(\underline{x}_{r0}\right)\right], && \text{(A.20)}\\
\left.\frac{\partial E_0(x)}{\partial x}\right|_{x=\underline{x}_{r0}} &= \eta\left.\frac{\partial\left[V_0(x) - R_0(x)\right]}{\partial x}\right|_{x=\underline{x}_{r0}}, && \text{(A.21)}\\
V_0(x)\left(\underline{x}_{l_0}\right) &= \gamma_0, && \text{(A.22)}\\
\left.\frac{\partial V_0}{\partial x}\right|_{x=\underline{x}_{l_0}} &= 0. && \text{(A.23)}
\end{aligned}
$$

Define matrix $\Theta(\overline{x}, \underline{x})$ as

$$
\Theta(\overline{x}, \underline{x}) \equiv \frac{1}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}} \begin{bmatrix} \underline{x}^{\beta_2} & -\overline{x}^{\beta_2} \\ -\underline{x}^{\beta_1} & \overline{x}^{\beta_1} \end{bmatrix}. \tag{A.24}
$$

For $k = 1$, constants G_v^1 and L_0^1 reflecting the growth opportunity and the liquidation option, respectively, are calculated from conditions (A.17) and (A.22):

$$
\begin{aligned}
\begin{bmatrix} G_v^1 \\ L_0^1 \end{bmatrix} &= \Theta(\overline{x}, \underline{x}_{l_0}) \begin{bmatrix} \frac{(\theta-1)\overline{x}(1-\tau)}{\delta} + TS_1\left(\overline{x}\right) - TS_0\left(\overline{x}\right) - I + L_1\overline{x}^{\beta_2} \\ \gamma_0 - \frac{\underline{x}_{l_0}(1-\tau)}{\delta} - TS\left(\underline{x}_{l_0}\right) \end{bmatrix} && \text{(A.25)}\\
&\equiv \Theta(\overline{x}, \underline{x}_{l_0}) \begin{bmatrix} \Pi^u\left(\overline{x}\right) \\ \Pi^d\left(\underline{x}_{r0}\right) \end{bmatrix}.
\end{aligned}
$$

The sum of both option values, $G_v^1 x^{\beta_1} + L_0^1 x^{\beta_2}$, can be expressed as

$$
\Pi^u\left(\overline{x}\right)\overline{\Lambda}(\overline{x}, \underline{x}_{r0}; x) + \Pi^d\left(\underline{x}_{r0}\right)\underline{\Lambda}(\underline{x}_{r0}, \overline{x}; x), \tag{A.26}
$$

where

$$
\begin{aligned}
\overline{\Lambda}(\overline{x}, \underline{x}; x) &\equiv \mathbb{E}\left[e^{-rT_{\overline{x}}}\mathbf{1}_{\{T_{\overline{x}}<T_{\underline{x}}\}}|x\right] = \frac{x^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}x^{\beta_2}}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}}, && \text{(A.27)}\\
\underline{\Lambda}(\underline{x}, \overline{x}; x) &\equiv \mathbb{E}\left[e^{-rT_{\underline{x}}}\mathbf{1}_{\{T_{\underline{x}}<T_{\overline{x}}\}}|x\right] = \frac{\overline{x}^{\beta_1}x^{\beta_2} - x^{\beta_1}\overline{x}^{\beta_2}}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}}, && \text{(A.28)}
\end{aligned}
$$

and T_y is the stopping time at realization y of process (1). Consequently, $\overline{\Lambda}(\overline{x}, \underline{x}; x)$ $(\underline{\Lambda}(\underline{x}, \overline{x}; x))$ is the present value of \$1 received upon process x hitting upper barrier $\overline{x}$ (lower barrier $\underline{x}$) conditional on not hitting $\underline{x}$ $(\overline{x})$ before and starting from level x (see Geman and Yor (1996)). The expressions in square brackets in (A.26) are net payoffs associated with hitting the corresponding thresholds.

For $k = 0$, the value of the growth option is calculated using the fact that investment opportunity is lost upon bankruptcy at $\underline{x}^0_{r0}$. Therefore, this value for $x \geq \underline{x}^0_{r0}$ can be decomposed as $G^0_v x^{\beta_1} + G^-_v x^{\beta_2}$, where:

$$\begin{bmatrix} G^0_v \\ G^-_v \end{bmatrix} = \Theta(\overline{x}, \underline{x}^0_{r0}) \times \tag{A.29}$$
$$\begin{bmatrix} \frac{(\theta-1)\overline{x}(1-\tau)}{\delta} + TS_1(\overline{x}) - TS_0(\overline{x}) - BC_1(\overline{x}) + BC_0(\overline{x}) - I + L_1\overline{x}^{\beta_2} \\ 0 \end{bmatrix}$$

and (A.29) is obtained by solving value-matching condition (A.17) with an auxiliary value-matching condition ensuring the continuity of the firm value at $\underline{x}^0_{r0}$. Now, the following simplification can be made:

$$G^0_v x^{\beta_1} + G^-_v x^{\beta_2} = G^0_v x^{\beta_1} \left[1 - \left(\frac{x}{\underline{x}^0_{r0}} \right)^{\beta_2 - \beta_1} \right]. \tag{A.30}$$

Constant L^0_0 is calculated analogously as in (A.15) as there is no growth option after bankruptcy.

