

The Dark Side of Secured Debt

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Keywords: Secured debt, Underinvestment, Overinvestment, Asset
substitution

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Abstract

It is generally accepted that secured debt reduces the agency costs of debt. Many studies have shown that secured debt alleviates the underinvestment and overinvestment/asset substitution problems. We demonstrate that secured debt can produce the opposite effects. We provide numerical examples where junior secured debt produces underinvestment and senior secured debt brings about overinvestment. This represents a cost of secured debt not recognized before. We discuss the empirical implications and stress the need to distinguish between junior and senior secured debt when making testable hypotheses.

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1 Introduction

A loan agreement is said to be secured when the borrower offers an asset to the lender as collateral. If the borrower defaults, the lender can take control of the asset and sell it. A number of studies (Smith and Warner (1979 a&b), Leeth and Scott (1989), Barclay and Smith (1995), Chen, Yeo, and Ho (1998)) indicate that secured debt is costly for the firm since it requires security registration, restricts asset usage, and increases the need for valuing and monitoring the collateral.

Naturally, there are also benefits of using secured debt. Scott (1977) argues that collateral increases firm value by diminishing the funds available to pay legal damages in bankruptcy. Another benefit of secured debt is the reduction of information asymmetries between borrowers and lenders. Chan and Kanatas (1985), Besanko and Thakor (1987), and Igawa and Kanatas (1990), among others, claim that collateral allows a firm to signal the high quality of a project to a lender. However, Barclay and Smith (1995) and Chen, Yeo, and Ho (1998) get little support for this hypothesis. More recently, Gonas, Highfield and Mullineaux (2004) find that, in their sample, firms with S&P rating tend to secure loans less often than firms not rated by S&P, and that larger firms are less likely to enter a secured loan agreement, which is consistent with the idea that secured debt diminishes asymmetric information.

Another recognized benefit of secured debt is the reduction of the conflict of interests between debtholders and equityholders relative to the firm's investment policy. When there is risky debt outstanding and managers make investment decisions that maximize stockholder wealth rather than firm value, managers will tend to avoid low-risk positive net present value (NPV) projects in which equity value decreases. This is the underinvestment problem of Myers (1977) and has been extensively studied in the literature.¹

¹See, for example, Stulz and Johnson (1985), Franks and Torous (1989), Leeth and Scott (1989), Chen, Weston, and Altman (1995), Chen, Yeo, and Ho (1998), Parrino and Weisbach (1999), Mauer and Ott (2000), Gonas, Highfield, and Mullineaux (2004), Siddiqi (2009), and Franzoni (2009).

By rejecting profitable projects, managers will destroy firm value, but shareholders will be better off. This happens because, if the firm takes these projects, the total risk of the assets of the firm will decrease and equity value will also decrease, despite the increment in firm value. In other words, the NPV of these projects, and something more, will go to bondholders, who will be better off with the projects than without them. There will be a wealth transfer from shareholders to bondholders and shareholders will be unwilling to take these good projects.

Additionally, with risky debt outstanding, managers will tend to accept high-risk negative NPV projects in which the value of equity increases. By acting in this way, managers will destroy firm value again, but shareholders will be wealthier. This is known as the overinvestment problem; see, for example, Chen, Weston, and Altman (1995), Chen, Yeo, and Ho (1998), and Parrino and Weisbach (1999).

Note that this overinvestment problem is not the same as the one discussed by Jensen (1986). He presents the situation where managers do not act in the best interest of shareholders. Actually, in his study there is a conflict of interests between managers and shareholders, which arises because of the existence of free cash flow.² Other papers that study Jensen's (1986) overinvestment problem are Stulz (1990), Franzoni (2009), D'Mello and Miranda (2010), and Fu (2010). The two overinvestment problems are different in nature. For example, debt diminishes the overinvestment problem of Jensen, since the interest payments on the debt reduces the funds under managerial control (D'Mello and Miranda (2010)). However, debt increases the overinvestment problem that we study, as debt fosters the conflict of interests between bondholders and shareholders (Smith and Warner (1979b)).

The overinvestment problem in this paper is very related to the asset substitution problem of Jensen and Meckling (1976). Actually, in Smith and Warner (1979b) and

²Defined as the cash flow in excess of what it is required to take all positive NPV projects.

Parrino and Weisbach (1999) both concepts are used indifferently. Although there are also authors that refer to asset substitution without mentioning overinvestment³ and vice versa.⁴ The asset substitution takes place when shareholders have incentives to substitute low-risk assets for high-risk ones. Since the payoff to equity is asymmetric, an increment in the risk of the assets of the firm increases shareholders wealth at the expense of bondholders. Thus, the pure asset substitution is a zero NPV transaction. However, there will be cases in which the value of the new high-risk asset is smaller than the value of the existing one. Then, if the risk of the new asset is sufficiently high it will be possible that firm value decreases while equity value increases. This will be a case of asset substitution with overinvestment. As in Smith and Warner (1979b), the overinvestment problem in this paper can be interpreted as an asset substitution problem in which the NPV is negative.⁵

There is a large body of literature that argue that secured debt reduces the agency costs of debt just described. On the one hand, Stulz and Johnson (1985), Leeth and Scott (1989), Chen, Yeo, and Ho (1998), and Pawlina (2010), among others, claim that secured debt reduces the underinvestment problem.⁶ The reason is that, with secured debt, the new asset is collateralized and supports the new debt in the event of bankruptcy. Accordingly, shareholders will be able to capture some of the project's NPV, that would go to existing bondholders otherwise. On the other hand, a number of authors maintain that secured debt can prevent the asset substitution problem (Smith

³Jensen and Meckling (1976), Jackson and Kronman (1979), Stulz and Johnson (1985), Leeth and Scott (1989), Leland (1998), Gonas, Highfield, and Mullineaux (2004), Bhanot and Mello (2006), and Siddiqi (2009).

⁴Chen, Weston, and Altman (1995), Chen, Yeo, and Ho (1998), and Mauer and Sarker (2005).

⁵Following Stulz and Johnson (1985) and Parrino and Weisbach (1999) in this paper the existing asset is not actually substituted by the new one; it is kept into the firm. So what the firm really does is to add new assets to its assets-in-place.

⁶Other ways to reduce the underinvestment problem are: using debt whose maturity can be extended by shareholders (Franks and Torous (1989)), hedging with derivatives (Gay and Nam (1998)), or using convertible debt (Smith and Warner (1979b), Green (1984), Lewis, Rogalski, and Seward (1999), and Siddiqi (2009)).

and Warner (1979b), Jackson and Kronman (1979), Stulz and Johnson (1985), Leeth and Scott (1989), Chen, Yeo, and Ho (1998), and Gonas, Highfield, and Mullineaux (2004) or the overinvestment problem due to the bondholder-shareholder conflict (Smith and Warner (1979b), Chen, Weston, and Altman (1995) and Parrino and Weisbach (1999)).

In this paper we provide striking new results about the ability of secured debt to reduce the agency costs of debt. Drawing on theoretical work of Stulz and Johnson (1985), we show that secured debt can increase the agency costs of debt and decrease firm value. This supposes a cost of secured debt not recognized before. We distinguish between junior and senior debt and we present numerical examples where junior secured debt aggravates the underinvestment problem while senior secured debt worsens the overinvestment problem. Moreover, we show that junior secured debt can produce underinvestment and senior secured debt can produce overinvestment in situations where these problems did not exist before. We discuss the important empirical implications of these findings.

The rest of the paper is organized as follows. In the next section we set up the investment decision problem of the firm and we value corporate liabilities for different financing choices, including secured debt. In Section, 3 we present several numerical examples that demonstrate that secured debt can increase the agency costs of debt, and we provide a number of testable hypotheses. Finally, Section 4 summarizes and concludes the paper.

2 Valuation framework

In this section, we value the debt and the equity of the firm for different financing choices. Our valuation framework follows Stulz and Johnson's (1985) and is similar to that of Black and Scholes (1973) and Merton (1974) for the valuation of corporate liabilities.

We consider a firm which owns one productive asset, A . We assume that $A(t)$ is the price at time t , with $0 \leq t \leq T$, of a traded asset that at time T will have the same value as the asset of the firm. The current value of the asset is A_0 . The firm is initially financed by unsecured debt, D , and equity, E . The debt consists of a single zero-coupon bond with face value F_D and maturity T . As in Stulz and Johnson (1985) and other similar studies, the firm does not pay dividends and liquidates at time T .

Default occurs if, at time T , the value of the firm's asset is smaller than the face value of the debt. In this case, the asset value is transferred to the bondholders. Other basic assumptions are:

- Markets are perfect: there are no taxes, no transaction costs, and no limits in short sales. Moreover, trading takes place continuously in time.
- The instantaneous riskless interest rate r is constant.
- In the event of default, priority rules are strictly enforced. This means that, in the case of bankruptcy, secured creditors have priority over unsecured creditors and shareholders (Scott (1977)). As Warner (1977) indicates, there are many cases in which these rules are not followed rigorously. Actually, Franks and Torous (1989) find frequent violations of the absolute priority rule in favor of shareholders in a sample of Chapter 11 processes. Despite this fact, and following Merton (1974), Stulz and Johnson (1985), and Frank and Torous (1989), we will assume that priority rules are strictly enforced. As indicated by Stulz and Johnson, the consequence is that secured debt could be overpriced, but it is unlikely that this will affect the qualitative results found in the paper.
- Markets are complete. Thus, there exists an equivalent risk-neutral probability measure under which discounted asset values are martingales. Hence, we can

compute present values by discounting future expected values under this measure at the risk-free interest rate.

- The asset price under the risk-neutral measure is governed by the following stochastic differential equation:

$$\frac{dA(t)}{A(t)} = rdt + \sigma_A dZ_A$$

where σ_A is a non-negative constant and Z_A is a standard Wiener process.

