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On the debt capacity of growth options[*†]

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Abstract

If debt capacity is defined as the incremental debt that is optimally associated with an additional asset, then the debt capacity of growth options is negative. Underinvestment costs of debt increase and free cash flow benefits of debt fall with additional growth options. Thus, if firm value increases with additional growth options, then leverage not only declines, but the firm's optimal total debt level declines as well. This result implies a negative relation between book leverage and growth options and provides a new economic interpretation of book leverage regressions.

Keywords: Growth options; Book leverage.

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Executive Summary

This paper makes two contributions to our understanding of optimal capital structure. First, we point out that the debt capacity of growth options is negative -- where by the debt capacity of an asset we mean the optimal (or value maximizing) increment to the level of debt associated with the addition of that asset. Previously, others have argued that the debt capacity of growth options is lower than the debt capacity of assets in place. This argument generated the empirical prediction (generally confirmed by the data) that market-value leverage ratios should be lower for firms with more growth options than for firms with more assets in place. It generally has been presumed, however, that although the debt capacity of growth options may be small, it is positive. We show that this is not the case. If the market value of a firm increases through the addition of growth options, we show that the optimal level of debt declines, other things being equal.

Second, we provide an economic interpretation of book leverage and make predictions about the relation between growth options and leverage measured with book values. Prior empirical studies employing book leverage generally use it as a robustness check and interpret it simply as another leverage measure. We argue that the logic behind using the market-to-book ratio as a measure of a firm's growth options implies that the book value of assets serves as a proxy for the value of assets in place. Thus, while the market-value leverage ratio measures the ratio of debt to the market value of the firm, the book-value leverage ratio measures the ratio of debt to the value of assets in place.

The weaker hypothesis that the debt capacity of growth options is lower than the debt capacity of assets in place is sufficient to predict a negative relation between growth options and leverage measured with market values. If the debt capacity of growth options is small but positive, however, then one should expect a positive relation between growth options and leverage measured with book values. Since growth options increase the market value of the firm, but not its book value, a positive debt capacity of growth options would increase book leverage ratios. Our hypothesis that the debt capacity of growth options is negative, however, generates the stronger empirical prediction that the relation between growth options and book leverage ratios should be negative. This hypothesis is supported both by the empirical evidence reported in this paper as well as by the results in prior studies.

1 Introduction

There is a growing literature examining the relation between firms' leverage choices and the composition of their investment opportunity sets. In particular, the empirical literature has documented a significant negative relation between "market leverage" (measured as the value of debt divided by the market value of the firm) and growth options. For example, Bradley, Jarrell and Kim (1984) and Long and Malitz (1985) show that industries associated with high growth opportunities tend to have low market leverage. Long and Malitz (1985), Smith and Watts (1992), Barclay, Smith and Watts (1995), all document a negative relation between market leverage and the market-to-book ratio, a commonly used proxy for growth options. Rajan and Zingales (1995) extend this analysis to show that the relation between market leverage and the market-to-book ratio is negative and significant across seven different countries.

These empirical papers are motivated by extant theories that provide a direct link between market leverage and growth options. For example, Myers (1977) suggests that growth options have lower collateral value and are subject to underinvestment. Because the underinvestment costs are exacerbated by high leverage, Myers predicts a negative relation between market leverage and growth options. Jensen (1986) argues that assets in place have higher collateral value and generate agency costs associated with free cash flow. Because debt helps to reduce the costs of free cash flow, Jensen predicts a positive relation between market leverage and assets in place. These and related theories, along with the confirming empirical evidence, have led the profession to conclude that "firms should use relatively more debt to finance assets in place and relatively more equity to finance growth opportunities" (Hovakimian, Opler and Titman (2001), p. 2).

We show that although this prior literature has made the correct directional or qualitative predictions, the theory implies stronger predictions about the relation between leverage and growth options. Specifically, we show that if debt capacity is defined as the incremental debt that is optimally associated with a new investment project, then the debt capacity of growth options is negative. The logic that produces this conclusion is straightforward. Other things equal, if the value of the firm

increases with additional growth options (with no change to the assets in place), the underinvestment costs of debt increase and the free cash flow benefits of debt decline. These higher costs and lower benefits of debt generated by the addition of growth options cause a reduction in the optimal level of total debt even though firm value is rising. Thus, the debt capacity of growth options is negative. Although the prior literature has suggested that the debt capacity of growth options is lower than the debt capacity of assets in place (as evidenced by the quotation above), it has not been recognized that the debt capacity of growth options is negative.

Our prediction that the debt capacity of growth options is negative allows a new economic interpretation of regressions of book leverage (debt divided by the book value of assets) on proxies for the investment opportunity set. If the book value of assets serves as a proxy for the value of assets in place, then book leverage proxies for the ratio of debt to assets in place. Other things equal, if the firm generates additional growth options, the total level of debt should decline. However, these additional growth options generally will not affect the book value of assets. Thus, book leverage also should decline. Consequently, a negative relation between book leverage and growth options is consistent with the prediction that the debt capacity of growth options is negative and hence offsets some of the positive debt capacity of assets in place.

Because the prior theories provided direct implications about the relation between growth options and market leverage, most prior empirical studies have focused on market leverage regressions. To the extent that the empirical studies examine book leverage, it generally has been as a robustness check for the market leverage results.[1] In this context, several papers have reported a negative relation between book leverage and growth options. For example, Rajan and Zingales (1995)

[1]For example, Barclay and Smith (1999) report book leverage regressions with several other robustness checks on the empirical relation between leverage and growth options. Similarly, Hovakimian, Opler and Titman (2001, p. 5) note that they "ran regressions with debt ratios measured entirely with book values, positing that some managers have book value rather than market value targets. The results in our second stage regressions, using these book value targets, were very similar to the results reported below that use market value targets." Other papers that report regressions of book leverage on investment opportunity set proxies inlude Titman and Wessels (1988), Rajan and Zingales (1995), Wald (1999), and Fama and French (2002).

document a negative relation between book leverage and the market-to-book ratio (a commonly used proxy for growth options) across seven countries including the United States. As the empirical capital structure literature has developed, more sophisticated methods to account for the correlation structure of the regression errors have been developed (see e.g. Fama and French (2002)). Thus for completeness, and to document the robustness of these results, we reexamine the empirical relation between book leverage and growth options. Nonetheless, we view our primary contribution to be the new interpretation of these empirical results, rather than the empirical results themselves.

The paper proceeds as follows. In section 2, we present a model that captures the interaction between the firm's investment opportunity set and its use of debt. Through this model, we demonstrate that growth options increase the underinvestment costs of debt and lower the free cash flow benefits of debt, which implies that the debt capacity of growth options is negative. We then demonstrate that the negative debt capacity of growth options implies a negative relation between growth options and book leverage. This result is robust to various modeling assumptions about stochastic investment opportunities, taxes, costs of financial distress and costly corporate control transactions. In section 3, we employ data from COMPUSTAT to test this prediction. Consistent with our hypothesis and prior empirical results, we find that book leverage falls as the firm's market-to-book ratio increases. We offer our conclusions in section 4.

2 Growth options and optimal leverage

2.1 Assumptions

In this section, we construct a two-period, three-date model of capital structure and real investment. We presume that agents are risk neutral and risk-free interest rates are zero. To finance an initial project with cost K at date $t = 0$, a firm acquires external funding from shareholders or bondholders. This project yields cash flows at $t = 1$ given by X, where X is an observable random variable with uniform distribution on $[a, b]$, $a \geq 0$.