Finally, constants G and B_0 reflecting the equityholders' value of the growth and debt restructuring options, respectively, are calculated from (A.18) and (A.20):[35]

$$\begin{bmatrix} G_0 \\ B_0 \end{bmatrix} = \Theta(\overline{x}, \underline{x}_{r0}) \times \tag{A.31}$$
$$\begin{bmatrix} \frac{(\theta-1)\overline{x}(1-\tau)}{\delta} + \left(\eta \left(V_1(\underline{x}_{r1}) - R_1(\underline{x}_{r1}) \right) - \frac{\theta \underline{x}_{r1}(1-\tau)}{\delta} + \frac{b(1-\tau)}{r} \right) \left(\frac{\overline{x}}{\underline{x}_{r1}} \right)^{\beta_2} - I \\ \eta \left(V_0(\underline{x}_{r0}) - R_0(\underline{x}_{r0}) \right) \left(\frac{\overline{x}}{\underline{x}_{r0}} \right)^{\beta_2} - \frac{\underline{x}_{r0}(1-\tau)}{\delta} + \frac{b(1-\tau)}{r} \end{bmatrix}.$$

The implicit formulae for the optimal investment threshold, $\overline{x}$, optimal debt restructuring trigger, $\underline{x}_{r0}$, and liquidation trigger, $\underline{x}_{l0}$, are obtained by pairwise rearranging equations (A.18)–(A.19), (A.20)–(A.21), and (A.22)–(A.23). ■

Proof of Proposition 3. Underinvestment occurs as long as $B_0 > B_1$, since in this case the optimal investment threshold, $\overline{x}$, is higher than a corresponding threshold

[35] The option-like components of equity can also be expressed along the lines of (A.26).

of an otherwise identical all-equity firm.[36] To show that in fact $B_0 > B_1$, both constants are expressed as follows:

$$\begin{aligned} B_0 &= \left[\frac{b}{r} - \frac{(1-\eta(1-\rho))\,\underline{x}_{r_0}}{\delta}\right. \\ &\quad \left. - \left((1-\eta)\left(\frac{(\theta-1)\,\overline{x}}{\delta} - I\right) + (B_1 - B_0)\,\overline{x}^{\beta_2}\right)\left(\frac{\underline{x}_{r_0}}{\overline{x}}\right)^{\beta_1}\right]\underline{x}_{r_0}^{-\beta_2}, \qquad \text{(A.32)} \\ B_1 &= \left(\frac{b}{r} - \frac{\theta(1-\eta(1-\rho))\,\underline{x}_{r_1}}{\delta}\right)\underline{x}_{r_1}^{-\beta_2}. \qquad \text{(A.33)} \end{aligned}$$

(A.32) is obtained by combining (A.6) and (A.31). (A.33) is obtained from (A.6). Now, define function $B_0(\cdot)$ so that the value of option to go bankrupt at an exogenously given trigger y is $B_0(y)\,x^{\beta_2}$ (of course, it must hold that $B_0\left(\underline{x}_{r_0}\right)x^{\beta_2} = B_0 x^{\beta_2}$). Then, the difference $B_0\left(\underline{x}_{r_1}\right) - B_1$ can be expressed as

$$\begin{aligned} B_0\left(\underline{x}_{r_1}\right) - B_1 &= \underline{x}_{r_1}^{-\beta_2}\left[\frac{(\theta-1)(1-\eta(1-\rho))\,\underline{x}_{r_1}}{\delta}\right. \qquad \text{(A.34)} \\ &\quad \left. - \left((1-\eta)\left(\frac{(\theta-1)\,\overline{x}}{\delta} - I\right) + \left(B_1 - B_0\left(\underline{x}_{r_1}\right)\right)\overline{x}^{\beta_2}\right)\left(\frac{\underline{x}_{r_1}}{\overline{x}}\right)^{\beta_1}\right], \end{aligned}$$

which is equivalent to

$$\begin{aligned} B_0\left(\underline{x}_{r_1}\right) - B_1 &= \left(1 - \left(\frac{\underline{x}_{r_1}}{\overline{x}}\right)^{\beta_1-\beta_2}\right)^{-1}\left[\frac{(\theta-1)(1-\eta)\,\underline{x}_{r_1}}{\delta}\left(1 - \left(\frac{\underline{x}_{r_1}}{\overline{x}}\right)^{\beta_1-1}\right)\right. \\ &\quad \left. + \frac{(\theta-1)\,\eta\rho\underline{x}_{r_1}}{\delta} + I(1-\eta)\left(\frac{\underline{x}_{r_1}}{\overline{x}}\right)^{\beta_1}\right]\underline{x}_{r_1}^{-\beta_2} \qquad \text{(A.35)} \end{aligned}$$

Expression (A.35) is positive as all its components are positive. This implies that even the value of the suboptimally exercised option $B_0\left(\underline{x}_{r_1}\right)x^{\beta_2}$ is higher than the value of the option $B_1 x^{\beta_2}$. This implies that the value of the restructuring option $B_0 x^{\beta_2}$, which is at least as high as $B_0\left(\underline{x}_{r_1}\right)x^{\beta_2}$, exceeds $B_1 x^{\beta_2}$ as well. ■

Proof of Proposition 4. Recall that the optimal investment threshold, $\overline{x}$ (cf. (6)), is given by

$$\overline{x} = \frac{\beta_1}{\beta_1 - 1}\frac{I\delta}{\theta - 1} + \frac{\beta_1 - \beta_2}{\beta_1 - 1}\frac{\delta\left(B_0^k - B_1^k\right)\overline{x}^{\beta_2}}{\theta - 1}. \qquad \text{(A.36)}$$

To evaluate the difference in investment thresholds, I proceed in the following steps. First, I show that the difference $B_0^k - B_1^k$ is larger for renegotiable debt ($k = 1$) if

[36] Proofs of Propositions 3 and 4 are presented for $\gamma_i = \tau = 0,\ i \in \{0,1\}$. Extensive numerical simulations in the parameter space $\{(\delta,\sigma,r,\eta,\rho,I,\tau,\theta,\gamma_0,\gamma_1,b) \in \mathbb{R}^{11} | \delta > 0, \sigma > 0, r > 0, 0 \le \eta \le 1, 0 \le \rho < 1, I > 0, 0 \le \tau < 1, \theta > 1, \gamma_0 > 0, \gamma_1 > 0, b \ge 0\}$ indicate that the results of both propositions hold also for strictly positive levels of the tax rate and liquidation values.

shareholders can make take-it or leave-it offers ($\eta = 1$). Then, I use the fact that no difference occurs when creditors hold the entire bargaining power ($\eta = 0$). (Recall that $B_i^0 = B_i^1$, $i \in \{0, 1\}$, for $\eta = 0$, cf. (A.6) and (A.31).) Finally, I show that $B_0^1 - B_1^1$ increases with bargaining power parameter η.