Following Black and Scholes (1973) and Merton (1974), the value of debt and equity at maturity are given by

$$\begin{aligned} D(T) &= \min \{F_D; A(T)\} \\ &= F_D - \max \{0; F_D - A(T)\} \\ E(T) &= \max \{A(T) - F_D; 0\} \end{aligned}$$

Hence, before maturity we can write

$$D(t) = F_D e^{-r(T-t)} - P(A(t); F_D; \sigma_A) \tag{1}$$

$$E(t) = C(A(t); F_D; \sigma_A) \tag{2}$$

where $P(A(t), F_D, \sigma_A)$ and $C(A(t), F_D, \sigma_A)$ denote, respectively, European put and call options on $A(t)$ with exercise price F_D and volatility σ_A . We omit the expiration date and the risk-free rate for easy of notation. Since $A(t)$ is lognormally distributed, expressions (1) and (2) can be computed with the Black-Scholes-Merton formula. We shall denote by D_0 and E_0 the initial values of debt and equity, that is, $D_0 = D(0)$ and $E_0 = E(0)$.

We now suppose that the firm has the opportunity to invest the amount I in a new asset, B . As before, we assume that $B(t)$ is the price at time t , with $0 \leq t \leq T$, of a traded asset that at time T will have the same value as B . The current value of this traded asset is denoted by B_0 . We also assume that $B(t)$ follows a Geometric Brownian Motion under the risk-neutral probability measure. Thus we can write

$$\frac{dB(t)}{B(t)} = rdt + \sigma_B dZ_B$$

where σ_B is a non-negative constant, and Z_B is a standard Wiener process with instantaneous correlation coefficient ρ_{AB} with Z_A .

We consider that the project can be financed using: 1) a mix of equity and unsecured debt, 2) junior secured debt, or 3) senior secured debt. All debt of the firm has the same maturity T and pays nothing until maturity. We assume that asset B is used as collateral of the secured debt. When the project is financed with junior secured debt, existing unsecured debtholders have a prior claim on asset A . With senior secured debt financing, both unsecured and secured debtholders have the same claim on asset A . We next value the debt and the equity of the firm in the three cases.

2.1 Equity and Unsecured Debt Financing

In this section we assume that the investment project is financed with equity and unsecured debt. Let p be the proportion of the required investment I that is financed with unsecured debt. Then, $1 - p$ is the proportion of equity financing used in the project. Obviously, if $p = 0$ the project is financed entirely with equity and if $p = 1$ the project is financed completely with unsecured debt. We call p_0 to the initial proportion of debt in the firm, that is $p_0 = \frac{D_0}{D_0 + E_0}$. Let $D'(t)$ denote the value at time t of the new unsecured debt, with face value $F_{D'}$ and the same maturity T as the existing debt. Then, we can

write at maturity

$$\begin{aligned}
D(T) &= F_D - \max \left\{ F_D - \frac{F_D}{F_D + F_{D'}} (A(T) + B(T)); 0 \right\} \\
D'(T) &= F_{D'} - \max \left\{ F_{D'} - \frac{F_{D'}}{F_D + F_{D'}} (A(T) + B(T)); 0 \right\} \\
E(T) &= \max \{ A(T) + B(T) - F_D - F_{D'}; 0 \}
\end{aligned}$$

So that at time $t < T$ we have

$$D(t) = F_D e^{-r(T-t)} - P \left(\frac{F_D}{F_D + F_{D'}} (A(t) + B(t)); F_D; \sigma \right) \quad (3)$$

$$D'(t) = F_{D'} e^{-r(T-t)} - P \left(\frac{F_{D'}}{F_D + F_{D'}} (A(t) + B(t)); F_{D'}; \sigma \right) \quad (4)$$

$$E(t) = C(A(t) + B(t); F_D + F_{D'}; \sigma) \quad (5)$$

where

$$\begin{aligned}
\sigma^2 &= x_A^2 \sigma_A^2 + x_B^2 \sigma_B^2 + 2x_A x_B \sigma_{AB} \\
x_A &= \frac{A_0}{A_0 + B_0} \\
x_B &= \frac{B_0}{A_0 + B_0}
\end{aligned}$$

Notice that these put and call values cannot be computed with the Black-Scholes-Merton formula. Since $A(t)$ and $B(t)$ are lognormal, the distribution of $A(t) + B(t)$ is unknown. Thus, we must employ numerical methods to price the debt and the equity of the firm. Another complication is that the face value of the new debt, $F_{D'}$, is not given. It must be computed recursively by making the current value of the new unsecured debt equal to the part of the investment to be financed with debt; that is by

solving the following equation

$$F_{D'}e^{-rT} - P\left(\frac{F_D}{F_D + F_{D'}}(A_0 + B_0); F_{D'}; \sigma\right) = Ip$$

If the project is financed entirely with equity ($p = 0$), then the above condition tells us of course that there is no need to issue new debt.

If we assume that managers make investment decisions that maximize shareholder wealth, then the project will be accepted when the value of equity of existing shareholders increases. That is, when $E(0) - I(1 - p) > E_0$, where $E(0)$ is the total value of equity at time 0 if new shares and debt are issued and the project is taken, E_0 is the value of equity if the project is not accepted, and $I(1 - p)$ is the amount of equity that needs to be raised to finance the project.

2.2 Junior Secured Debt Financing

Now, we assume that the investment project is financed with junior secured debt with face value F_J . Asset B is used as collateral. As before, it is assumed that the maturity of both types of debt (existing and new) is the same. Since unsecured debt has greater priority on asset A than junior secured debt, the claim of junior secured debtholders on $A(T)$ is $\max\{A(T) - F_D; 0\}$. Thereby, we have the following payoffs at maturity

$$J(T) = \min\{F_J; B(T) + \max\{A(T) - F_D; 0\}\} \quad (6)$$

$$= F_J - \max\{F_J + F_D - \max\{A(T) + B(T); B(T) + F_D\}; 0\}$$

$$D(T) = \min\{F_D; A(T) + \max\{B(T) - F_J; 0\}\} \quad (7)$$

$$= F_D - \max\{F_D + F_J - \max\{A(T) + B(T); A(T) + F_J\}; 0\}$$

$$E(T) = \max\{0; A(T) + B(T) - F_D - F_J\} \quad (8)$$

where $J(T)$ indicates the value of junior secured debt at maturity T .

At time t , with $0 \leq t < T$, the values of the contingent claims are given by

$$J(t) = F_J e^{-r(T-t)} - \text{PMAX}(A(t) + B(t); B(t) + F_D; F_D + F_J; \sigma_1; \sigma_2; \rho_{12}) \quad (9)$$

$$D(t) = F_D e^{-r(T-t)} - \text{PMAX}(A(t) + B(t); A(t) + F_J; F_D + F_J; \sigma_1; \sigma_3; \rho_{13}) \quad (10)$$

$$E(t) = C(A(t) + B(t); F_D + F_J; \sigma) \quad (11)$$

where σ is defined as before and

$$\begin{aligned} \sigma_1 &= \sigma \\ \sigma_2 &= \frac{B_0}{B_0 + F_D} \sigma_B \\ \sigma_3 &= \frac{A_0}{A_0 + F_J} \sigma_A \\ \rho_{12} &= \frac{1}{\sigma_1 \sigma_2} \frac{B_0}{B_0 + F_D} (x_A \sigma_{AB} + x_B \sigma_B^2) \\ \rho_{13} &= \frac{1}{\sigma_1 \sigma_3} \frac{A_0}{A_0 + F_J} (x_A \sigma_A^2 + x_B \sigma_{AB}) \end{aligned}$$

Here, x_A and x_B have been defined earlier, and $\text{PMAX}(S_1(t); S_2(t); X; \sigma_1; \sigma_2; \rho_{12})$ represents the value of a European put option with strike X on the maximum of two assets $S_1(t)$, $S_2(t)$, with volatilities σ_1 and σ_2 and correlation coefficient ρ_{12} . As before, expressions (9), (10), and (11) must be computed numerically. The face value of the junior secured debt, F_J , is computed by solving the equation

$$F_J e^{-rT} - \text{PMAX}(A_0 + B_0; B_0 + F_D; F_D + F_J; \sigma_1; \sigma_2; \rho_{12}) = I$$

2.3 Senior Secured Debt Financing

Now we consider the case where the project is financed with senior secured debt, with maturity T and face value F_S . As before, asset B is used as collateral. Since senior secured creditors rank equally with unsecured creditors for their claims on asset A , their claim on A at maturity is

$$\frac{\max\{F_S - B(T); 0\}}{\max\{F_S - B(T); 0\} + F_D} A(T)$$

Thus, the payoffs are

$$S(T) = \min \left\{ F_S; B(T) + \left(\frac{\max\{F_S - B(T); 0\}}{\max\{F_S - B(T); 0\} + F_D} \right) A(T) \right\} \quad (12)$$

$$= F_S - \max \{ F_S - \max\{Q(T), B(T)\}; 0 \}$$

$$D(T) = \min \left\{ F_D; \max \left\{ A(T) + B(T) - F_S; \frac{F_D A(T)}{F_D + F_S - B(T)} \right\} \right\} \quad (13)$$

$$= F_D - \max \{ F_D + F_S - \max \{ S_1(T); S_2(T) \}; 0 \}$$

$$E(T) = \max \{ 0; A(T) + B(T) - F_D - F_S \} \quad (14)$$

where $S(T)$ stands for the value of senior secured debt at maturity T . In these expressions, the following definitions are used

$$Q(T) = \frac{F_S B(T) - B^2(T) + B(T)F_D + F_S A(T) - B(T)A(T)}{F_S - B(T) + F_D}$$

$$S_1(T) = A(T) + B(T)$$

$$S_2(T) = \frac{F_D A(T)}{F_D + F_S - B(T)} + F_S$$

Prior to maturity we can write

$$S(t) = F_S e^{-r(T-t)} - \text{PMAX} (Q(t); B(t); F_S; \sigma_Q, \sigma_B; \rho_{QB}) \quad (15)$$

$$D(t) = F_D e^{-r(T-t)} - \text{PMAX}(S_1(t); S_2(t); F_D + F_S; \sigma_{S_1}, \sigma_{S_2}; \rho_{S_1 S_2}) \quad (16)$$

$$E(t) = C(A(t) + B(t); F_D + F_S; \sigma) \quad (17)$$

where $\sigma_Q, \rho_{QB}, \sigma_{S_1}, \sigma_{S_2}$, and $\rho_{S_1 S_2}$ are given in the Appendix.