Cash flows from the initial project may be reinvested at $t = 1$. At that date, the firm has access to investment opportunities which are non-stochastic and thus independent of the cash flows from the initial project.[2] Following Stulz (1990) and Morellec (2002), we assume that the marginal product of investment is decreasing and given by a step function. Notably, the payoff (at $t = 2$) from investment is $H > 1$ per unit for the first I^* units and $L < 1$ per unit in excess of I^*. As a result, investment up to I^* has a positive NPV whereas investment in excess of I^* has negative NPV. This specification allows us to capture the idea that overinvestment is more severe for firms that generate large cash flows (see Harford (1999)).

Conflicts of interests between managers and shareholders can take a variety of forms. Within our model, we introduce such conflicts by presuming that the manager receives private benefits from investment. These private benefits increase with the projects' NPV and are such that it is always optimal for the manager to invest. Moreover, we assume that investment policy is not contractible for at least two reasons. First, it is difficult to pre-specify the distribution of payoffs for the entire array of projects that might be available to the firm in the future. Second, any commitment by the manager to invest only in positive NPV projects would not be credible since such commitments would depend on the manager's private information.[3]

The agency cost of managerial discretion depends on the allocation of control rights within the firm. In our model, shareholders are represented by a stockholder-elected board of directors that acts in the best interests of shareholders. The board cannot dictate investment policy because those decisions depend on the manager's private information. Thus, the board must delegate decision-making authority with respect to investments. However, the board can replace managers if anticipated overinvestment costs are too high. We presume that if the board replaces the incum-

[2]We show in the Appendix that a correlation between cash flows from assets in place and the number of growth options available to the firm does not affect the nature of the results.

[3]Because we assume that the optimal level of investment, I^*, is known and nonstochastic, it is somewhat artificial in our setting to assume that the level of investment is not contractible. In section 1 of the appendix we assume that the supply of positive NPV projects available to the firm is a random variable which is unobservable to board of directors and outside investors. The basic results of the model are unaffected under this alternative formulation.

bent manager, they have access to conservative managers who can oversee current operations but are ineffective in managing new investments (i.e. $I^* = 0$).[4]

2.2 Overinvestment and firm value

Before analyzing debt policy, it will be useful to identify explicitly the sources of value within the firm. The current value of the firm is the sum of the values of its assets in place and investment opportunities. Because the manager has decision rights over investment policy, and investment policy is not contractible, the time-zero value of the firm's investment opportunities depends on the investment policy that the manager is expected to select. In addition, the manager always wants to invest. As a result, the value of the firm's investment opportunities depends on the level of the resources expected to be available for investment. Within our framework, raising funds to invest more than I^* would harm existing shareholders because new investors buy securities at their fair market price but investment in excess of I^* has a negative NPV. Hence, the board would not allow the manager to raise outside funds that would permit a level of investment greater than I^* at $t = 1$. (We discuss below the allocation of control rights with respect to financing policy.) However, the manager may use the cash flows from assets in place to invest in negative NPV projects. Therefore, the expected agency cost of free cash flow is

$$(1 - L) \int_{I^*}^{b} \frac{X - I^*}{b - a} dX = \frac{(1 - L)}{2\,(b - a)} (b - I^*)^2, \tag{1}$$

and the value of the unlevered firm satisfies

$$v = \frac{a + b}{2} + (H - 1)\, I^* - \frac{(1 - L)}{2\,(b - a)} (b - I^*)^2. \tag{2}$$

If managers automatically selected the investment policy that maximizes shareholder value (or if investment policy were contractible), the value of the firm would equal the expected present value of the cash flows from assets in place ($\frac{a+b}{2}$) plus the

[4]This assumption makes managerial replacement costly; a similar assumption is made by Zwiebel (1996). While it is essential for our analysis to have replacement costs, their particular functional form does not affect the nature of the results.

NPV of profitable investment projects ($(H-1)\,I^*$). Within our model, however, investment decisions are not contractible and managers have incentives to overinvest. Thus, the value of the firm depends on the agency cost of managerial discretion. Equations (1) and (2) describe the extent to which overinvestment by the manager reduces firm value.

2.3 Leverage and underinvestment

As Jensen (1986) argues, debt can control the free cash flow problem by limiting the resources under the manager's control, and hence, the amount the manager can invest. Moreover, financing policy is observable and contractible: the board must approve financing decisions. Thus, the board can use its control of financing policy to set leverage. Although within our basic model the only role of debt is to control the manager's ability to overinvest, the debt policy that maximizes firm value does not eliminate overinvestment. Indeed, if the firm issues debt, it induces underinvestment when firm value is low. As a result, the debt level that maximizes the value of equity is the one that best balances the costs of over- and underinvestment.[5]

We assume that debt issued at date $t = 0$ matures at date $t = 1$. Proceeds from the debt issue may be paid as a dividend at date $t = 0$ or used to finance assets in place. Within our model, debt financing affects firm value in two ways. First, by reducing the resources available for investment at $t = 1$, debt reduces managers' ability to invest in negative NPV projects, thereby reducing the severity of the free cash

[5]The corporate finance literature has modeled at least three types of leverage-related circumstances that lead to a failure to undertake positive NPV projects: Stockholder-bondholder conflicts (Myers (1977)), default (Stulz (1990)), and financing constraints (Fazzari, Hubbard, and Petersen (1988)). Although these mechanisms are not mutually exclusive, we focus in this paper on the second source of underinvestment costs. Adding financing constraints would strenghten the basic result of the paper that the debt capacity of growth options is negative. Also, it is important to recognize that Myers' underinvestment cost relies on the same basic structure as the one modeled in this paper (i.e. debt induced incentives to default on growth options) and hence we expect the basic result of the paper to hold in that setting as well. Incorporating the cost of underinvestment highlighted by Myers would require a more detailed modeling of the incentives of the manager, an important component of which is established by compensation policy.

flow problem. Second, by increasing the risk of default, debt reduces the likelihood that the firm invests in positive NPV projects, thereby inducing underinvestment.

Note that the underinvestment cost of debt in our model is not monotonic in the amount of growth options, I^*. As the amount of growth options increases, the underinvestment cost of debt first increases because these additional growth options would be lost in default. However, as the amount of growth options increases, the probability of default also decreases. Eventually, this second effect dominates the first, and the underinvestment cost of debt declines.[6] Because the underinvestment cost of debt is not monotonic, the source of the benefits of debt is important in deriving a monotonic relation between the optimal level of debt and growth options. Below, we show that if the benefits of debt accrue from reducing overinvestment, the magnitude this effect always dominates the underinvestment costs at optimal leverage, and generates a monotonic relation between total debt and growth options.

We denote the values of equity and debt, when the firm has issued debt with face value D, by $e(D)$ and $d(D)$. We consider a stock-based definition of insolvency wherein the firm defaults on its debt obligations if the expected present value of its cash flows is less than its promised debt payment (D). If the firm can raise outside equity to finance positive NPV investments, the present value its cash flows is $X + I^*(H-1)$ for $X \leq I^*$. As a result, the firm defaults on its debt obligations whenever $X < D - I^*(H-1)$.[7] Thus, if absolute priority is enforced upon default and the firm loses its investment opportunities when it becomes insolvent, the values of equity and debt respectively satisfy

$$e(D) = \int_{D-I^*(H-1)}^{b} \frac{X - D + I^*(H-1)}{b-a} dX + (L-1) \int_{D+I^*}^{b} \frac{X - D - I^*}{b-a} dX, \quad (3)$$

[6] We model the cost of debt as arising from the underinvestment cost associated with default. Myers (1977) models the underinvestment cost as arising from the bondholder-stockholder conflict. Although it is not generally recognized, the Myers-type underinvestment cost also is not monotonic in the amount of growth options.