Consider first the value of an option to restructure debt in the absence of the investment option, $\hat{B}_i^k x^{\beta_2}$. (Obviously, $\hat{B}_1^k = B_1^k$.) After substituting (7) for $\underline{x}_{r_1}$ in (A.33) and observing that $\hat{B}_0^k x^{\beta_2}$ is obtained analogously, it follows that

$$\hat{B}_i^k x^{\beta_2} = \frac{(1-\beta_2)^{\beta_2 - 1}}{\beta_2^{\beta_2}} \frac{r^{\beta_2 - 1} \left(\rho^k \theta^i x\right)^{\beta_2}}{b^{\beta_2 - 1} \delta^{\beta_2}} \equiv K \left(\rho^k \theta^i x\right)^{\beta_2}, \tag{A.37}$$

With renegotiation, the relevant difference $\hat{B}_0^1 - B_1^1$ equals $K\left[\rho(1-\theta)x\right]^{\beta_2}$, which is larger than the analogous difference for non-renegotiable debt, $K\left[(1-\theta)x\right]^{\beta_2}$ (β_2 is negative). Therefore, when the effect of the growth option is disregarded, the difference in the option values to restructure debt for the original and the expanded firm is larger when debt is renegotiable.

Now, observe that $B_0^0 x^{\beta_2}$, i.e., the option to go bankrupt, must be worth less than (A.37) evaluated for $k = i = 0$, as the expansion option increases the opportunity cost of bankruptcy (cf. (A.32)). In other words, $B_0^0 x^{\beta_2}$ is always more out-of-the-money (or less in-the-money) than $\hat{B}_0^0 x^{\beta_2}$. Therefore, $B_0^0 - B_1^0 < \hat{B}_0^0 - B_1^0 = K x^{\beta_2}\left(1 - \theta^{\beta_2}\right)$.

Now, I show that for $\eta = 1$, $B_0^1 - B_1^1 > \hat{B}_0^1 - B_1^1 = K(\rho x)^{\beta_2}\left(1 - \theta^{\beta_2}\right)$. Again, let function $B_0(y)\, x^{\beta_2}$ be the value of the debt restructuring option exercised (possibly not optimally) at an exogenously given trigger y. The renegotiation option, $B_0^1(y)\, x^{\beta_2}$, for $\eta = 1$ is then given by

$$B_0^1(y)\, x^{\beta_2} = \left[\frac{b(1-\tau)}{r} - \frac{\rho y (1-\tau)}{\delta} + \left(B_0^1(y) - B_1^1\right) \overline{x}^{\beta_2} \left(\frac{y}{\overline{x}}\right)^{\beta_1}\right] \left(\frac{x}{y}\right)^{\beta_2}. \tag{A.38}$$

After substituting $\theta \underline{x}_{r_1}$ for y, (A.38) can be expressed as

$$B_0^1\left(\theta \underline{x}_{r_1}\right) x^{\beta_2} = \hat{B}_0^1 x^{\beta_2} + \left(B_0^1\left(\theta \underline{x}_{r_1}\right) - B_1^1\right) x^{\beta_2} \left(\frac{\theta \underline{x}_{r_1}}{\overline{x}}\right)^{\beta_1 - \beta_2}. \tag{A.39}$$

Furthermore, by subtracting the product of (A.33) and x^{β_2} from (A.38) (with $y = \theta \underline{x}_{r_1}$), one obtains that $B_0^1\left(\theta \underline{x}_{r_1}\right) > B_1^1$. This inequality is equivalent to $B_0^1\left(\theta \underline{x}_{r_1}\right) > \hat{B}_0^1$. In turn, the latter implies that $B_0^1 > \hat{B}_0^1$, as B_0^1 is a constant corresponding to the option with an unconstrained exercise policy and, and such, cannot be smaller than $B_0^1\left(\theta \underline{x}_{r_1}\right)$. Therefore, referring back to equation (6), the possibility of renegotiation occurring upon default combined with equityholders making take-it or leave-it offers exacerbates underinvestment compared to the situation where bankruptcy occurs upon default.

In fact, the proof of Proposition 4 is also straightforward for all $\eta \geq \eta^*$, where η^* is defined as such a level of the equityholders' bargaining power at which the equality $\eta^* G_v = G$ is satisfied. First, consider the value of the debt restructuring option that is (suboptimally) exercised at $\theta \underline{x}_{r_1}$. It holds that

$$B_0^1 \left(\theta \underline{x}_{r_1}\right) x^{\beta_2} = \hat{B}_0^1 x^{\beta_2} + \left(\eta \tilde{G}_v - \tilde{G}\right) \left(\theta \underline{x}_{r_1}\right)^{\beta_1} \left(\frac{x}{\theta \underline{x}_{r_1}}\right)^{\beta_2}, \tag{A.40}$$

where $\tilde{G}$ and $\tilde{G}_v$ denote the constants corresponding to the equityholders' and the firm's growth options, respectively, with the modified debt restructuring policy (i.e., at $\theta \underline{x}_{r_1}$). Obviously, $B_0^1 \left(\theta \underline{x}_{r_1}\right)$ cannot be larger than B_0^1 since it is based on a suboptimal exercise policy (In fact, $B_0^1 \left(\theta \underline{x}_{r_1}\right) = B_0^1$ for $\eta = \eta^*$, that is, when $\underline{x}_{r_0} = \theta \underline{x}_{r_1}$.) Therefore, it is sufficient to show that $\eta \tilde{G}_v - \tilde{G}$ is non-negative for $\eta > \eta^*$ (which is equivalent to $B_0^1 \left(\theta \underline{x}_{r_1}\right) > \hat{B}_0^1$). But this is immediate since $\eta \tilde{G}_v - \tilde{G} = 0$ for $\eta = \eta^*$ and is increasing with η. To see the latter point, notice that for any given expansion policy $\tilde{G}_v$ does not depend on η and $\tilde{G}$ is decreasing with η. Again, the latter is due to the fact that trigger $\theta \underline{x}_{r_1}$, upon which some value of the equityholders' growth option is lost, increases with η.