Since the distribution of some of the underlying assets in (15), (16), and (17) is unknown, numerical methods must be used to compute these expressions. The face value of the new debt, F_S , is obtained solving the equation

$$F_S e^{-rT} - \text{PMAX}(Q(0); B(0); F_S; \sigma_Q, \sigma_B; \rho_{QB}) = I.$$

3 Secured debt and investment decisions

We next analyze how secured debt affects the investment decisions of the firm through different examples. When markets are perfect and efficient, Modigliani and Miller (1958) show that the value of the firm is independent of its capital structure⁷ and we can separate investment decisions and financing decisions. However, in the real world, capital markets are not perfect and the investment policy of a firm is affected by its capital structure. Following Myers (1977), Smith and Warner (1979b), Chen, Weston, and Altman (1995), and Parrino and Weisbach (1999), among others, we assume that managers act in the shareholders' interest. In the presence of risky debt this produces conflict of interests between bondholders and shareholders as maximizing equity value is not equivalent to maximizing firm value (Fama and Miller (1972, p. 179)). Investment projects will be accepted when the value of existing shares increases and rejected if the value decreases, regardless of the NPV of the project. As indicated earlier, this will cause, in general, underinvestment or overinvestment. These agency problems are costly for

⁷Modigliani and Miller's Proposition I.

the firm and offset the tax advantage of debt. Mauer and Ott (2000) find that the cost of underinvestment in their model ranges from 2-9% of firm value, while the cost of overinvestment is estimated to be 9.4% in Mauer and Sarker (2005).

In this section we present different examples of a firm that can invest in a project using alternative financing choices. To study the investment decisions of the firm, we compute the increment in the value of existing shares for each financing alternative. As pointed out earlier, it is assumed that the values of both the asset-in place of the firm and the new asset are lognormally distributed, thus, contingent claims on the total assets of the firm must be priced numerically. We use Monte Carlo simulation. To obtain reliable results we need to use a large number of simulations. Concretely, we generate 1,000,000 (500,000 plus 500,000 antithetic) paths in each of the following cases.

3.1 Example based on Stulz and Johnson (1985)

Our first analysis draws upon Table 1 of Stulz and Johnson (1985). They consider a firm which already owns two assets A and B whose values are lognormally distributed. The firm is financed with: a) equity, unsecured debt, and junior secured debt or b) equity, unsecured debt, and senior secured debt. The face values of the debt are given. In this situation, Stulz and Johnson price junior and senior debt and calculate the values of the security provision.⁸

In their table, Stulz and Johnson perform a comparative statics analysis of debt values. In row 11, the current values of the assets are $A_0 = 50$ and $B_0 = 50$. The two assets have the same standard deviation of returns, $\sigma_A = \sigma_B = 0.20$. The correlation coefficient between returns is $\rho_{AB} = -0.50$. The face value of unsecured debt, F_D , is 1000 and it is equal to the face value of secured debt. Other parameters are $r = 0.15$ and $T = 20$ years. With these data they obtain that the value of junior secured debt is

⁸Obtained as the price of the secured debt minus the price of an identical unsecured debt.

38.9 and the value of senior secured debt 43.4.

Our setting is slightly different. We assume that the firm owns initially only the asset A and that the purchase of asset B is financed with the proceeds of equity and/or debt issues. Hence, the net present value of the investment project is computed as B_0 minus the amount of money raised, I . If asset B is financed with new debt, this means that the amount of money raised will be equal to the current value of the new debt. In the example of Stulz and Johnson, this implies that the NPV of the project is 11.1 when financed with junior secured debt and 6.6 when financed with senior secured debt.

This situation is analyzed in detail in our Table 1. The table is based on the previous example and presents five cases, depending on the initial investment I . The first two cases (columns 2 and 3) correspond to the situations just described: $I = 38.9$ and $I = 43.4$, so that the net present values of the project are 11.1 and 6.6, respectively. The initial values of debt and equity before taking the project are $D_0 = 32.67$ and $E_0 = 17.33$, computed with expressions (1) and (2), respectively.

[Insert Table 1 about here]

If the project is financed entirely with equity, the total value of equity will be 51.68 in both cases, since it does not depend on I . The new value of the existing debt will be 48.26. Notice that if we add equity and debt we do not get exactly 100 ($A_0 + B_0$); this is due to the fact that we are valuing each claim with Monte Carlo simulation, using expressions (5) and (3) (with $p = 0$).⁹ To see if the project will be accepted or not, we must look at the value of the equity of existing shareholders, that is the total value of equity minus the new equity raised. In the first case studied, the new value of the existing shares will be $51.68 - 38.90 = 12.78$, and in the second case, $51.68 - 43.40 = 8.28$. Since both quantities are smaller than the initial value of equity, the wealth of existing

⁹Obviously, we could have priced the debt directly as $D(t) = A(t) + B(t) - E(t)$.

shareholders will decrease with the project, and the project will not be accepted, despite its positive NPV. Thus, there will be underinvestment and we indicate it in the table by writing (U) next to the value of equity.

We now study financing the project with a combination of equity and debt. We assume that the firm wants to maintain its current capital structure so that the project is financed with the proportions of equity and debt that existed initially in the firm ($1-p_0$ and p_0 , respectively). That is, we assume that asset B is financed with a proportion of debt equal to 0.6534 and a proportion of equity equal to 0.3466. Therefore, the amounts of equity to be raised are 13.48 in column 2 of Table 1 and 15.04 in column 3, and the amounts of debt that needs to be issued are 25.42 and 28.36, respectively.

The table shows that, when the initial investment is $I = 38.90$ and the project is financed in the manner just described, the face value of the new unsecured will be 588.02 and its current value 25.41. Notice that this value is not identical to the amount of debt required by the project due to numerical errors in the Monte Carlo simulations. The current value of the original unsecured debt will be 43.21, and the total value of equity 31.28. To see if the project will be taken or not, we compute the value of the existing shares: $31.28 - 13.48 = 17.80$. Since this is greater than 17.33, the wealth of existing shareholders increases with the project and the project will be accepted, so that there will not be underinvestment. Recall that in this case $NPV = 11.1$.

When the initial investment is $I = 43.4$ ($NPV=6.6$), the amounts of equity and debt to be issued are 15.04 and 28.36, respectively, and the total value of equity will be 29.25. Then, the value of the existing shares will now be $29.25 - 15.04 = 14.21$, which is smaller than 17.33, so that the project will not be accepted and there will be underinvestment, as indicated in the table.

If asset B is financed completely with new unsecured debt ($p = 1$) we see in the table that the face value of the debt must be $F_{D'} = 998.92$ in the first case (column 2) and

$F_{D'} = 1164.54$ in the second (column 3), so that their current values will be 38.92 and 43.40, respectively. Then, the values of existing shares will be 22.07 and 19.26, respectively, the project will be taken in both cases, and there will not be underinvestment.

When junior secured debt financing is used, the table shows that the face value of the new debt is 999.47 in the first case (column 2). This is very close to the face value of the junior secured debt in the example of Stulz and Johnson (1000). The current value of this debt is 39.00, again very close to the value obtained by these authors (38.90). The value of unsecured debt is 38.96 and the value of equity goes up to 22.17, so that the project is accepted and that there is not underinvestment. In the second case (column 3), the project is also accepted since the value of equity increases to 18.82.

Finally, with senior secured debt financing, the value of equity also increases in the two cases, and the project will be accepted again. In particular, in the second case (column 3), we have that the face value of the senior secured debt is 1000.47, very close to the face value in Stulz and Johnson (1000), and that the current value of this debt is 43.40, which is exactly the value they obtained. We also see in the table that the value of the existing secured debt goes up to 34.47 and the value of equity increases to 22.08.

In summary, in the first two cases of Table 1 (columns 2 and 3) we replicate and extend the calculations in row 11 of Table 1 of Stulz and Johnson (1985). We see that the underinvestment that takes place when the acquisition of asset B is financed with equity disappears with junior or senior secured debt financing. Nonetheless, this underinvestment also disappears with unsecured debt financing, so that the usefulness of secured debt is not well appreciated. For this reason, we analyze three more cases in Table 1, that correspond to $I = 46, 49,$ and $51,$ ($NPV = 4, 1,$ and $-1,$ respectively).

Junior secured debt can exacerbate the underinvestment problem

In column 4 of the table, we see that when the NPV is 4, there is underinvestment if the

project is financed entirely with equity or with the mix of equity and debt, but there is not underinvestment if the project is financed with unsecured debt. This happens because the value of equity with unsecured debt financing is 17.84, which is greater than the initial equity value, so existing shareholders will be wealthier with the project. However, if the project is financed with junior secured debt, the value of equity decreases to 16.82 and the project will not be accepted; the firm will pass up the opportunity to increase its value by 4 and there will be underinvestment. Relative to unsecured debt financing, this is a situation where junior secured debt is not alleviating the underinvestment problem but it is producing it. To the best of our knowledge, this is the first time in the literature that this result is reported.