[7] When the firm does not have access to financial markets at date $t = 1$, the amount invested in new projects is capped by the cash flows from assets in place and the default condition is defined by a liquidity constraint. Therefore, the underinvestment problem associated with debt financing is more severe and the value of equity is lower. See section 1 of the Appendix.

and

$$d(D) = \int_{D-I^*(H-1)}^{b} \frac{D}{b-a} dX + \int_{a}^{D-I^*(H-1)} \frac{X}{b-a} dX, \tag{4}$$

where we assume that $a < D - (H-1) I^*$.[8]

Equation (3) shows that the value of the shareholders' claim equals the cash flow from assets in place in the non-default states plus the NPV of the investment opportunities. This NPV depends on the firm's investment policy. Three cases are possible: (i) underinvestment (for $X \in [a, D - I^*(H-1)]$), (ii) optimal investment (for $X \in [D - I^*(H-1), D + I^*]$), and (iii) overinvestment (for $X \in (D + I^*, b]$). As we show below, the debt level that maximizes firm value balances the underinvestment cost associated with low values of the firm's operating cash flows against the overinvestment cost associated with high values of the firm's operating cash flows.

2.4 Optimal leverage

The board of directors has control rights over financing policy and thus can enforce financial policies that maximize shareholder value. When analyzing leverage decisions that maximize equity value (what we call optimal leverage), it is important to draw a clear distinction between the value of equity ex ante (before the debt issuance) and ex post (after debt has been issued). The value of equity ex post is given by the present value of the payoffs accruing to shareholders after the debt has been sold (see equation (3) above). The value of equity ex ante is the sum of the value of equity ex post and the market value of debt at the time it is issued. As a result, although the default policy of the firm typically is selected ex post so as to maximize equity value, optimal leverage is determined ex ante so as to maximize firm value. Therefore, the optimal debt level is defined by

$$D \in \arg\max_{[0,b]} v(D), \tag{5}$$

where firm value, $v(D) = e(D) + d(D)$, is given by

$$v(D) = \frac{a+b}{2} + I^*(H-1) \frac{b + I^*(H-1) - D}{b-a} - (1-L) \frac{(b - I^* - D)^2}{2(b-a)}. \tag{6}$$

[8] When $D = D^*$, this is equivalent to assuming that $a < b - I^*[H + (H-1)/(1-L)]$.

Consistent with the argument above, equation (6) demonstrates that although debt controls the free cash flow problem (third term on the right hand side of equation (6)), it also reduces the value of its growth options (second term on the right hand side of equation (6)). These effects of debt financing on the value of the firm's investment opportunity set are represented on Figure 1 which describes the trade-off made by the firm when determining the value-maximizing amount of debt.

[Insert Figure 1 Here]

A higher the selected debt level increases the probability that the firm will default and thus increases the probability of underinvestment (the probability of default and underinvestment is $(D - I^*(H-1) - a)/(b-a)$). This increased probability of default lowers the value of the firm's growth options. On the other hand, a higher selected debt level lowers the probability of overinvestment (the probability of overinvestment is $[b - (D + I^*)] / (b - a)$) and also lowers the cost associated with overinvestment when it occurs (when it occurs, the cost of overinvestment is $(L-1)[b - (D + I^*)]/2$). This trade-off is reflected in the first-order condition

$$-\frac{I^*(H-1)}{b-a} + (1-L)\frac{(b - I^* - D)}{b-a} = 0,$$

from which we get the following proposition.

Proposition 1 *The debt level that maximizes firm value satisfies*

$$D^* = \max\left\{b - I^*\frac{H-L}{1-L}, 0\right\}. \tag{7}$$

Proposition 1 determines the debt level that maximizes firm value.[9] This debt level is selected within our model because the board of directors has ultimate discretion over financing policy. As a result, the manager would be replaced for failure to select the debt level described by equation (7).

[9]In our model, higher growth options generally mean a higher market-to-book ratio and less debt. However the market-to-book and debt relation runs both ways. Indeed, higher debt for a given level of growth options leads the market to assign a lower value to those options (because of the greater likelihood of default), yielding a lower market component of the market-to-book ratio.

Proposition 1 relates the debt level that maximizes shareholder value to the characteristics of the firm's assets in place and investment opportunities. Equation (6) shows that more growth options in the investment opportunity set (i.e. an increase in I^*) increases underinvestment costs of debt and, at the same time, decreases the expected cost of overinvestment. If the underinvestment costs of debt rise, and the free cash flow benefits of debt fall, then the optimal amount of debt in the firm's capital structure also must fall. In particular, the derivative of the debt level that maximizes firm value with respect to the supply of positive NPV projects (I^*) is

$$\frac{\partial D^*}{\partial I^*} = -\frac{H-L}{1-L} < 0. \tag{8}$$

The value of the firm's investment opportunities depends not only on the supply of positive NPV projects I^* but also on the rate of return on both profitable projects, H, and unprofitable projects, L. Thus we examine next the impact of these rates of return on the optimal use of debt. First, as the return on the good investment projects increases, the underinvestment cost of debt increases. This effect is captured by the derivative of the debt level that maximizes firm value with respect to the profitability of positive NPV projects (H). We have

$$\frac{\partial D^*}{\partial H} = -\frac{I^*}{1-L} < 0, \tag{9}$$

It thus is optimal for the firm to issue less debt as H increases. Second, as the opportunity cost of investment in excess of I^* decreases (as L increases), the overinvestment cost decreases. This effect is captured by the derivative of D^* with respect to the profitability of investment in excess of I^* (L):

$$\frac{\partial D^*}{\partial L} = -I^* \frac{H-1}{(1-L)^2} < 0. \tag{10}$$

It thus is optimal for the firm to issue less debt as L increases.

We then have the following result.

Proposition 2 *The optimal debt level is decreasing in the value of the firm's investment opportunities.*

Proposition 2 states that, as firm value increases because the value of its growth options increase (i.e., because of an increase in I^*, L or H), the amount of debt that maximizes firm value decreases. In other words, the debt capacity of growth options is negative. In the appendix, we show that this result is robust by extending our basic model to include: (1) stochastic investment opportunities, and (2) taxes and direct costs of financial distress. Our model ignores the costs of adjusting leverage. In a multiperiod model, if adjusting leverage is costly and more growth options today implies more cash flows tomorrow, then firms may have incentives to issue more debt today to control for future overinvestment. Intuitively, this would be the case if the costs of adjustment were non-zero and the correlation between growth options and future cash flows were high.[10] (Note that in the limiting case with no adjustment costs, today's choice of leverage would not reflect tomorrow's costs of overinvestment.) Moreover, if the costs of adjusting leverage were high, we would expect firms to be farther from their optimal leverage, which in turn would weaken the predicted negative relation between growth options and observed leverage.

2.5 Optimal leverage and book values

To facilitate the testing of Proposition 2, we now examine its implications for book leverage. The logic behind using the market-to-book ratio as a proxy for the value of a firm's growth options implies that the book value of assets serves as a proxy for the value of the firm's assets in place. Therefore, book leverage, defined by

$$BL = \frac{D^*}{K}. \tag{11}$$

where K is the historical cost of the firm's assets (defined above), provides a measure of debt divided by the (book) value of the firm's assets in place.