To prove Proposition 4 for $\eta < \eta^*$, observe the following. Constant B_0^1 of the debt restructuring option can be represented as $a(\eta)\hat{B}_0^1$, where $a(\eta) < 1$ for $\eta < \eta^*$. To show that $B_0^1 - B_1^1$ increases with η it is sufficient to show the following: that $a'(\eta) > 0$ and that $\eta G_v - G$ increases with η. Starting from the latter, the argument is the same as in the previous case: for a given expansion policy, G_v remains unchanged and G decreases with η due to an increasing trigger $\underline{x}_{r_0}$. As the effect of the investment option on the timing of the debt restructuring is reduced ($\eta G_v - G$ is initially negative), trigger $\underline{x}_{r_0}$ moves closer to $\theta \underline{x}_{r_1}$. (Recall that the latter trigger corresponds to option $\hat{B}_0^1 x^{\beta_2}$.) Therefore, the relative disparity between the option constant B_0^1 and $\hat{B}_0^1$, captured by the inverse of $a(\eta)$, decreases as well.

■

Proof of Proposition 5. The proof is straightforward and follows from equation (4). Sice all the remaining factors in the second component of the RHS are positive, $\eta G_v - G > 0$ implies that $\underline{x}_{r_0}$ is higher than the renegotiation threshold in the absence of the expansion option. ■

References

Acharya, Viral V., and Jennifer N. Carpenter, 2002, Corporate bond valuation and hedging with stochastic interest rates and endogenous bankruptcy, *Review of Financial Studies* 15, 1355–1383.

Acharya, Viral V., Jingzhi Huang, Marti G. Subrahmanyam, and Rangarajan K. Sundaram, 2006, When does strategic debt service matter?, *Economic Theory* 29, 363–378.

Anderson, Ronald, and Suresh Sundaresan, 1996, Design and valuation of debt contracts, *Review of Financial Studies* 9, 37–68.

Asquith, Paul, Robert Gertner, and David Scharfstein, 1994, Anatomy of financial distress: An examination of junk bond issuers, *Quarterly Journal of Economics* 109, 625–658.

Baldursson, Fridrik, and Ioannis Karatzas, 1997, Irreversible investment and industry equilibrium, *Finance and Stochastics* 1, 69–89.

Barclay, Michael J., Erwan Morellec, and Clifford W. Smith, 2006, On the debt capacity of growth options, *Journal of Business* 79, 37–60.

Betker, Brian L., 1995, Management's incentives, equity bargaining power, and deviations from the absolute priority in Chapter 11 bankruptcies, *Journal of Business* 68, 161–183.

Bolton, Patrick, and David S. Scharfstein, 1996, Optimal debt structure and the number of creditors, *Journal of Political Economy* 104, 1–25.

Boyle, Glenn W., and Graeme A. Guthrie, 2003, Investment, uncertainty, and liquidity, *Journal of Finance* 58, 2143–2166.

Christensen, Peter Ove, Christian Riis Flor, David Lando, and Kristian R. Miltersen, 2002, Dynamic capital structure with callable debt and debt renegotiations, Working Paper, University of Southern Denmark.

Dangl, Thomas, and Josef Zechner, 2004, Credit risk and dynamic capital structure choice, *Journal of Financial Intermediation* 13, 183–204.

Davydenko, Sergei A., and Ilya A. Strebulaev, 2007, Strategic actions and credit spreads: An empirical investigation, *Journal of Finance* forthcoming.

Dixit, Avinash K., and Robert S. Pindyck, 1994, *Investment under Uncertainty* (Priceton University Press).

Dumas, Bernard, 1991, Super contact and related optimality conditions, *Journal of Economic Dynamics and Control* 15, 675–685.

Ericsson, Jan, 2001, Asset substitution, leverage and maturity, *Finance* 21.

Fan, Hua, and Suresh M. Sundaresan, 2000, Debt valuation, renegotiation and optimal dividend policy, *Review of Financial Studies* 13, 1057–1099.

Fischer, Edwin O., Robert Heinkel, and Josef Zechner, 1989, Dynamic capital structure choice: Theory and tests, *Journal of Finance* 44, 19–40.

François, Pascal, and Erwan Morellec, 2004, Capital structure and asset prices: Some effects of bankruptcy procedures, *Journal of Business* 77, 387–411.

Franks, Julian R., and Walter N. Torous, 1989, An empirical investigation of U.S. firms in renegotiation, *Journal of Finance* 44, 747–769.

———, 1994, A comparison of financial recontracting in distressed exchanges and Chapter 11 reorganizations, *Journal of Financial Economics* 35, 349–370.

Geman, Hélyette, and Marc Yor, 1996, Pricing and hedging double-barrier options: A probabilistic approach, *Mathematical Finance* 4, 365–378.

Hackbarth, Dirk, Christopher A. Hennessy, and Hayne E. Leland, 2002, Optimal debt mix and priority structure: The role of bargaining power, Working Paper, University of California at Berkeley.

———, 2007, Can the tradeoff theory explain debt structure?, *Review of Financial Studies* forthcoming.

Hege, Ulrich, and Pierre Mella-Barral, 2000, Bargaining power and optimal leverage, *Finance* 21, 85–101.

———, 2005, Repeated dilution of diffusely held debt, *Journal of Business* 21, 737–786.

