Financing and Debt Maturity Choices by Undiversified

Owner-Managers: Theory and Evidence

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Financing and Debt Maturity Choices by Undiversified

Owner-Managers: Theory and Evidence

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To My Parents

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SUMMARY

We examine the financing and debt maturity choices made by undiversified large shareholders or owner-managers. The interplay between the objective of the undiversified, self-interested owner-manager who controls the firm and the valuation of the firm's marketed claims by well-diversified outside investors, has a major impact on leverage and debt maturity choices as well as credit spreads. The effect of this interplay is particularly significant in a world where the representative investor (who determines asset prices in the economy) is risk-averse leading to nonzero market prices of systematic risk and risk premia of the firm's investment opportunities. In a perfect information framework with no taxes or bankruptcy costs, we show that, the owner-manager could, depending on the projects' characteristics, finance them exclusively with debt, exclusively with equity, or with a combination of equity and debt. *Ceteris paribus*, leverage increases with the expected growth rate of firm value under its investment opportunities, and decreases with its volatility. Debt maturity varies non-monotonically in a U-shaped manner with the expected growth rate, and decreases with the volatility. Our results reconcile empirical evidence on the variation of financing choices with firm characteristics that is not completely consistent with previous theories. The significant impact of the expected returns (therefore, risk premia) of firms' investment opportunities on their leverage ratios, debt maturities, and credit spreads are important implications of our theory that cannot be obtained in these models *or* in models in which all agents are risk-neutral so that risk premia are zero. We empirically test the implications of our theory for the relationships among firms' financing and debt maturity choices and the expected growth rate and volatility of their asset values. Controlling for all the significant

determinants of firms' financing and debt maturity choices identified by earlier studies, we show significant empirical support for our predictions.

The whole dissertation is organized as follows. In Chapter I, we present our theory in a parsimonious two-time period model, which highlights the key analytical results and economic intuition on the variation of financing and debt maturity vis-à-vis the quality of underlying project. In Chapter II, we recast our theory with a more sophisticated continuous-time structural model under rational expectations. The results obtained from the two-period model are confirmed and enriched along new dimensions of project drift, volatility and credit spreads. Furthermore, the continuous-time model yields a set of empirical implications that can be readily tested with corporate finance and debt maturity data. We present our empirical analysis in Chapter III, where we test our model predictions using data from COMPUSTAT, CRSP and FISD databases.

CHAPTER I

TWO PERIOD BINOMIAL MODEL

1.1. Introduction

Since the seminal study of Jensen and Meckling (1976), the importance of agency conflicts among a firm's stakeholders; shareholders, bondholders, and the manager; in understanding a firm's financing and investment decisions is now widely accepted. In particular, a number of studies focus on the impact of conflicts of interest between managers and shareholders on firms' capital structures (for example, Grossman and Hart 1982, Jensen 1986, Harris and Raviv 1990 and Stulz 1990). However, as more recent studies such as Zwiebel (1996) emphasize, these theories assume that financing choices are made by diversified, value-maximizing (original or current) shareholders. In reality, it is unclear whether "outside" shareholders, especially in diffusely owned firms, have a significant influence on firms' financing decisions, which are usually made by managers. In fact, in a recent survey of corporate managers, Graham and Harvey (2001) find that the most important factor influencing managers' capital structure choices is "financial flexibility". Bertrand and Schoar (2003) document that manager "fixed effects" explain a substantial portion of the variation in financing choices across firms.

In this chapter, we examine the financing and debt maturity choices of an owner-manager, or alternatively, a manager who acts in the interests of large shareholders or "insiders", in a parsimonious two-period binomial model. In contrast with the firm's diversified "outside" investors (shareholders and bondholders), the manager of the firm is undiversified since she has significant human capital invested in the firm, and her income from operating the firm is a substantial portion of her wealth. The undiversified owner-

manager chooses simultaneously the firm's capital structure, and the maturity of its debt, to maximize her discounted expected utility.

We propose an analytically tractable two-period framework to illustrate manager's financing and debt maturity decisions. We assume a world with perfect information, no tax advantages of debt or bankruptcy costs. The firm's market value follows a binomial tree. In each period, firm value grows by the proportion ($1+u$) with probability p and declines by the proportion ($1-u$) with probability $1-p$. Our analytical results show that 1) the manager chooses all-equity financing when p is below a non-trivial threshold value p_1. In most parameter range, there also exist non-trivial thresholds in the order of p_2, p_3, p_4. such that 2) if $p \in (p_1, p_2)$, the manager chooses long-term debt, 3) if $p \in (p_2, p_3)$, she chooses short-term debt, and 4) if $p \in (p_3, p_4)$, she chooses long-term debt again. The maturity of the firm's debt varies in a *non-monotonic* manner with the quality of the project, measured by the probability p of the up-tick in the binomial tree.