The market-to-book ratio of the firm at date 0 is

$$M/B = \frac{v\left(D^*\right)}{K}, \tag{12}$$

[10]Note that while in an industry like the railroads in the 1850s, current growth options led to future assets in place, for a firm like a pharmaceutical company growth options today could be replaced by new growth options in a way that would make the firm's investment opportunity set completely stationary over time.

with (using equations (6) and (7) and simplifying)

$$v\left(D^{*}\right)=\frac{a+b}{2}+\left(I^{*}\right)^{2}\frac{2H\left(1-L\right)+H-1}{2\left(b-a\right)\left(1-L\right)}. \tag{13}$$

Using equations (11)-(13), we can analyze the impact of a change in the market-to-book ratio due to a change in the firm's investment opportunities (represented by I^{*}, H, and L) on the firm's book leverage.[11] This impact is measured by the following derivative

$$\frac{\partial BL}{\partial M/B}=\frac{\partial D^{*}}{\partial I^{*}}\frac{\partial I^{*}}{\partial v\left(D^{*}\right)}+\frac{\partial D^{*}}{\partial H}\frac{\partial H}{\partial v\left(D^{*}\right)}+\frac{\partial D^{*}}{\partial L}\frac{\partial L}{\partial v\left(D^{*}\right)}. \tag{14}$$

Because $\frac{\partial v(D^{*})}{\partial I^{*}}>0$, $\frac{\partial v(D^{*})}{\partial H}>0$ and $\frac{\partial v(D^{*})}{\partial L}>0$, we have with equations (8), (9) and (10):

$$\frac{\partial BL}{\partial M/B}<0. \tag{15}$$

We then have the following result.

Proposition 3 *Book leverage decreases with the firm's market-to-book ratio.*

Prior studies of the relation between a firm's investment opportunities and its use of debt have focused on market leverage – generally the book value of debt divided by an estimate of the market value of the firm. But, a negative relation between growth options and market leverage is a necessary but not sufficient condition to demonstrate the negative debt capacity of growth options. Such a negative relation would obtain even if the debt capacity of growth options were positive but less than the debt capacity of assets in place. Thus, market leverage regressions have low power with respect to testing the proposition that the debt capacity of growth options is negative.

To overcome this problem, we propose a new economic interpretation for book leverage regressions. Proposition 2 shows that if the firm generates additional growth

[11] The model does not make specific predictions regarding the relation between book leverage and the market-to-book ratio if there is an increase in the cash flows from assets in place. Clearly, an increase in cash flows would raise both firm value and the debt level. In order to control for this effect in the empirical tests, we use the profitability of the firm as a control variable in our regressions.

options, its optimal level of debt declines. However, the additional growth options do not affect the book value of assets. Thus, book leverage also declines as the negative debt capacity of growth options offsets some of the positive debt capacity of assets in place. Proposition 3 provides an empirical specification to test this hypothesis by showing that if the debt capacity of growth options in negative, then there will be a negative relation between book leverage and the firm's market-to-book ratio. We test this prediction in the empirical section below.

3 Empirical analysis

Several prior papers have reported a negative relation between growth options and book leverage. For example, Rajan and Zingales (1995) document a negative relation between book leverage and the market-to-book ratio (a commonly used proxy for growth options) in seven countries including the United States.[12] However, Fama and French (2002) argue that their methods understate standard errors. "Previous work uses either cross-section regressions or panel (pooled time-series and cross-section) regressions. When cross-section regressions are used, the inference problem due to correlation of the residuals across firms is almost always ignored. The articles that use panel regressions ignore both the cross-correlation problem and the bias in the standard errors of regression slopes that arises because the residuals are correlated across years." Moreover, because the focus of these studies was on market leverage, the book leverage regressions generally were included only as a robustness check for the market leverage results. To provide a direct test of our hypothesis and to document the robustness of the prior results, we reexamine below the empirical relation between book leverage and growth options. We focus on the market-to-book ratio as our proxy for growth options, but also examine other proxies including advertising and R&D expenditures, and the earnings-price ratio. We also control for the other determinants of leverage as summarized in the survey paper by Harris and Raviv (1991).

[12]See also Barclay and Smith (1999), Hovakimian, Opler and Titman (2001, p. 5), Rajan and Zingales (1995), Titman and Wessels (1988) and Fama and French (2002).

3.1 Data and variable definitions

To estimate the empirical relation between growth options and leverage, we construct a large sample of firms from COMPUSTAT. We restrict our sample to U.S. companies with SIC codes between 2000 and 5999 to focus on the U.S. industrial corporate sector. Our data span the years 1950 to 1999 and include slightly more than 109,000 firm-year observations for 9,037 unique firms. Calculating financial ratios across this large number of observations produces extreme outliers. For example, if one measures book leverage as the ratio of total debt to the book value of assets, as expected, more than 99 percent of the observations fall between zero and one. However, the maximum book leverage in the full sample is 1,423. To avoid giving these extreme observations undue influence on the regression results, we truncate our sample by setting the largest and smallest 0.5 percent of the observations to missing for each variable that is a financial ratio. This reduces our basic sample to 104,746 firm-year observations. (We discuss the effects of this truncation as we report robustness checks below.) Table 1 provides descriptive statistics for the variables used on our analysis.

[Insert Table 1 Here]

We define the variables used in our empirical analysis as follows.

Book leverage (BL). We measure book leverage as the ratio of the book value of total debt divided by the book value of assets. Total debt is defined as long-term debt (COMPUSTAT data item 9) plus debt in current liabilities (COMPUSTAT data item 34).[13] The book value of assets is defined as total assets/liabilities and stockholders equity (COMPUSTAT data item 6). In our sample, average book leverage is 25%.

Growth options (GO). We measure growth options using the firm's market-to-book ratio (the market value of the firm divided by the book value of assets). The market value of the firm is defined as the market value of equity (fiscal-year-end

[13] If the notes to the financial statements indicate that the figure for long-term debt includes the current portion of long-term debt, then we subtract the current portion on long-term debt from debt in current liabilities to avoid double counting.

price per share (data item 199) times number of shares outstanding (data item 54)) plus liabilities (data item 181) plus preferred stock (data item 10) minus balance sheet deferred taxes and investment tax credits (data item 35). The book value of assets is defined above (data item 6). The mean market-to-book ratio is 1.59.

Following Harris and Raviv (1991), we also include the following control variables in our regressions:

Regulation. To control for the effects of regulation, we construct a dummy variable that is set equal to one for firms in regulated industries and zero otherwise. Regulated industries in our sample include railroads (SIC code 4011) through 1980, trucking (4210 and 4213) through 1980, airlines (4512) through 1978, telecommunications (4812 and 4813) through 1982 and gas and electric utilities (4900 to 4939). Only 7 percent of our observations reflect regulated firms.

Firm size. We measure firm size as the natural log of sales (data item 12) in constant 1996 dollars. Mean log sales is 18.91, which corresponds to sales of $163.12 million.

Profitability. Profitability is measured as operating income before depreciation (data item 13) divided by total assets (data item 6). Average profitability is 11%.

Fixed-asset ratio. The fixed-asset ratio is defined as net property plant and equipment (data item 8) divided by total assets (data item 6). In our sample, the average fixed-asset ratio is 34 percent.

Taxes. We use several variables to proxy for the firm's effective marginal tax rate and non-debt tax shields. First, we construct a dummy variable that is equal to one if the firm has a net operating loss carryforward (data item 52), and zero otherwise. Firms with net operating loss carryforwards are expected to be in a low or zero marginal tax bracket. Second, we construct a dummy variable that is set equal to one for firms with investment tax credits (data item 208), and zero otherwise. Only 8% of our observations report ITCs. Both of these tax variables have been problematic in estimating the effect of taxes on corporate leverage. For example, firms with net operating loss carryforwards tend to be high-leverage firms in financial distress. Thus the coefficient on this variable in leverage regressions tends to have

the opposite sign from what is predicted by the tax hypothesis.[14] To determine the sensitivity of our results to these tax proxies, we also estimate our regressions using the simulated marginal tax rates developed in Graham (1996). However, since the simulated tax rates are not available prior to 1980, and the inclusion of these tax rates have little impact on the coefficients of interest in the regressions, we postpone the discussion of these results to the section on sensitivity checks below.