Hubbard, R. Glenn, 1998, Capital-market imperfections and investment, *Journal of Economic Literature* 36, 193–225.

Leahy, John V., 1993, Investment in competitive equilibrium: The optimality of myopic behavior, *Quarterly Journal of Economics* 108, 1105–1133.

Leland, Hayne E., 1994, Corporate debt value, bond covenants, and optimal capital structure, *Journal of Finance* 49, 1213–1252.

———, 1998, Agency costs, risk management and capital structure, *Journal of Finance* 53, 1213–1243.

———, and Klaus Bjerre Toft, 1996, Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads, *Journal of Finance* 51, 987–1019.

LoPucki, Lynn M., and William C. Whitford, 1990, Bargaining over equity's share in the bankruptcy reorganization of large, publicly held companies, *University of Pennsylvania Law Review* 139, 129–169.

Mauer, David C., and Steven H. Ott, 2000, Agency costs, underinvestment and optimal capital structure: The effects of growth options to expand, in Michael J. Brennan, and Lenos Trigeorgis, ed.: *Project Flexibility, Agency, and Product Market Competition : New Developments in the Theory and Application of Real Options Analysis* (Oxford University Press).

Mauer, David C., and Sudipto Sarkar, 2004, Real options, agency conflicts and optimal capital structure, *Journal of Banking and Finance* 29, 1405–1428.

Mauer, David C., and Alexander J. Triantis, 1994, Interactions of corporate financing and investment decisions: a dynamic framework, *Journal of Finance* 49, 1253–1277.

Mella-Barral, Pierre, 1999, The dynamics of default and debt reorganization, *Review of Financial Studies* 12, 535–578.

———, and William Perraudin, 1997, Strategic debt service, *Journal of Finance* 52, 531–556.

Mello, Antonio S., and John E. Parsons, 1992, Measuring the agency cost of debt, *Journal of Finance* 47, 1887–1904.

Moyen, Nathalie, 2007, How big is the debt overhang problem?, *Journal of Economic Dynamics and Control* 31, 433–472.

Myers, Stewart C., 1977, Determinants of corporate borrowing, *Journal of Financial Economics* 5, 147–175.

Parrino, Robert, and Michael S. Weisbach, 1999, Measuring investment distortions arising from stockholder-bondholder conflicts, *Journal of Financial Economics* 53, 3–42.

Rubinstein, Ariel, 1982, Perfect equilibrium in a bargaining model, *Econometrica* 50, 97–109.

Subramanian, Ajay, 2007, Managerial flexibility, agency costs and optimal capital structure, Working paper, Georgia State University.

Sundaresan, Suresh, and Neng Wang, 2007, Investment under uncertainty with strategic debt service, *American Economic Review: Papers and Proceedings* 97, 256–261.

Titman, Sheridan, and Sergey Tsyplakov, 2003, A dynamic model of optimal capital structure, Working paper, University of Texas at Austin.

Vercammen, James, 2000, Irreversible investment under uncertainty and the threat of bankruptcy, *Economics Letters* 66, 319–325.

Optimal Investment, Liquidation and Debt Restructuring Policies

	Coupon rate b	Bargaining power η	Creditors efficiency ρ	Volatility σ	Return shortfall δ	Interest rate r	Growth options $\frac{1}{I}, \theta$
Investment threshold, $\overline{x}$	(i)	(ii)	(iii)	$+$	$+$	$+/-^{*}$	$-$
Renegotiation threshold, $\underline{x}_{r_0}^1$	$+$	$-$	$+$	$-$	$+$	$-^{**}$	(iv)
Bankruptcy threshold, $\underline{x}_{r_0}^0$	$+$	0	0	$-$	$+$	$-^{**}$	$-$
Liquidation threshold, $\underline{x}_{l_0}$	$+$	$-$	$+$	$-$	$+$	$+$	$-$

Table 1: Comparative statics concerning the optimal investment, $\overline{x}$, renegotiation, $\underline{x}_{r_0}^1$, bankruptcy, $\underline{x}_{r_0}^0$, and liquidation, $\underline{x}_{l_0}$, thresholds. "$+$", "0", and "$-$" denote a positive, zero, and negative, respectively, sensitivity with respect to the changes in a given parameter, and "$+/-$" indicates an ambiguous sign of the relationship. The numbers in brackets refer to the explanatory notes in the text. $^{*/}$ The negative effect of the decreasing value of debt (with r) on underinvestment can dominate for low r and σ. $^{**/}$ Despite the indirect effect of the value of the investment opportunity generally decreasing with r.

Valuation of Corporate Securities

	Coupon rate b	Bargaining power η	Creditors efficiency ρ	Volatility σ	Return shortfall δ	Interest rate r	Growth options I^{-1}, θ
Equity value, E_0	$-$	$+$	$-$	$+$	$-$	$+$	$+$
Debt value, D_0	$+-$	$-$	$+$	$+/-^{*}$	$-$	$+/-^{**}$	(v)
Firm value, V_0	$+-$	$-$	$+$	$+/-$	$-$	$+/-$	$+$

Table 2: Comparative statics concerning the valuation of equity, debt, and the firm as a whole. "+" ("−") denotes a positive (negative) sensitivity with respect to a given parameter, and "+−" ("+/−") indicates a humped (an ambiguous sign of the) relationship. The numbers in brackets refer to the explanatory notes in the text. */ The "junk bond effect" (Leland (1994)) resulting in a positive relationship between the debt value and cash flow volatility in the neighborhood of the endogenous debt restructuring trigger is present. **/ The positive effect of a higher risk-neutral drift on the debt value can dominate for low r and σ combined with a strictly positive δ.