This finding is at odds with the extended idea that secured debt reduces the underinvestment problem. In words of Stulz and Johnson (1985, p. 502): “Secured debt is a form of debt which allows shareholders to sell claims to some payoffs of a new project which otherwise would accrue to the existing creditors of the firm. It follows that issuing secured debt, compared to issuing other forms of debt, decreases the benefits which accrue to existing bondholders and increases the benefits which accrue to shareholders from the adoption of a new project, thereby making it more attractive for shareholders to undertake the project.” This sentence implies of course that secured debt will reduce any underinvestment due to unsecured debt financing. A similar statement can be found in Leeth and Scott (1989, p. 381): “In some cases, the firm will reject profitable investment projects when only equity or unsecured debt financing is available. Partially financing a new project using unsecured debt allows existing debtholders to capture some of the project’s net value. ... Using a security provision, the new assets support the new debt in the event of bankruptcy, reducing the gains to existing creditors.” This means that with secured debt financing shareholders will be able to capture the reduction in the wealth of the bondholders and the NPV of the project. If the NPV is positive, shareholders will always be better off with the project, so that there cannot be underinvestment.

The way to reconcile our findings with the previous literature is to realize that these arguments are valid for senior secured debt but not for junior secured debt. It is true that, “if the firm can finance the purchase of asset B partly by issuing new debt ... the security provision diverts from the unsecured bondholders some payoffs of asset B which would otherwise accrue to them” (Stulz and Johnson (1985, p. 516)), but what is not true, in general, is that this will be “advantageous for the shareholders,” as these authors state. As shown in expressions (6) and (7), with junior secured debt, existing unsecured debtholders keep their claim on asset A and have another claim on asset B , which implies that, in case of bankruptcy, they could receive a payment after junior secured debtholders are paid in full. As a consequence, the value of unsecured debt never decreases (Stulz and Johnson (1985), p. 517)). In Table 1 we see that the initial value of unsecured debt is $D_0 = 32.67$, and goes up with junior secured debt financing to 38.96, 37.82, 37.20, 36.50, and 36.03, depending on the initial investment I . Thus, unsecured debtholders are able to capture at least part of the NPV of a profitable project. If the NPV of the project is not too high, the increment in the value of unsecured debt will come at the expense of the NPV of the project and the value of equity, which will decrease. Accordingly, the project will not be taken and there will be underinvestment.

Note that this cannot happen with senior secured debt. In column 4 of Table 1 we see that if the project is financed with senior secured debt, the value of equity will increase to 20.70, the project will be accepted, and there will not be underinvestment. Expression (12) tells us that, with senior secured debt, the new creditors have a claim on the collateralized asset B plus another claim on a fraction of asset A . Hence, unsecured creditors do not have full claim on asset A anymore, and, as a result, their wealth can decrease with the new debt. This implies that shareholder wealth can increase with senior secured debt, so that shareholders can capture the NPV of the project plus the reduction in bondholders wealth, which will palliate the underinvestment.

Column 5 of Table 1 shows that when the NPV is equal to 1, there will be underinvestment with all types of financing except with senior secured debt. Clearly, the underinvestment gets worse with junior secured debt, but it is eliminated with senior secured debt, which is consistent with the explanations provided before.

Senior secured debt can worsen the overinvestment problem

We have shown that senior secured debt reduces the underinvestment problem in situations where junior secured debt don't. So, we could be tempted to conclude that senior secured debt is better suited than junior secured debt to palliate the agency problems between bondholders and shareholders. The last column of Table 1 shows that this is not always true. It presents the situation where the initial investment is $I = 51$. Since the current value of asset B is just 50, this is a bad project and it should be rejected by a value-maximizing firm. The table shows that this will be the case if the project is financed with equity, equity and unsecured debt, unsecured debt or junior secured debt. However, if the project is financed with senior secured debt, equity value increases from 17.33 to 17.96 and the project will be accepted. The firm will overinvest, and its market value will decrease by 1. Thus, our second contribution to the literature is to show that senior secured debt can exacerbate the overinvestment problem.

Once again, this result contradicts previous studies, since it is commonly agreed that secured debt reduces the overinvestment/asset substitution problem. For example, Smith and Warner (1979b, p. 127) suggest that "... the issuance of secured debt lowers the total costs of borrowing by controlling the incentives for stockholders to take projects which reduce the value of the firm; since bondholders hold title to the assets, secured debt limits asset substitution." Note that, as explained earlier, this asset substitution is actually an overinvestment problem. Similarly, Leeth and Scott (1989, p. 380) claim that: "Collateral provisions may benefit borrowers by reducing the conflict

between bondholders and stockholders concerning the firm's investment, financing, and dividend policies. Specifically, pledging collateral may lower a firm's total cost of debt by preventing asset substitution ...” These arguments are valid for junior secured debt but not for senior secured debt. As shown in expressions (12) and (13), and as explained before, with senior secured debt, unsecured bondholders no longer have full claim on asset A and their wealth can decrease with the new debt. If the NPV of the project is negative but not too small, it is possible that the reduction in unsecured debtholders wealth more than compensates the value destroyed with the project, so that equity value can increase, producing overinvestment.

Thus senior secured debt can effectively transfer wealth from existing unsecured bondholders to shareholders. Going back to Table 1, we see that with senior secured debt the value of unsecured debt indeed decreases. When the initial investment is $I = 49.0$ or $I = 51.0$ (NPV equal to 1 or -1, respectively), the value of unsecured debt decreases from 32.67 to 31.93 or 30.99, respectively.

To make our point more clear we present the cases studied in Table 1, and many others, graphically in Figure 1. The figure shows the increment in the value of equity of our firm when asset B is financed with different alternatives. For simplicity, we only plot the alternatives of unsecured and secured debt financing. The horizontal axis is the NPV of the project and the vertical axis is the increment in the value of the equity of existing shareholders. When the NPV of the project is positive but the increment in equity value is negative, the firm underinvests as it will reject profitable projects. This is indicated in the fourth quadrant of the graphic. When the NPV of the project is negative and the increment in equity value is positive, the firm overinvests as it will take unprofitable projects. This is highlighted in the second quadrant of the figure.

[Insert Figure 1 about here]

The two cases in row 11 of Table 1 of Stulz and Johnson (1985) for junior and senior secured debt are plotted as a dark circle and a dark square, respectively. As indicated earlier, these cases correspond to $I = 11.1$ (junior secured debt) and $I = 6.6$ (senior secured debt), with increments in the value of equity of 22.17 and 22.08, respectively. We see in the graphic that the firm will take the project in the two cases, so that there will not be underinvestment.

However, if we decrease the NPV of the project (we increase the initial investment I), the firm underinvests with unsecured debt when the NPV is approximately 3 or less. Junior secured debt worsens the underinvestment problem, as the decrease in equity value is higher and the firm underinvests sooner (it rejects projects with higher NPVs). Using the data of Stulz and Johnson (1985, Table 1, row 11), this happens when the NPV of the project is between 0 and 4.9. As shown in Table 1, there are even cases (NPV close to 4) where junior secured debt creates an underinvestment that did not exist with unsecured debt.

Figure 1 also shows that there is no overinvestment with unsecured debt or junior secured debt financing. When the required investment is higher than B_0 and when the firm issues unsecured debt or junior secured debt, the project is rejected as equity value decreases. However, we see that senior secured debt produces overinvestment. When the NPV of the project is between 0 and -2.5 and when the investment is financed with senior secured debt, the project is accepted since the value of equity increases. Thus, for a small range of net present values, senior secured debt originates an overinvestment problem that did not exist before.

Our findings might have important empirical implications. To gain some insight into the ability of secured debt to reduce or to increase the agency costs of debt, we next study examples in which the underinvestment and overinvestment are probable. We refer to them in Table 2 as Case 1 (3 subcases) and Case 2, respectively.

3.2 A typical example of underinvestment

The underinvestment problem is more likely to occur when the amount of risky debt outstanding is high, when the risk of the new asset is much smaller than the risk of the existing assets of the firm, and when the NPV of the project is small. Accordingly, in the second column of Table 2 we study the following example (Case 1A). We assume that the value of the asset-in-place of the firm is $A_0 = 400$ and that its volatility is high, $\sigma_A = 0.50$. The firm has a significant amount of debt,¹⁰ $F_D = 2400$, that matures in $T = 5$ years. The interest rate is $r = 0.10$. The firm can invest $I = 900$ in a new asset B that has low risk, $\sigma_B = 0.10$, and a current value of $B_0 = 1000$. The correlation coefficient of the return of the new asset with the return of the existing one is $\rho_{AB} = 0.5$. Using expressions (1) and (2) we get $D_0 = 352.74$ and $E_0 = 47.26$, thus, the proportion of debt is very high, $p_0 = 0.8818$.

[Insert Table 2 about here]

If the project is financed completely with equity, the total value of equity will be 205.38 and the value of existing will jump to 1193.24. Since the total equity value is smaller than the amount of equity to be issued (900), this will not be a feasible way of financing the project.

If the project is financed with equity and unsecured debt, in the proportions $1 - p_0$ and p_0 , respectively, the firm will need to issue debt with a face value of 3289.87. The current value of this debt will be 793.58. The value of existing debt will jump to 578.93. However, the total value of equity will be just 27.08. Since this value is smaller than the amount of equity to be raised,¹¹ it will be impossible for the firm to finance the project this way.

¹⁰So that the conflict of interests between bondholders and shareholders can be significant.

¹¹ $900(1-0.8818)$.

If only unsecured debt is used, column 2 of Table 2 shows that the firm will need to issue new debt with a face value of 4473.22. New creditors will pay for this debt its fair market price, 900.36, which will allow the firm to finance the project. The value of existing debt will increase to 483.07 and the value of equity will decrease to 17.73. Consequently, shareholders will be unwilling to take the project and there will be underinvestment.

If the firm issues junior secured debt to finance the project, we see in the table that the face value of the new debt is much smaller, 1609.22. The value of the existing unsecured debt will increase to 437.35, capturing part of the NPV of the project. The remaining of the NPV will go to shareholders, as the value of equity will increase to 63.75. Thus, the project will be taken and the underinvestment problem will disappear.