3.2 Regression Results

Our basic regression has the form

$$BL_{i,t} = \alpha_i + \beta_i GO_{i,t} + \gamma_i CV_{i,t} + \varepsilon_{i,t}, \tag{16}$$

in which $CV_{i,t}$ is the vector of control variables. Table 2 reports the regressions of book leverage on the market-to-book ratio and the control variables described above. Because our data has a panel structure (including both time series and cross-sectional observations), we need to account for the correlation structure of the regression errors.

As in Fama and MacBeth (1973) and Fama and French (2002), we first estimate annual cross-sectional regressions. Then we average the slope coefficients of the cross-sectional regressions. The t-statistics are calculated using the time-series standard error of the average slope coefficients. This procedure has the advantage that the time-series standard errors are robust to contemporaneous correlation in the regression residuals across firms. However, the standard errors from this estimation method still are affected by time-series correlation in the regression errors.

[14] Our regressions attempt to identify the impact of the factors included on the right-hand side (RHS) of the regression on the firm's target leverage. If it is expensive to adjust the firm's capital structure, some deviation from target leverage will be optimal. With respect to most of the RHS variables, the deviations appear symmetric and the regression coefficient identifies variations in target leverage across the population as the RHS variable varies. But in the case of tax loss carryforwards, there appears to be a material selection-bias problem. Firms with tax loss carryforwards frequently are firms financially distressed. Such firms tend to have leverage that is greater than their target leverage. Thus, this raises the possibility that the coefficient for the tax loss carryforwards variable reflects deviations from target leverage rather than variations in target leverage.

In addition, although this method fully exploits any cross-sectional variation in the sample, information from the time series is largely ignored.

As an alternative method for dealing with the correlation structure of the residuals, table 2 also reports a fixed-effects regression. In this regression, we subtract the firm-specific time-series mean for each variable from each observation The slope coefficients are then estimated using ordinary least squares and the standard errors are adjusted for the appropriate degrees of freedom. (This technique is equivalent to adding a dummy variable for each firm in the sample.) The fixed-effects regression removes correlation in the residuals that is caused by firm-specific effects. In contrast to the cross-sectional regression, the fixed-effects regression preserves information from the time-series variation in the sample. However, the fixed-effects regression ignores most of the information contained in the variation across firms.

[Insert Table 2 Here]

The coefficient on the market-to-book ratio is negative and statistically significant in both the cross-sectional and fixed-effects regressions. In the cross-sectional regression, the coefficient is -0.01 and the t-statistic is -4.99. Thus, even after adjusting the standard error for any time-series correlation in the residuals, this coefficient will remain significant. In the fixed-effects regression, the coefficient is also -0.01, and the t-statistic is -18.05. A coefficient of -0.1 implies that an increase in the market-to-book ratio from 1.0 to 2.0 would be associated with a decrease of one percentage point in book leverage.

Although the magnitude of the coefficient on the market-to-book ratio is relatively small (in comparison, Barclay, Smith and Watts (1995) estimate a coefficient of -0.06 when market leverage is regressed on the market-to-book ratio), it is important to remember the interpretation of this coefficient. Other things equal, when firms add valuable investment opportunities that increase the market value of the firm (but do not increase the value of assets in place), the optimal total debt actually declines. Using the example from the previous paragraph, if the market value of the firm doubles while the value of asset in place (as measured by the book value of assets) remains the same, the total amount of debt declines slightly, which is consistent with our hypothesis that the debt capacity of growth options is negative.

Moreover, if for some firms in our sample, both the cost of adjusting leverage and the correlation between growth options and future cash flows were high, then (as noted above) our estimated coefficient would be biased towards zero.[15]

3.3 Robustness Checks

To test the robustness of our results, we estimate regressions with the following specifications:

Truncation. As reported above, we truncate the extreme 0.5 percent of the distribution for the financial ratios in our sample. Truncation has a material effect on the coefficients in the regression. In particular, the market-to-book ratio is not statistically significant in regressions with no truncation of extreme outliers. The results generally are not sensitive, however, to the amount of truncation. We estimate our regressions truncating from 0.1 percent to 10 percent of the extreme observations from each tail of the distribution. The qualitative results are not affected by the amount of truncation within this range.[16]

Alternative definitions of debt. The COMPUSTAT data implies a broad definition of corporate debt. For example, in addition to bonds and mortgages, long-term debt also includes capitalized lease obligations and other similar long-term fixed claims. To determine whether our results are sensitive to the measure of debt, we reestimate our base regressions using five alternative definitions of debt to calculate

[15] We thank the referee for this insight.

[16] The only paper of which we are aware that reports a positive and significant coefficient when book leverage is regressed on the market-to-book ratio is Fama and French (2002). Fama and French use a different approach than we do to deal with extreme outliers. Because all of the financial ratios in their (and our) regressions are scaled by book assets, Fama and French exclude all firms with book assets less than $2.5 million. Using their sample period (1965 to 1999), their truncation procedure would reduce our sample size by slightly less than 3 percent. Despite the fact that they dop three times as many observations as we do, their procedure, however, does not eliminate the problem with outliers. For example, if we use their sample period and truncation procedure in our sample, the maximum market-to-book ratio would be 303, which is well over one hundred standard deviations from the mean. When we replicate the Fama-French regressions, we find that the sign of the coefficient on the market-to-book ratio flips from positive to negative when we truncate these extreme outliers.

the book leverage ratio. These definitions are:

- long-term debt plus debt in current liabilities plus preferred stock minus cash and short-term investments,
- long-term debt plus debt in current liabilities plus preferred stock,
- long-term debt plus debt in current liabilities minus capitalized leases,
- long-term debt plus debt in current liabilities minus capitalized leases minus convertible debt
- long-term debt plus debt in current liabilities minus capitalized leases minus convertible debt minus short-term debt (debt in current liabilities).

To make the regression comparable, we use data from 1969 to 1999 because data are not available for all of the required fields before 1969. Using the same control variables as in Table 2, the coefficients for the market-to-book ratio for these five regression range from -0.014 to -0.04 and the t-statistics range from -9.26 to -21.90.

Growth-option proxies. The market-to-book ratio is the most common proxy used to estimate the value of a firm's growth options. However, other proxies also have been employed. We estimate our regressions using R&D to sales, R&D plus advertising to sales, and the earnings-price ratio as alternate growth-option proxies. The R&D to sales and R&D plus advertising to sales generate the same qualitative results as the market-to-book ratio. The earnings price ratio also produces consistent results so long as we restrict the sample to firms with positive earnings-price ratios.

Tax proxies. The tax proxies in our base case regression are crude at best. Graham (1996) provides a more sophisticated proxy for the firms expected marginal tax rate. If we replace the investment-tax-credit dummy variable with Graham's expected marginal tax rate, the coefficient and t-statistic for the market-to-book ratio are largely unaffected.

Time periods. COMPUSTAT greatly expanded their coverage in 1965. Thus, the years 1950 to 1964 have relatively few observations per year. When we estimate

our regression using only data from 1965 to 1999, both the coefficient and the t-statistics for the market-to-book ratio increase. In fact, if we restrict the sample to a more recent time period, such as 1980 to 1999, the coefficient and t-statistic for the market-to-book ratio are even larger.