Agency Costs of Debt

	Coupon rate b	Bargaining power η	Creditors efficiency ρ	Volatility σ	Return shortfall δ	Interest rate r	Growth options I^{-1}, θ
Agency costs w/renegotiation, AC^1	$+$	$+$	$-$	$-$	$+$	$-$	$+$
Agency costs no renegotiation, AC^0	$+$	0	$-$	$-$	$+$	$-$	$+$
Agency costs ratio, $\frac{AC^1}{AC^0}$	≈ 0	$+$	$-$	$-$	$-$	$+$	$+$

Table 3: Comparative statics concerning impact of the option to renegotiate on the agency cost of debt. "+", "0" and "−" denote a positive, zero, and negative, respectively, sensitivity with respect to the changes in a given parameter.

Optimal Capital Structure and Debt Capacity

x	σ	δ	r	η	ρ	I	τ	LEV_0^* (DC_0)	b_0^*	LEV_1^* (DC_1)	b_1^*	$\%\Delta LEV_0^*$ ($\%\Delta DC_0$)	$\%\Delta b_0^*$	$\%\Delta LEV_1^*$ ($\%\Delta DC_1$)	$\%\Delta b_1^*$
0.8	0.2	0.04	0.05	0.75	0.50	10	0.35	63.64	0.87	47.15	0.71	−0.04	0.28	−0.13	0.14
								(16.00)		(9.95)		(0.28)		(0.14)	
1.0	0.2	0.04	0.05	0.75	0.50	10	0.35	63.48	1.13	45.66	0.86	−0.04	0.33	−0.15	0.10
								(21.08)		(12.74)		(0.35)		(0.17)	
0.8	0.1	0.04	0.05	0.75	0.50	10	0.35	74.93	0.88	48.27	0.53	−0.03	0.22	−0.09	0.13
								(17.47)		(9.76)		(0.23)		(0.12)	
0.8	0.2	-0.11	0.05	0.75	0.50	10	0.35	60.07	0.28	50.86	0.25	0.00	0.00	0.00	0.00
								(4.34)		(3.27)		(0.00)		(0.00)	
0.8	0.2	0.04	0.08	0.75	0.50	10	0.35	69.89	1.49	46.78	1.06	−0.04	0.31	−0.13	0.19
								(18.25)		(10.29)		(0.32)		(0.15)	
0.8	0.2	0.07	0.08	0.75	0.50	10	0.35	72.46	0.77	61.79	0.69	−0.04	0.10	−0.07	0.06
								(8.77)		(6.74)		(0.10)		(0.04)	
0.8	0.2	0.04	0.05	0.25	0.50	10	0.35	63.61	0.87	79.47	1.45	−0.04	0.28	−0.02	0.34
								(16.00)		(18.86)		(0.28)		(0.30)	
0.8	0.2	0.04	0.05	0.75	0.75	10	0.35	68.58	0.97	57.19	0.88	−0.06	0.24	−0.15	0.09
								(17.15)		(12.55)		(0.26)		(0.11)	
0.8	0.2	0.04	0.05	0.75	0.50	8	0.35	63.60	0.91	45.66	0.69	-0.04	0.34	-0.15	0.11
								(16.87)		(10.18)		(0.36)		(0.16)	
0.8	0.2	0.04	0.05	0.75	0.50	10	0.15	41.71	0.60	44.74	0.76	−0.06	0.33	−0.21	−0.01
								(17.74)		(12.78)		(0.35)		(0.16)	

Table 4: Optimal capital structure and debt capacity for non- and renegotiable debt. Leverage is defined as D_0/V_0. LEV_k^* denotes optimal leverage, b_k^* is the optimal coupon, $\%\Delta LEV_k^*$ is the relative change in leverage due to the presence of the growth option, $\%\Delta b_k^*$ is the relative change in coupon rate (face of value of debt) due to the presence of the growth option, DC_k is the debt capacity, defined as the maximum amount of debt that can be issued, and ΔDC_k is the relative change in debt capacity attributed to the growth option.

Probabilities of Debt Restructuring and Investment

	Coupon rate b	Bargaining power η	Creditors efficiency ρ	Volatility σ	Return shortfall δ	Interest rate r	Growth options I^{-1}, θ
Probability of investment, $\overline{p}$	$-$	(ii)	(iii)	$+/-$	$-$	$+/-$	$+$
Probability of renegotiation, $\underline{p}_r^1$	$+$	$+$	$-$	$-$	$+$	$-$	$-/+^*$
Probability of bankruptcy, $\underline{p}_r^0$	$+$	0	0	$-$	$+$	$-$	$-$

Table 5: Comparative statics concerning the first-passage time probabilities associated with investment, $\overline{p}$, debt renegotiation, $\underline{p}_r^1$, and bankruptcy, $\underline{p}_r^0$. "+", "0" and "−" denote a positive, zero, and negative, respectively, sensitivity with respect to the changes in a given parameter, and +/−" indicates an ambiguous sign of the relationship. The numbers in brackets refer to the explanatory notes in the text. $^{*/}$ See Proposition 5.