Lastly, with senior secured debt the value of equity will go up a little more, to 64.33, and the project will be accepted again.

In column 3 of Table 2 (Case 1B) the NPV of the project is 10 instead of 100. We now see that there is underinvestment with both unsecured debt. The underinvestment is weaker with junior secured debt and disappears with senior secured debt.

Column 4 (Case 1C) shows that if we decrease the NPV of the project so that it becomes negative (-10), the project will be accepted with senior secured debt, despite its negative NPV. Thus, senior secured debt will produce overinvestment.

To visualize the results we plot in Figure 2 the increment in the value of equity that unsecured and secured debt produces in Case 1 of Table 2 as a function of the NPV of the project.

[Insert Figure 2 about here]

We see that with unsecured debt the underinvestment problem is severe and occurs unless the NPV of the project is greater than 355. Junior secured debt practically avoids

the underinvestment for any NPV, and senior secured debt eliminates the underinvestment but produces overinvestment if the NPV of the project is not very negative.

It is worth mentioning that with junior secured debt the pricing algorithm is unable to find a face value of debt that makes the current value of junior secured debt equal to the required investment (1100). The highest amount of junior secured debt that can be raised is about 1041.17, which corresponds to a face value of 7479.39.¹²

The underinvestment in Figure 2 is due in part to the low volatility of asset B , which reduces the volatility of the firm's assets and makes equity less valuable. Thus, in Figure 3 we analyze what happens with the underinvestment when we increase σ_B .

[Insert Figure 3 about here]

We see that, with unsecured debt financing, there exists underinvestment unless the standard deviation of the returns of asset B exceeds 0.31. We also see that there is no underinvestment if the project is financed with junior or senior secured debt, irrespective of σ_B . Interestingly, junior secured debt makes this profitable project less attractive to shareholders than unsecured debt when the risk of the new asset exceeds the risk of the existing one.

Finally, we verify that with junior secured debt, the value of unsecured debt always increases. In columns 2–4 of Table 2, the initial value of unsecured debt is $D_0 = 352.74$, and with junior secured debt it goes up to 437.35, 362.98, and 353.60 in the cases 1A, 1B, and 1C, respectively. However, with senior secured debt financing, it goes down to 340.17 in case 1C.

To summarize, we can conclude that when the risk of asset A is high, the risk of asset B is low, and the amount of debt of the firm is significant, both junior and senior secured

¹²This happens because the secured debt uses as collateral asset B , which is less valuable (1000) than the new debt. Moreover, unsecured creditors have greater priority on asset A , which has small current value (400).

debt will probably palliate the underinvestment problem if it occurs. However, if the NPV of the project is slightly negative, senior secured debt can produce overinvestment.

3.3 A typical example of overinvestment

In the last column of Table 2, we present a typical case of overinvestment. We call it Case 2. The overinvestment is more likely to happen when the firm has a significant amount of debt and when the risk of the new asset is greater than the risk of the existing asset. Thus, in Case 2 of Table 2 we suppose that the face value of unsecured debt is the same as before (2400), the risk of the existing asset A is $\sigma_A = 0.30$, and the risk of asset B is $\sigma_B = 0.50$. The required investment is now $I = 1,100$ so that the project has negative NPV (-100). The other parameter values are as in Case 1. With these data the initial value of equity is $E = 5.07$ whereas the value of unsecured debt is $D = 394.93$. Thus, the proportion of debt is now even higher than in Case 1, $p_0 = 0.9873$.

If the project is financed with equity, the total value of equity will be 466.48, which is not enough to cover the initial investment, so that this alternative is not feasible.

If the project is financed with equity and unsecured debt, the table shows that the total value of equity will go up to 49.14. which is greater than the amount of equity to be issued,¹³ so this financing alternative is feasible. This is due to the increment in the risk of the assets of firm, which goes from 0.30 to 0.41. The total equity value is greater than the amount of equity to be raised plus the initial value of equity. Then, the wealth of existing shareholders will increase and the project will be accepted, despite its negative NPV.

Something similar happens if the project is financed with equity and unsecured debt. Total equity value will go up to 46.41 and the firm will overinvest again.

¹³ $1100(1-0.9873)$.

With junior secured debt, the pricing algorithm is unable to find a face value of debt that makes the current value of junior secured debt equal to the required investment (1100). The highest amount of junior secured debt that can be raised is now about 1002. Thus, it is not possible to finance the project with junior secured debt.

Finally, we see in the table that senior secured debt exacerbates the overinvestment problem because it increases the value of equity to 99.08. The value of unsecured debt jumps down from 394.93 to 200.13, absorbing the negative NPV of the project and the increment in shareholder wealth.

These results are shown graphically in Figure 4 where we change the initial investment so that the NPV of the project goes from -400 to 400. We see that there is no underinvestment in any of the cases, but there is serious overinvestment for unsecured and senior secured debt financing. We also see that this project cannot be financed with junior secured debt if the NPV is negative.

[Insert Figure 4 about here]

3.4 No investment distortions

In Figure 5 we present a last case, in which unsecured debt does not produce investment distortions for any NPV but secured debt does. We assume that $A_0 = 1600$, $\sigma_A = 0.3$, $B_0 = 1600$, and $\sigma_B = 0.2$. The rest of the parameters are as in Figures 2 and 4.

[Insert Figure 5 about here]

We see that when the project is financed with unsecured debt, it will be accepted when the NPV is positive and rejected when the NPV is negative. However, junior secured debt will produce underinvestment unless the NPV is sufficiently high, and senior secured debt will produce overinvestment for any negative NPV. Thus, in a situation

like this the firm should avoid using junior secured debt when there are moderately good investment opportunities available. Likewise, the firm should avoid financing the project with senior secured debt when the projects at hand are bad. This will imply that these bad projects will not be undertaken, since unsecured debt or junior secured debt will reduce equity value.

3.5 Empirical implications

The theoretical studies of Smith and Warner (1979a), Chan and Kanatas (1985), Besanko and Thakor (1987), and Stulz and Johnson (1985) provide testable hypotheses about the use of secured debt based on the assumption that financing decisions are made to maximize firm value while investment decisions are made to maximize equity value. Thus, there can be underinvestment and overinvestment problems and the firm will prevent them by, among other things, financing investment projects with secured debt. These hypotheses, and others, are tested empirically by Leeth and Scott (1989), Barclay and Smith (1995), Chen, Yeo, and Ho (1998), and Gonas, Highfield, and Mullineaux (2004).

From the discussion in the previous sections of this paper, we know that junior and senior secured debt behave differently, so predictions about the use of the different types of debt must be carefully made. For example, with respect to unsecured debt, a common prediction (Pawlina (2010)) is that firms with more growth opportunities should use less debt. The reason is obvious as the agency costs of debt increase with the amount of debt outstanding. From Figure 2 we know that if the firm has a substantial amount of debt, the risk of the existing assets is high, the risk of the investment projects is low, and the growth opportunities available are good,¹⁴ then unsecured debt will produce underinvestment and should be avoided. Thus, the prediction of Pawlina (2010) is

¹⁴But not too good, so that the NPV is, on average, positive but not too large.

consistent with the graphic. Moreover, the empirical findings of Barclay and Smith (1995) and McConnell and Servaes (1995) support the hypothesis. However, from Figure 4 we have that if the firm is highly levered, the risk of the existing assets is low, the risk of the investment projects is high, and there are attractive growth opportunities available, then the prediction is wrong as there will be no need to reduce the underinvestment problem.

With respect to secured debt, the usual hypothesis (Leeth and Scott (1989)) is that firms with more growth options should use more of this type of debt since secured debt reduces the underinvestment and overinvestment problems. Again, this hypothesis is consistent with Figure 2 but not with Figure 4. It should be expected instead that a value-maximizing firm, in situation where the overinvestment is likely, use equally unsecured and secured debt to finance investment projects. Thus, it is not surprising that the hypothesis of Leeth and Scott (1989) is supported by the findings of Chen, Yeo, and Ho (1998) but not by the results of Barclay and Smith (1995).

We argue that we must distinguish between junior and senior secured debt and that we must know whether the underinvestment or the overinvestment (Figure 2 or Figure 4, respectively) is likely to make meaningful empirical predictions. As shown previously, there will be cases in which the underinvestment is reduced with senior but aggravated with junior secured debt and cases where the overinvestment is reduced with junior but aggravated with senior secured debt.

In this section we provide testable hypotheses about the use of secured debt that differentiates between junior and senior debt. We take into account the characteristics of the firm (D and σ_A), the characteristics of the project (σ_B), and the quality of the growth opportunities available to the firm (NPV). We consider both the case where the firm maximizes its value and the case where the firm maximizes shareholder wealth.

We first assume that financing decisions are made to maximize firm value. Then, the

firm should avoid the underinvestment and overinvestment problems when they are more likely. From Section 3.2 we have that the underinvestment will be greater when the firm is highly levered, the standard deviation of the rate of return of the existing assets is high and the risk of the projects available to the firm is low. Thus, in this case we should expect that firms with enhanced growth opportunities use senior, junior, and unsecured debt to finance the projects. If the firm has good growth opportunities available, we should expect a greater use of senior and junior secured debt. Firms with some attractive growth opportunities are expected to use senior secured debt more frequently. Finally, firms with bad or few¹⁵ growth opportunities are expected not to use secured debt and to finance investment projects with unsecured debt.¹⁶

Also, from Section 3.3 we have that the overinvestment problem will be stronger when the amount of initial unsecured debt of the firm is high, the standard deviation of return of the existing assets of the firm is low, and the risk of the projects is high, we should expect that firms with good growth opportunities use both secured and unsecured debt financing. If the firm has bad or few growth opportunities available, we should expect that the firm does not use secured debt and finances the project with unsecured debt instead. This will produce overinvestment, but the overinvestment will be minimized with the use of unsecured debt. Junior secured debt could further reduce the overinvestment, but the firm may not be able to raise enough money to finance the project in this way.