4 Conclusions

This paper makes two contributions to our understanding of optimal capital structure. First, we point out that the debt capacity of growth options is negative – where by the debt capacity of an asset we mean the optimal (or value maximizing) increment to the level of debt associated with the addition of that asset. Previously, others have argued that the debt capacity of growth options is lower than the debt capacity of assets in place. This argument generated the empirical prediction (generally confirmed by the data) that market-value leverage ratios should be lower for firms with more growth options than for firms with more assets in place. It generally has been presumed, however, that although the debt capacity of growth options may be small, it is positive. We show that this is not the case. If the market value of a firm increases through the addition of growth options, we show that the optimal level of debt declines, other things being equal.

Second, we provide an economic interpretation of book leverage and make predictions about the relation between growth options and leverage measured with book values. Prior empirical studies employing book leverage generally use it as a robustness check and interpret it simply as another leverage measure. We argue that the logic behind using the market-to-book ratio as a measure of a firm's growth options implies that the book value of assets serves as a proxy for the value of assets in place. Thus, while the market-value leverage ratio measures the ratio of debt to the market value of the firm, the book-value leverage ratio measures the ratio of debt to the value of assets in place.

The weaker hypothesis that the debt capacity of growth options is lower than the debt capacity of assets in place is sufficient to predict a negative relation between growth options and leverage measured with market values. If the debt capacity of

growth options is small but positive, however, then one should expect a positive relation between growth options and leverage measured with book values. Since growth options increase the market value of the firm, but not its book value, a positive debt capacity of growth options would increase book leverage ratios. Our hypothesis that the debt capacity of growth options is negative, however, generates the stronger empirical prediction that the relation between growth options and book leverage ratios should be negative. This hypothesis is supported both by the empirical evidence reported in this paper as well as by the results in prior studies.

Appendix

This appendix investigates the robustness of the results derived in section 2. Because it is clear from the analysis in section 2 that increasing the profitability of investment opportunities decreases optimal leverage, we focus in this section on the impact of the number of growth options on the firm's use of debt.

A.1. Stochastic investment opportunities

In this section, we consider that both cash flows from assets in place as well as the number of growth options are random. Specifically, we assume that the number of positive NPV projects available to the firm at $t = 1$ is given by I where I is a random variable with a uniform distribution on $\left[\underline{I}, \overline{I}\right]$, $\underline{I} \geq 0$. Moreover, we presume that investors know the distribution of I but cannot observe its realization.

Because the number of growth options is unobservable and the manager always want to invest, any claim by management that cash flows are too low to finance positive NPV projects is not credible. In this setting, the value of the firm satisfies

$$\begin{aligned} v(D) &= \int_a^b \frac{X}{b-a} dX + (L-1) \int_{\underline{I}}^{\overline{I}} \frac{1}{\overline{I}-\underline{I}} \int_{D+I}^b \frac{X-D-I}{b-a} dX dI \\ &\quad + (H-1) \int_{\underline{I}}^{\overline{I}} \frac{1}{\overline{I}-\underline{I}} \left[\int_D^{D+I} \frac{X-D}{b-a} dX + \int_{D+I}^b \frac{I}{b-a} dX \right] dI \end{aligned} \tag{A.1}$$

Using the same line of reasoning as in Section 2, it is possible to show that the value-maximizing debt level is

$$D^* = \max \left\{ b - E(I) \frac{H-L}{1-L}, 0 \right\} \tag{A.2}$$

Equation (A.2) shows that more growth options in the investment opportunity set increases underinvestment costs of debt and, at the same time, decreases the expected cost of overinvestment. The underinvestment costs of debt rise, the free cash flow benefits of debt fall; the optimal amount of debt in the firm's capital structure thus falls. In particular, the derivative of the debt level that maximizes firm value with respect to the number of positive NPV projects is

$$\frac{\partial D^*}{\partial \overline{I}} = -\frac{H-L}{2(1-L)} < 0, \text{ and } \frac{\partial D^*}{\partial \underline{I}} = -\frac{H-L}{2(1-L)} < 0. \tag{A.3}$$

The value of the firm's investment opportunities depends not only on the number of positive NPV projects, but also on the return to both profitable projects, H, and unprofitable projects, L. As in Section 2, we have

$$\frac{\partial D^*}{\partial H} = -\frac{E(I)}{1-L} < 0, \tag{A.4}$$

and

$$\frac{\partial D^*}{\partial L} = -E(I)\frac{H-1}{(1-L)^2} < 0. \tag{A.5}$$

It thus is optimal for the firm to issue less debt as L or H increases. Equations (A.3)-(A.5) show that when the number of growth options in the firm's investment opportunity set is stochastic, the optimal debt level is decreasing in the value of the firm's investment opportunities. Using equations (A.3)-(A.5), it is then possible to show that book leverage decreases with the firm's market-to-book ratio.

A.2. Stochastic investment opportunities, taxes and costs of financial distress

In this section, we incorporate in the previous setting both a tax advantage of debt and costs of financial distress. Moreover, we consider that both cash flows from assets in place as well as the number of growth options, I^*, are random. Specifically, we assume that (i) the firm's operating cash flows are taxed at a constant rate, τ,[17] (ii) proportional costs of financial distress α_X (for assets in place) and α_I (for growth options) are incurred upon default, and (iii) the number of positive NPV projects at $t = 1$ is given by

$$I^* = \rho X + \overline{I}, \tag{A.6}$$

where $\overline{I} \geq -\rho a$ and $\rho \in [-1, 1]$. This specification implies that the value of assets in place and the number of growth options available to the firm are correlated

[17] We consider for simplicity that the tax shield of debt applies to the total payments made to bondholders. This assumption captures in a one-period model the features of the debt tax shield for an infinite-horizon company.

(presumably positively). Moreover, it ensures that the number of growth options in the firm's investment opportunity set is positive (i.e. $I^* \geq 0$).[18]

Within this setting, firm value satisfies

$$\begin{aligned} v(D) &= (1-\tau)\left[\int_a^b \frac{X + I^*(H-1)}{b-a}dX - \int_a^{\frac{D-\overline{I}(H-1)}{(1+\rho(H-1))}} \frac{\alpha_X X + \alpha_I I^*(H-1)}{b-a}dX\right] \\ &\quad +\tau\left(D\int_D^b \frac{1}{b-a}dX + \int_0^D \frac{X}{b-a}dX\right) + (1-\tau)(L-1)\int_{\frac{D+\overline{I}}{1-\rho}}^b \frac{X-D-I^*}{b-a}dX \end{aligned} \tag{A.7}$$

Solving this equation and taking its derivative with respect to debt gives

$$\begin{aligned} \frac{\partial v(D)}{\partial D} &= \tau\frac{b-D}{b-a} + (1-\tau)(1-L)\frac{b(1-\rho)-\overline{I}-D}{(b-a)(1-\rho)} \\ &\quad -\alpha_X(1-\tau)\frac{D-\overline{I}(H-1)}{(b-a)(1+\rho(H-1))^2} - \alpha_I(1-\tau)\frac{(\overline{I}-\rho D)(H-1)}{(b-a)(1+\rho(H-1))^2} \end{aligned} \tag{A.8}$$

From this equation, we can see that an increase in the firm's debt level has several effects on firm value. First, the tax shield provided by debt is more important (first term of the RHS). Second, overinvestment is less severe (second term). Third, direct costs of financial distress and underinvestment costs of debt increase (third and fourth terms).