Valuation of the Firm's Claims when Debt Is Renegotiable

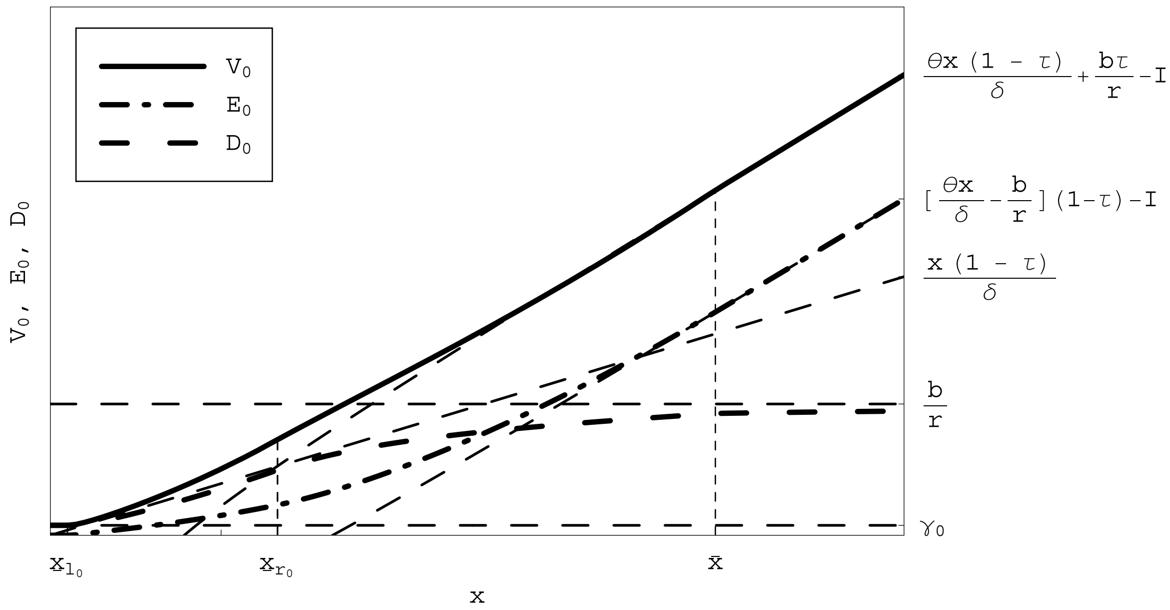

Figure 1: Value of the firm, V_0, its debt, D_0, and equity, E_0, before investment, with the shareholder's option to renegotiate the debt. $\underline{x}_{l_0}$ is the optimal liquidation trigger, $\underline{x}_{r_0}$ is the equityholders' renegotiation trigger, and $\overline{x}$ is the equity value-maximizing investment threshold.

Equityholders' Optimal Investment Thresholds

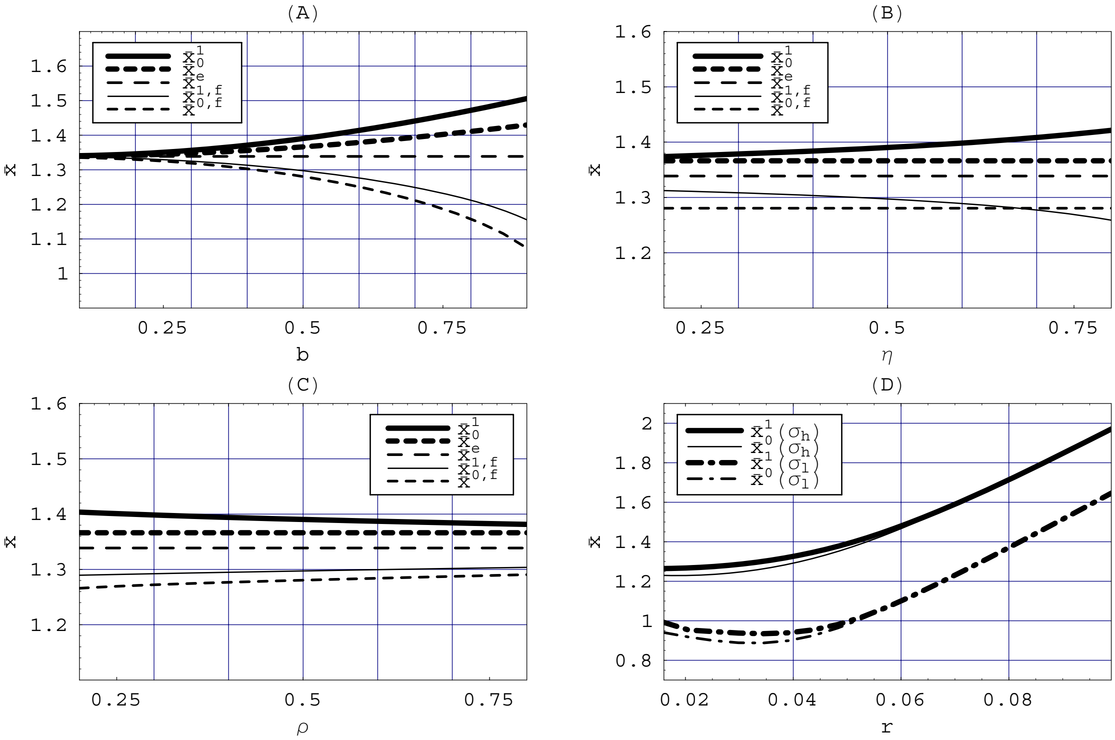

Figure 2: Optimal investment threshold as a function of coupon rate b, equityholders' bargaining power η, creditors' efficiency ρ, and interest rate r. $\overline{x}^{1,f}$ and $\overline{x}^{1}$ denote the firm and the equity value-maximizing threshold, respectively, in the presence of renegotiation option; $\overline{x}^{0,f}$ and $\overline{x}^{0}$ denote the firm and the equity value-maximizing threshold, respectively, for non-renegotiable debt. $\overline{x}^{e}$ is the all-equity firm investment threshold. High and low volatility regimes (Panel D) correspond to $\sigma_h = 0.2$ and $\sigma_l = 0.1$, respectively.