We finally assume that the firm makes investment and financing decisions that maximize equity value. The reduction of the underinvestment problem benefits both shareholders and the firm. However, the minimization of the overinvestment problem benefits the firm but not shareholders. Therefore, when the firm maximizes equity value it will seek to palliate the underinvestment and to exacerbate the overinvestment. Accordingly,

¹⁵This will imply that, on average, the NPV of the investment projects is negative.

¹⁶Then equity value will decrease and managers will eventually decide not to take these projects.

the firm will reduce the underinvestment when it is more likely, and the empirical implications are as before. To exacerbate the overinvestment problem it is expected that the firm uses more frequently senior secured debt always, but especially when the *underinvestment* problem is more likely. This is so because, as shown in Figure 2, in this case, the only way to produce overinvestment is with senior secured debt. There will not be overinvestment with unsecured debt, and there will not be possible, in general, to finance the project with junior secured debt. Thus, we should expect that when the amount of debt outstanding is large, the risk of the assets of the firm is high, the risk of the projects is low, and there are few growth opportunities, firms that maximize equity value use senior secured debt more frequently. We should also expect the use of senior secured debt when the overinvestment is likely and the available projects are bad (see Figure 4). This will be the case when the firm is highly levered, the risk of the existing assets of the firm is low, the risk of the projects is high, and there are few growth opportunities. In this situation, we should also observe that firms use unsecured debt since it will produce overinvestment as well.

4 Summary and Conclusions

Existing literature commonly agrees with the idea that secured debt reduces the agency costs of debt. Smith and Warner (1979 a&b), Stulz and Johnson (1985), Leeth and Scott (1989), Chen, Yeo, and Ho (1998), and Gonas, Highfield, and Mullineaux (2004) argue that secured debt decreases the conflict of interests between bondholders and shareholders relative to the firm's investment decisions.

This paper shows that secured debt can increase the agency costs of debt. Building on the classical model of Merton (1994) and following the work of Stulz and Johnson (1985), we study the investment decisions of a firm with risky debt outstanding when managers

maximize shareholders wealth instead of firm value. We demonstrate that some good projects that would be taken if financed with equity or unsecured debt, will be rejected if financed with junior secured debt. We also show that some bad projects that would not be taken if financed with equity or unsecured debt, will be accepted if financed with senior secured debt. Thus, secured debt can exacerbate the underinvestment problem of Myers (1977) and the overinvestment/asset substitution problem of Jensen and Meckling (1976).

These findings represent a cost for the firm that has so far been omitted from the literature, and can have important empirical implications. We underline the need for testable hypotheses that distinguish between junior and senior secured debt. We provide a number of empirical predictions about the use of unsecured, junior secured, and senior secured debt, taking into account the characteristics of the firm, the characteristics of the project, and the quality of the growth opportunities available. This is done from the perspectives of a value-maximizing firm and an equity-maximizing firm.

Naturally, the overall conclusion is not that that firms should not use secured debt, since we are focusing just on one side effect of this type of debt. Rather, our findings suggest that competing theories might play a more important role explaining the prevalent use of secured debt¹⁷ than previously thought, and emphasize the importance of the type of debt financing (Pawlina (2010)).

¹⁷See, for example, Leeth and Scott (1989), Chen, Yeo, and Ho (1998), and Linn and Stock (2005).

Appendix

Values of σ_Q and ρ_{QB} in expression (15).

$$\sigma_Q^2 = \sigma_C^2 + \sigma_D^2 - 2\sigma_{CD}$$

$$\begin{aligned} \sigma_C^2 = & \left(x_A^C\right)^2 \sigma_A^2 + \left(x_B^C\right)^2 \sigma_B^2 + \left(x_E^C\right)^2 \sigma_E^2 + \left(x_F^C\right)^2 \sigma_F^2 + \\ & + 2x_A^C x_B^C \sigma_{AB} - 2x_A^C x_E^C \sigma_{AE} - 2x_A^C x_F^C \sigma_{AF} - 2x_B^C x_E^C \sigma_{BE} - 2x_B^C x_F^C \sigma_{BF} - 2x_E^C x_F^C \sigma_{EF} \end{aligned}$$

$$\sigma_D^2 = \left(x_B^D\right)^2 \sigma_B^2$$

$$\sigma_E^2 = \sigma_A^2 + \sigma_B^2 + 2\sigma_{AB}$$

$$\sigma_F^2 = 4\sigma_B^2$$

$$\sigma_{CD} = x_B^D \left(x_A^C \sigma_{AB} + x_B^C \sigma_B^2 + x_E^C \sigma_{EB} + 2x_F^C \sigma_B^2 \right)$$

$$\sigma_{AE} = \sigma_A^2 + \sigma_{AB}$$

$$\sigma_{AF} = 2\sigma_{AB}$$

$$\sigma_{BE} = \sigma_B^2 + \sigma_{AB}$$

$$\sigma_{BF} = 2\sigma_B^2$$

$$\sigma_{EF} = 2(\sigma_{AB} + \sigma_B^2)$$

where

$$\begin{aligned} x_B^D &= \frac{-B_0}{(F_D + F_S) - B_0} \\ x_A^C &= \frac{F_S A_0}{F_S A_0 + B_0(F_S + F_D) - B_0 A_0 - B_0^2} \\ x_B^C &= \frac{(F_S + F_D) B_0}{F_S A_0 + B_0(F_D + F_S) - B_0 A_0 - B_0^2} \\ x_E^C &= \frac{-B_0 A_0}{F_S A_0 + B_0(F_D + F_S) - B_0 A_0 - B_0^2} \\ x_F^C &= \frac{-B_0^2}{F_S A_0 + B_0(F_D + F_S) - B_0 A_0 - B_0^2} \end{aligned}$$

Values of σ_{S1} , σ_{S2} , and ρ_{S1S2} in expression (16).

$$\begin{aligned}\rho_{QB} &= \frac{1}{\sigma_Q\sigma_B} \left(x_A^C\sigma_{AB} + x_B^C\sigma_B^2 + x_E^C\sigma_{BE} + x_F^C\sigma_{BF} - x_B^D\sigma_B^2 \right) \\ \sigma_{S1} &= \sigma \\ \sigma_{S2}^2 &= x_Z^2\sigma_Z^2 \\ \rho_{S1S2} &= \frac{1}{\sigma_{S1}\sigma_{S2}} \left(x_Ax_Z \left(\sigma_A^2 - x_B^D\sigma_{AB} \right) + x_Bx_Z \left(\sigma_{AB} - x_B^D\sigma_B^2 \right) \right)\end{aligned}$$

where

$$\begin{aligned}\sigma_Z^2 &= \sigma_A^2 + \left(x_B^D \right)^2 \sigma_B^2 - 2x_B^D\sigma_{AB} \\ x_Z &= \frac{C_0/D_0}{C_0/D_0 + F_S} \\ x_B^D &= \frac{-B_0}{(F_D + F_S) - B_0}.\end{aligned}$$

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Table 1: Example based on Stulz and Johnson (1985, Table 1, row 11).

I	38.9	43.4	46.0	49.0	51.0
NPV	11.1	6.6	4.0	1.0	-1.0
Equity financing					
E	(U)51.68	(U)51.68	(U)51.68	(U)51.68	51.68
D	48.26	48.26	48.26	48.26	48.26
Equity and unsecured debt financing					
E	31.28	(U)29.25	(U)28.22	(U)26.71	25.82
D	43.21	42.37	41.86	41.26	40.84
D'	25.41	28.34	30.04	32.00	33.31
$F_{D'}$	588.02	668.97	717.62	775.66	815.58
Unsecured debt financing					
E	22.07	19.26	17.84	(U)16.04	14.88
D	38.94	37.26	36.25	34.99	34.10
D'	38.92	43.40	46.02	49.03	51.00
$F_{D'}$	998.92	1164.54	1269.67	1401.17	1495.85
Junior secured debt financing					
E	22.17	18.82	(U)16.82	(U)14.57	13.04
D	38.96	37.82	37.20	36.50	36.03
J	39.00	43.42	45.98	48.99	51.00
F_J	999.47	1202.65	1340.29	1529.36	1677.94
Senior secured debt financing					
E	24.70	22.08	20.70	19.12	(O)17.96
D	36.39	34.47	33.33	31.93	30.99
S	38.89	43.40	45.99	49.00	50.98
F_S	868.91	1000.47	1081.98	1182.74	1253.76

The table shows that junior secured debt can produce underinvestment and senior secured debt can produce overinvestment. The table provides the values of equity (E) and debt for different financing alternatives. Initially the firm owns asset A and is financed with equity and unsecured debt. The firm can acquire asset B by investing the amount I . Five cases are considered, depending on the value of I . The first two (columns 2 and 3) correspond to an extended version of row 11 of Table 1 in Stulz and Johnson. The junior and senior secured debt that they price are shown in boldface. The face value of the new debt is computed so that the value of debt equals the amount of debt required by the project. The project is taken if the value of equity of existing shareholders increases. If the project is not taken but the NPV is positive, the firm underinvests, and it is indicated by (U). If the project is taken but the the NPV is negative, the firm overinvests, and it is denoted by (O). The parameters are as in Stulz and Johnson (1985, Table 1, row 11): $A_0 = 50, B_0 = 50, \sigma_A = 0.2, \sigma_B = 0.2, \rho_{AB} = -0.5, F_D = 1000, T = 20$, and $r = 0.15$. The initial values of equity and debt are $E_0 = 17.33$ and $D_0 = 32.67$, respectively. D and D' are the values of unsecured debt (initial and new). J and S are the values of secured debt (junior and senior). $F_D, F_{D'}, F_J$, and F_S are the corresponding face values of debt.

Table 2: Typical cases of underinvestment and overinvestment.