The optimal debt level D^* solves

$$\left.\frac{\partial v(D)}{\partial D}\right|_{D=D^*} = 0. \tag{A.9}$$

Therefore, the optimal debt level can be expressed as

$$D^* = \frac{1-\rho}{\Omega}\left[b\left(1-L+\frac{\tau}{1-\tau}\right) - \overline{I}\left(\frac{1-L}{1-\rho} + (\alpha_I - \alpha_X)\frac{(H-1)}{(1+\rho(H-1))^2}\right)\right], \tag{A.10}$$

[18] To analyze the impact of the correlation coefficient ρ on debt policy for firms having the same unconditional number of growth options $E(I^*)$, we could also presume that

$$\overline{I} = E(I^*) - \rho E(X).$$

However, this assumption would not affect the sign of the relation between book leverage and the number of growth options in the firm's investment opportunity set.

where

$$\Omega = 1 - L + \frac{\tau(1-\rho)}{1-\tau} + (1-\rho)\frac{\alpha_X + \alpha_I \rho(H-1)}{(1+\rho(H-1))^2}. \tag{A.11}$$

The number of growth options available to the firm is represented by $\overline{I}$. The derivative of the optimal debt level with respect to the number of growth options satisfies

$$\frac{\partial D^*}{\partial \overline{I}} = -\frac{1}{\Omega}\left[1 - L + (\alpha_I - \alpha_X)\frac{(1-\rho)(H-1)}{(1+\rho(H-1))^2}\right]. \tag{A.12}$$

This yields the following result.

Proposition 4 *The optimal debt level is decreasing in the number of positive NPV projects available to the firm whenever*

$$\frac{1}{\Omega}\left[1 - L + (\alpha_I - \alpha_X)\frac{(1-\rho)(H-1)}{(1+\rho(H-1))^2}\right] \geq 0, \tag{A.13}$$

where Ω is defined in equation (A.11). When the correlation coefficient between the cash flows from assets in place and the firm's investment opportunity set is positive ($\rho \geq 0$), debt reduces with additional growth options if

$$(1-\rho)\alpha_X \leq \frac{(1-L)(1+\rho(H-1))^2}{H-1} + (1-\rho)\alpha_I. \tag{A.14}$$

The higher the correlation between investment projects and cash flows from assets in place, the greater the likelihood that this inequality is satisfied.

Several factors are important in determining the impact of growth options on the value-maximizing debt level. First, as the number of growth options increases, overinvestment costs fall but underinvestment costs rise. Second, if the firm has more growth options, it defaults less often, reducing expected bankruptcy costs and increasing the tax advantage of debt. Because of the intangible nature of growth options, the costs of financial distress associated with investment opportunities (α_I) typically are larger than those associated with assets in place (α_X). Moreover, the correlation coefficient between the cash flows from assets in place and the firm's investment opportunity set (ρ) typically is positive. In this case, our model predicts that the firm's use of debt decreases with the number growth options.

When the correlation coefficient between the cash flows from assets in place and the number of growth options is negative, the term Ω in the denominator of equation (A.13) potentially is negative. In this case, the debt level that maximizes firm value would increase with the number of growth options. Figure 2 represents the factor Ω as a function of ρ and H. Input parameter values are set as follows: $\tau = 0.2$, $\alpha_X = 0.2$, $\alpha_I = 0.5$, $L = 0.9$, $\rho \in [-1, 0]$ and $H \in [1, 2]$.

[Insert Figure 2 Here]

Figure 2 shows that for Ω to be negative (and, hence, for the optimal debt level to be increasing with the number of growth options), the correlation coefficient ρ has to be extremely negative while, at the same time, the average profitability of growth options $H-1$ has to be quite high. For example when $\rho = -0.6$, the average profitability of the firm's growth options $(H-1)$ must be larger than 90% for debt to be decreasing in the number of growth options available to the firm. Furthermore, this result is sensitive to the magnitude of the loss incurred on growth options upon default (α_I). The lower this loss, the more extreme these parameter values must be. For example, when $\alpha_I = 0.3$ and $\rho = -0.6$, the average profitability of the firm's growth options must be larger than 123% for debt to decrease with the number of growth options. These simulation results suggest that the optimal debt level falls with additional growth options across a wide range of input parameter values.

References

Barclay, M., and C. Smith, 1999, "The Capital Structure Puzzle: Another Look at the Evidence", *Journal of Applied Corporate Finance* 12, 8-20.

Barclay, M., C. Smith, and R. Watts, 1995, "The Determinants of Corporate Leverage and Dividend Policies", *Journal of Applied Corporate Finance* 7, 4-19.

Bradley, M., G. Jarrell, and E. H. Kim, 1984, "On the Existence of an Optimal Capital Structure: Theory and Evidence", *Journal of Finance* 39, 857-878.

Fama, E., and K. French, 2002, "Testing Tradeoff and Pecking Order Predictions About Dividends and Debt", *Review of Financial Studies* 15, 1-33.

Fama, E., and J. MacBeth, 1973, "Risk, Return and Equilibrium: Empirical Tests", *Journal of Political Economy* 71, 607-636.

Fazzari, S., R. Hubbard, and B. Petersen, 1988, "Financing Constraints and Corporate Investment", *Brooking Papers on Economic Activity* 88, 141-195.

Graham, J., 1996, "Debt and the Marginal Tax Rate", *Journal of Financial Economics* 41, 41-73.

Harford, J., 1999, "Corporate Cash Reserves and Acquisitions", *Journal of Finance* 54, 1969-1997.

Harris, M. and A. Raviv, 1991, "The Theory of Capital Structure", *Journal of Finance* 46, 297-355.

Hovakimian, A., T. Opler, and S. Titman, 2001, "The Debt-Equity Choice", *Journal of Financial and Quantitative Analysis* 36, 1-24

Jensen, M., 1986, "Agency Costs of Free Cash Flow, Corporate Finance and Takeovers", *American Economic Review* 76, 323-329.

Long, M., and I. Malitz, 1985, "The Investment-Financing Nexus: Some Empirical Evidence", *Midland Finance Journal*, 53-59.

Morellec, E., "Can Managerial Discretion Explain Observed Leverage Ratios?", Forthcoming *Review of Financial Studies*.

Myers, S., 1977, "Determinants of Corporate Borrowing", *Journal of Financial Economics* 5, 147-175.

Rajan, R., and L. Zingales, 1995, "What Do We Know About Capital Structure? Some Evidence from International Data", *Journal of Finance* 50, 1421-1467.

Smith, C., and R. Watts, 1992, "The Investment Opportunity Set, and Corporate Financing, Dividend, and Compensation Policies", *Journal of Financial Economics* 32, 262-292.

Stulz, R., 1990, "Managerial Discretion and Optimal Financial Policies", *Journal of Financial Economics* 26, 3-27.

Titman, S. and R. Wessels, 1988, "The Determinants of Capital Structure Choice", *Journal of Finance* 43, 1-18.

Wald, J., 1999, "How Firm Characteristics Affect Capital Structure: An International Comparison", *Journal of Financial Research* 22, 161-187.

Zwiebel, J., 1996, "Dynamic Capital Structure under Managerial Entrenchment", *American Economic Review* 86, 1197-1215.

Figure 1: Agency costs and debt financing. The value of the shareholders' claim equals the cash flow from assets in place in the non-default states plus the NPV of the investment opportunities. This NPV depends on the firm's investment policy. Three cases are possible: (i) underinvestment (for $X \in [a, D - I^* (H - 1)))$, (ii) optimal investment (for $X \in [D - I^* (H - 1), D + I^*]$), and (iii) overinvestment (for $X \in (D + I^*, b]$).