The Agency Cost of Debt

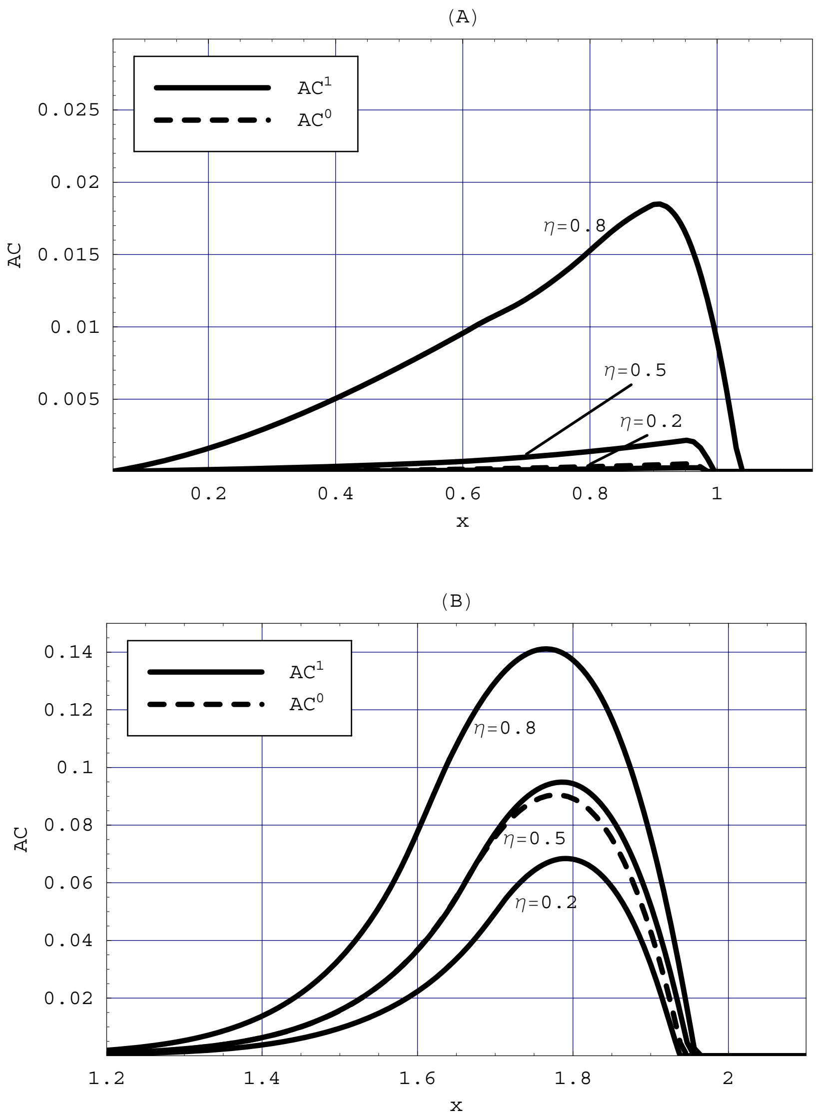

Figure 3: The agency cost of debt due to underinvestment, measured as the ratio of the difference between the first-best and second-best value of the firm and the value of debt in the absence, AC^0, and in the presence, AC^1, of the renegotiation option for different values of the equityholders' bargaining power parameter η and varying levels of the cash flow process, x, for drift parameter α equal to 0.01 (Panel A) and -0.06 (Panel B).

Probabilities of Debt Restructuring and Investment

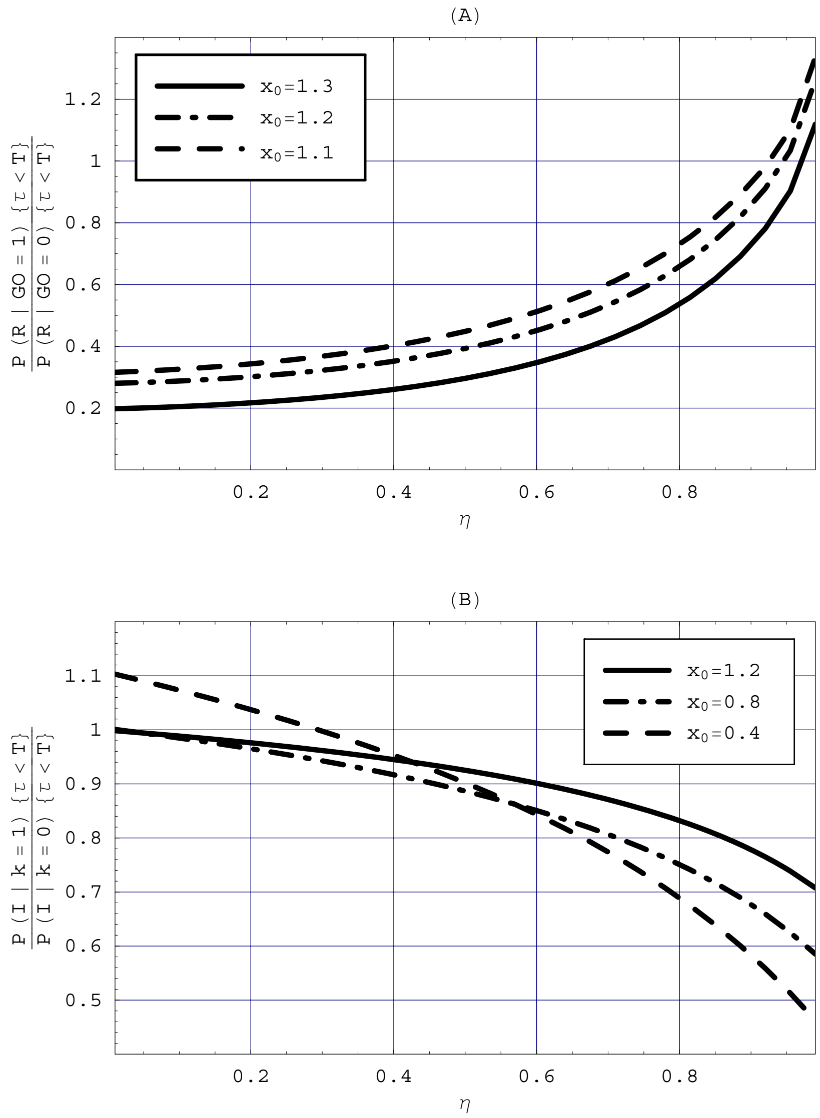

Figure 4: The ratio of probabilities of debt renegotiation with and without the growth option (Panel A) and of investment with renegotiable and non-renegotiable debt (Panel B) within $T = 5$ years as a function of shareholders' bargaining power η for different starting values of the cash flow process, x_0.