	Case 1			
	1A	1B	1C	Case 2
A_0	400	400	400	400
σ_A	0.50	0.50	0.50	0.30
E_0	47.26	47.26	47.26	5.07
D_0	352.74	352.74	352.74	394.93
B_0	1000	1000	1000	1000
σ_B	0.10	0.10	0.10	0.50
I	900	990	1010	1100
Equity and unsecured debt financing				
E	–	–	–	(O)49.14
D	–	–	–	264.20
D'	–	–	–	1085.83
$F_{D'}$	–	–	–	9863.74
Unsecured debt financing				
E	(U)17.73	(U)10.87	9.62	(O)46.41
D	483.07	399.23	380.48	253.89
D'	900.36	989.99	1009.99	1100.36
$F_{D'}$	4473.22	5951.39	6370.87	10401.42
Junior secured debt financing				
E	63.75	(U)46.42	36.45	–
D	437.35	362.98	353.60	–
J	899.99	990.46	1009.82	–
F_J	1609.22	2161.39	2673.11	–
Senior secured debt financing				
E	64.33	53.24	(O)50.34	(O)99.08
D	435.95	356.53	340.17	200.13
S	900.15	989.97	1010.20	1097.82
F_S	1586.35	1915.18	2020.24	5757.20

The table shows that junior secured debt may or may not be able to eliminate the underinvestment and that it cannot be used to finance some bad projects. Senior secured debt can eliminate the underinvestment but it can produce or exacerbate the overinvestment. Initially the firm owns asset A and can acquire asset B by investing the amount I . The face value of the new debt is computed so that the value of debt equals the amount of debt required by the project. The project is taken if the value of equity of existing shareholders increases. If the project is not taken but the NPV is positive, the firm underinvests, and it is indicated by (U). If the project is taken but the the NPV is negative, the firm overinvests, and it is denoted by (O). E is the value of equity. D and D' are the values of unsecured debt (initial and new). J and S are the values of secured debt (junior and senior). F_D , F'_D , F_J , and F_S are the corresponding face values of debt. The rest of parameters are: $\rho_{AB} = 0.5$, $F_D = 2400$, $T = 5$, and $r = 0.10$. Equity financing is not shown because it is not feasible in any of the cases. Other alternatives are not feasible in some cases. Underinvestment is more likely in Case 1 and overinvestment in Case 2.

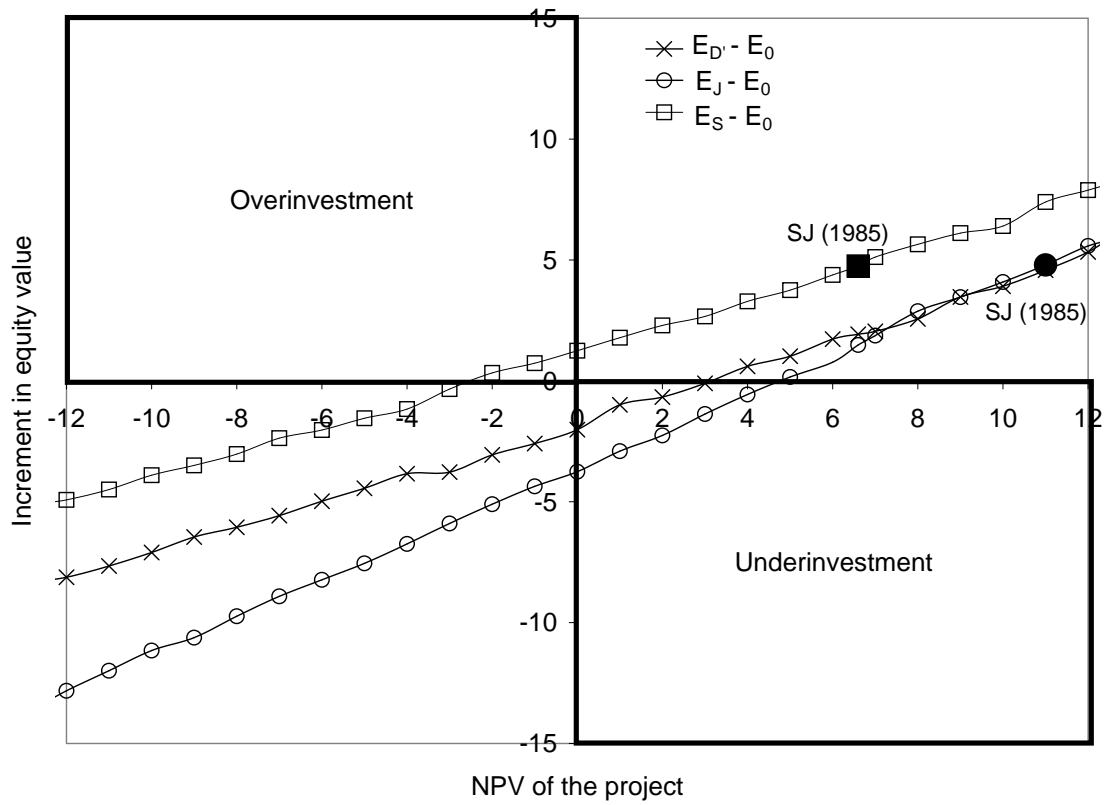


Figure 1: Example based on Stulz and Johnson (1985, Table 1, row 11). The figure plots the increment in the value of equity for unsecured and secured debt financing as a function of the NPV of the project. The values of the parameters are: $A_0 = 50$, $B_0 = 50$, $\sigma_A = 0.2$, $\sigma_B = 0.2$, $\rho_{AB} = -0.5$, $F_D = 1000$, $T = 20$, and $r = 0.15$. E_0 represents the value of equity before taking the investment project, while $E_{D'}$, E_J , and E_S refer to the value of equity when the project is taken and financed with unsecured, junior secured, and senior secured debt, respectively. The cases considered by Stulz and Johnson are indicated by a dark circle (junior secured debt) and a dark square (senior secured debt).

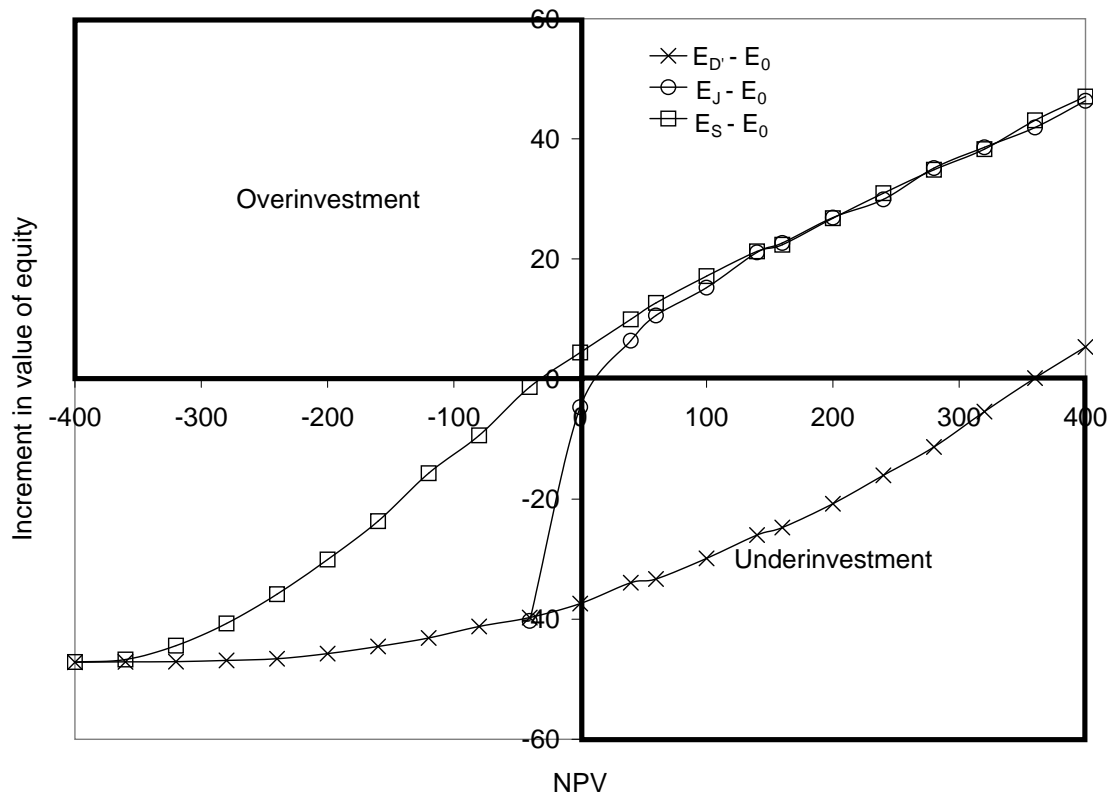


Figure 2: A typical case of underinvestment with unsecured debt financing. The figure shows the increment in the value of equity for unsecured and secured debt financing as a function of the NPV of the project. The value of the parameters correspond to Case 1 of Table 2: $A_0 = 400$, $B_0 = 1000$, $\sigma_A = 0.5$, $\sigma_B = 0.1$, $\rho_{AB} = 0.5$, $F_D = 2400$, $T = 5$, and $r = 0.1$. E_0 represents the value of equity before taking the investment project, while $E_{D'}$, E_J , and E_S refer to the value of equity when the project is taken and financed with unsecured, junior secured, and senior secured debt, respectively.