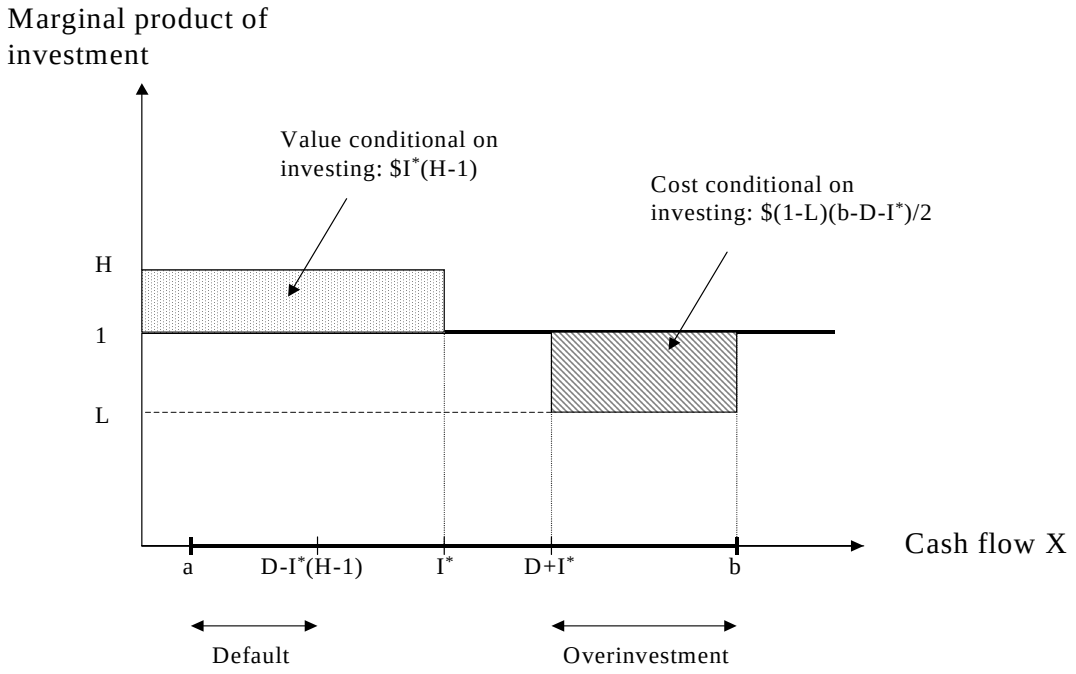

Figure 2: Stochastic investment opportunities, taxes and costs of financial distress. When the correlation coefficient between the cash flows from assets in place and the number of growth options is negative, the term Ω in the denominator of equation (A.11) potentially is negative. In this case, the debt level that maximizes firm value would increase with the number of growth options. Figure 1 represents the factor Ω as a function of ρ and H. Input parameter values are set as follows: $\tau = 0.2$, $\alpha_X = 0.2$, $\alpha_I = 0.5$, $L = 0.9$, $\rho \in [-1, 0]$ and $H \in [1, 2]$.

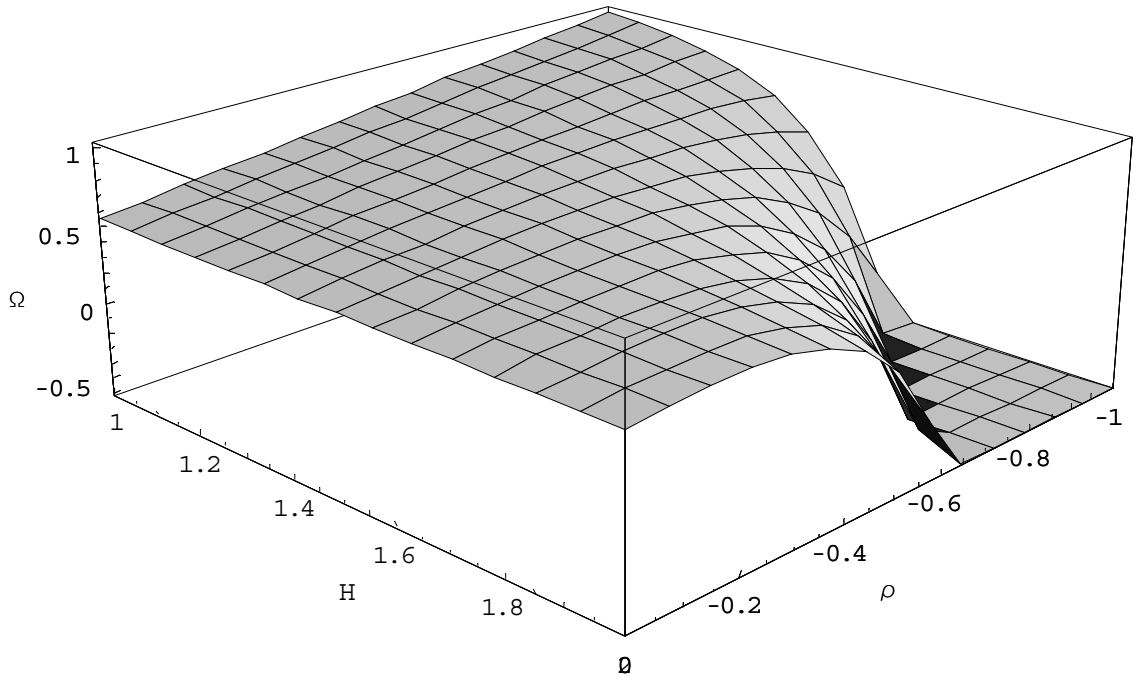

Table 1: Summary statistics. Summary statistics for book leverage and variables commonly used to explain leverage. Sample: All firms on COMPUSTAT between 1950 and 1999 with SIC codes from 2000 to 5999 (104,746 firm-year observations)

Variable	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
Book leverage	0.25	0.19	0.10	0.23	0.37
Market-to-book ratio	1.59	1.24	0.94	1.20	1.74
Regulation dummy	0.07	0.25	0.00	0.00	0.00
Log of real sales	18.91	2.09	17.62	18.94	20.26
ITC dummy	0.08	0.26	0.00	0.00	0.00
Fixed asset ratio	0.34	0.22	0.17	0.29	0.46
Profitability	0.11	0.17	0.08	0.13	0.19
Net-operating-loss dummy	0.20	0.40	0.00	0.00	0.00

Table 2: Regressions estimating the determinants of book leverage. Book leverage (total debt divided by the book value of assets) is regressed on the firm's market-to-book ratio, a dummy variable for regulated firms, the log of real sales, a dummy variable for firms with investment tax credits, the firm's fixed-asset ratio, the firm's profitability (return on assets), and a dummy variable for firms with net-operating-loss carryforwards. The table reports estimates from cross-sectional regressions with Fama-MacBeth standard errors and from fixed-effects regressions. t-statistics are in parentheses. Sample: All firms on COMPUSTAT between 1950 and 1999 with SIC codes between 2000 and 5999 (104,746 firm-year observations).

Dependent Variable	(1) Cross-Sectional Regression	(2) Fixed-Effects Regression
Intercept	0.17 (8.71)	NA
Market-to-book ratio	-0.01 (-4.99)	-0.01 (-18.05)
Regulation dummy	0.10 (9.83)	0.08 (14.57)
Log of real sales	0.00 (4.34)	0.02 (47.06)
ITC dummy	-0.02 (-6.06)	0.00 (-3.34)
Fixed asset ratio	0.17 (15.41)	0.25 (57.14)
Profitability	-0.46 (-11.84)	-0.24 (-67.65)
Net-operating-loss dummy	0.07 (12.46)	0.05 (44.71)

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