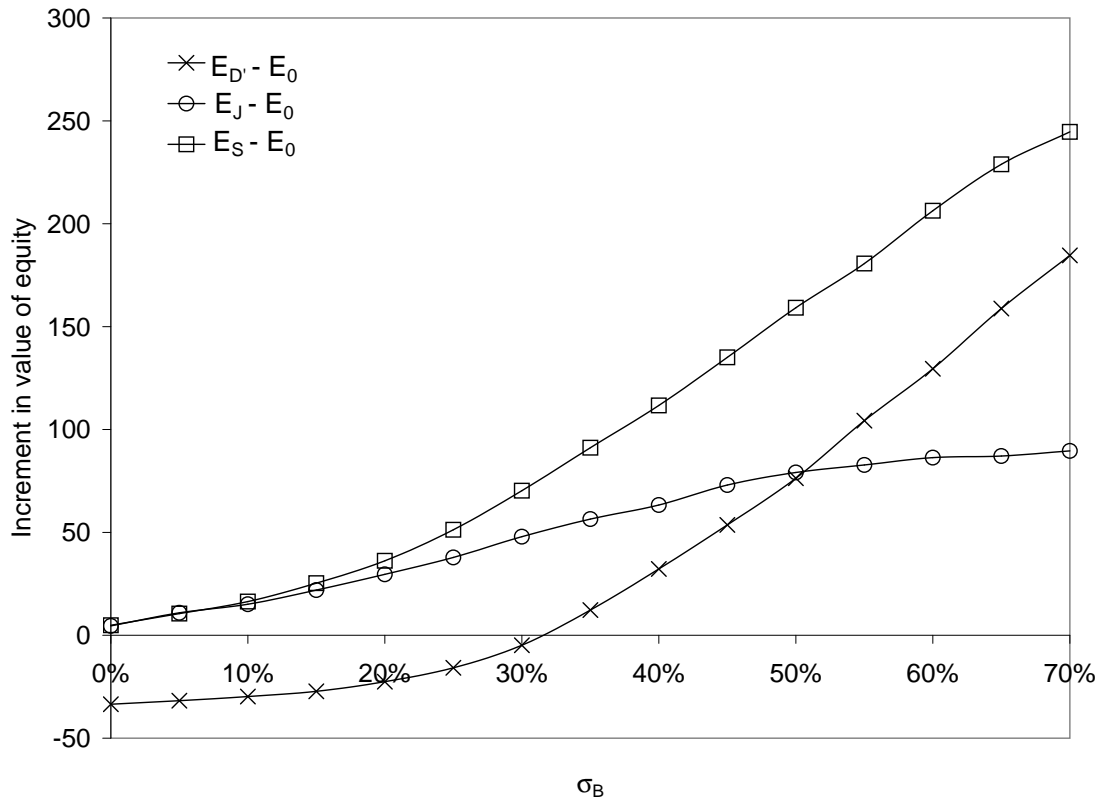


Figure 3: Effect of the risk of the new project on the investment decisions of the firm. The figure displays the increment in the value of equity for unsecured and secured debt financing as a function of the risk of the project. The value of the remaining parameters correspond to Case 1 of Table 2: $A_0 = 400, B_0 = 1000, I = 900, \sigma_A = 0.5, \rho_{AB} = 0.5, F_D = 2400, T = 5$, and $r = 0.1$. E_0 represents the value of equity before taking the investment project, while $E_{D'}, E_J$, and E_S refer to the value of equity when the project is taken and financed with unsecured, junior secured, and senior secured debt, respectively.

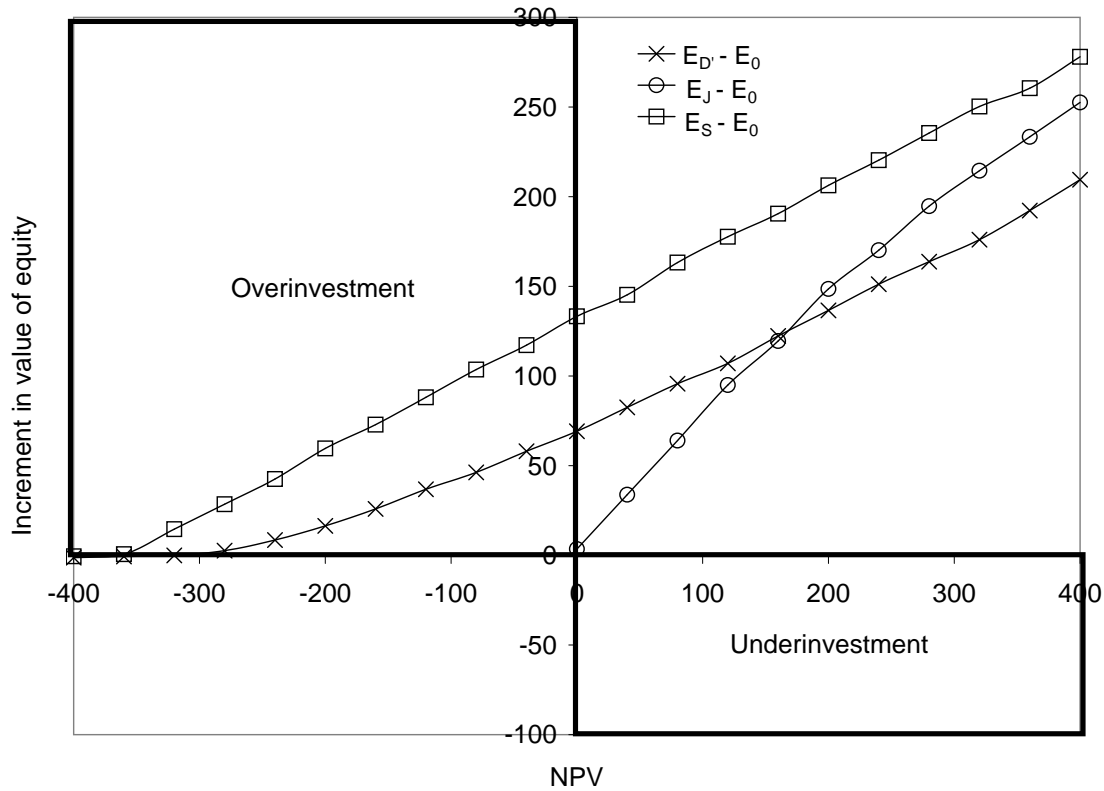


Figure 4: A typical case of overinvestment with unsecured debt financing. The figure plots the increment in the value of equity for unsecured and secured debt financing as a function of the NPV of the project. The value of the parameters correspond to Case 2 of Table 2: $A_0 = 400$, $B_0 = 1000$, $\sigma_A = 0.3$, $\sigma_B = 0.5$, $\rho_{AB} = 0.5$, $F_D = 2400$, $T = 5$, and $r = 0.1$. E_0 represents the value of equity before taking the investment project, while $E_{D'}$, E_J , and E_S refer to the value of equity when the project is taken and financed with unsecured, junior secured, and senior secured debt, respectively.

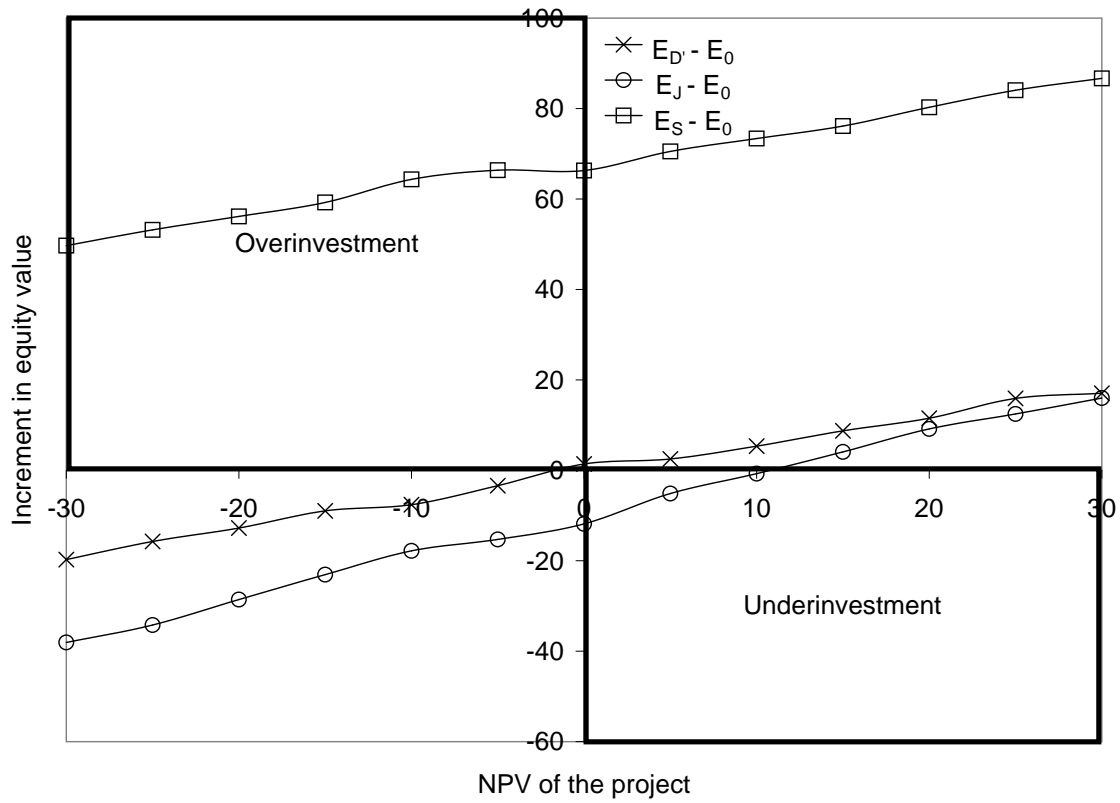


Figure 5: No investment distortions with unsecured debt financing. The figure shows the increment in the value of equity for unsecured and secured debt financing as a function of the NPV of the project. The values of the parameters are: $A_0 = 1600$, $B_0 = 1600$, $\sigma_A = 0.3$, $\sigma_B = 0.2$, $\rho_{AB} = 0.5$, $F_D = 2400$, $T = 5$, and $r = 0.1$. E_0 represents the value of equity before taking the investment project, while E_D , E_J , and E_S refer to the value of equity when the project is taken and financed with unsecured, junior secured, and senior secured debt, respectively.