In this simple binomial model, the probability p of the up-tick path reflects the quality of the project that is the key to the financing decisions made by the utility-maximizing owner-manager. In contrast, the outside investors value the firm's debt and equity dependent only upon the risk-neutral probability 0.5. Thus, higher p project induces the owner manager to choose higher level of debt to increase her equity stake. In choosing the debt maturity, the manager balances the tradeoff between the possibility of refinancing short maturity debt at a lower cost versus the possibility of higher liquidity risk and loss of control benefits thereof. The complex opposing effects of liquidity risk and refinancing opportunity on the manager's utility lead to a non-monotonic, U-shape debt maturity pattern.

To the best of our knowledge, this is the first study to simultaneously examine optimal leverage and debt maturity choices by a utility-maximizing owner-manager using a discrete-time model. Flannery (1986) and Diamond (1991) examine debt maturity choices by managers in two-period "asymmetric information" models where financing is restricted exclusively to debt. Flannery (1986) predicts that debt maturity declines monotonically with project quality whereas Diamond (1991) predicts a non-monotonic variation; specifically high and low quality projects are financed with shorter maturity debt compared with projects of intermediate quality. Kale and Noe (1990) and Goswami, Noe and Rebello (1995) also examine debt maturity choices in asymmetric information frameworks in a discrete time model. They show that if the asymmetry of information is concentrated around long-term cash flows, firms finance with coupon-bearing long-term debt. If the asymmetry of information is concentrated around near-term cash flows, firms finance with coupon-bearing long-term debt. Finally, if the asymmetry of information is uniformly distributed, firm finances with short-term debt.

In contrast with these predictions, however, Mitchell (1991, 1993) documents a *positive* relation between debt maturity and *ex post* project quality measured by the growth of net operating income, and Guedes and Opler (1996) document that very high quality firms are dominant in the extremely long-maturity debt market. Berger et al (2005) document that borrowers with low ratings are more likely to issue longer-term debt, a finding that is inconsistent with Diamond's (1991) predictions. Furthermore, empirical evidence is inconclusive on whether signaling and information asymmetries play crucial roles in affecting financing and debt maturity choices, see for example, Barclay and Smith (1995) and Stohs and Mauer (1996). "Information asymmetry" does

not necessarily play an important role in explaining firms' leverage and debt maturity choices.

As mentioned earlier, these empirical findings can be reconciled within our framework where debt maturity varies in a non-monotonic manner with project quality. The significant differences between our predictions and those of Flannery (1986) and Diamond (1991) arise due to important distinctions between our frameworks. First, ours is a "perfect information" model where the manager may issue *both* debt and equity. Therefore, leverage and debt maturity are simultaneously determined endogenously. Our first prediction holds that if the project quality is below a threshold level, the manager will choose all-equity financing, which may explain Mayer and Sussman (2004)'s finding that large profitable firms use debt financing while loss-making small firm more frequently resort to equity financing. Our subsequent predictions link the variations of debt maturity with project quality that cannot be obtained in these "pure debt financing" models. Second, in Diamond's (1991) framework, negative NPV projects are also riskier than positive NPV projects. In our "perfect information" model, however, all projects that are financed have positive NPV, and we make no assumptions about the relationship between the risk of a project and its NPV.

Zwiebel (1996) develops a three-period model of dynamic financing where a manager's financing choices reflect the tradeoff between empire building desires and control challenges. Investors and the manager are risk neutral in his setting. His analysis, however, leads to counterfactual implication that long-term debt is preferred when the firm's project quality low. Similar to Zwiebel (1996), financing decisions are controlled by managers in our framework. However, we do not assume the risk neutrality of the manager the presence of control challenge. Furthermore, our analysis leads to a larger set

of predictions regarding the variation of leverage and debt maturity choices with underlying project characteristics.

1.2. The Two-Period Model

1.2.1. Model Setup

We consider a two-period binomial model with dates 0, 1, 2. A cash constrained entrepreneur or owner-manager approaches the capital markets at date zero to finance a project. She could finance the project through debt, equity, or a combination of debt and equity. The initial required investment is I, but the project's *market value* is $V(0) > I$ (in our rational world with perfect information, a necessary condition for the project to be financed is that it have nonnegative NPV). In order to highlight the impact of the owner-manager's incentives on financing choices, we abstract from other factors that influence financing choices such as taxes and firm-level bankruptcy costs.

T=0, V=1

T=1, V= 1+u

T=1, V = 1- u

p

1-p

p

p

1-p

1-p

T=2, V = $(1 + u)^2$

T=2, V = (1 + u)(1-u)

T=2, V = $(1 - u)^2$
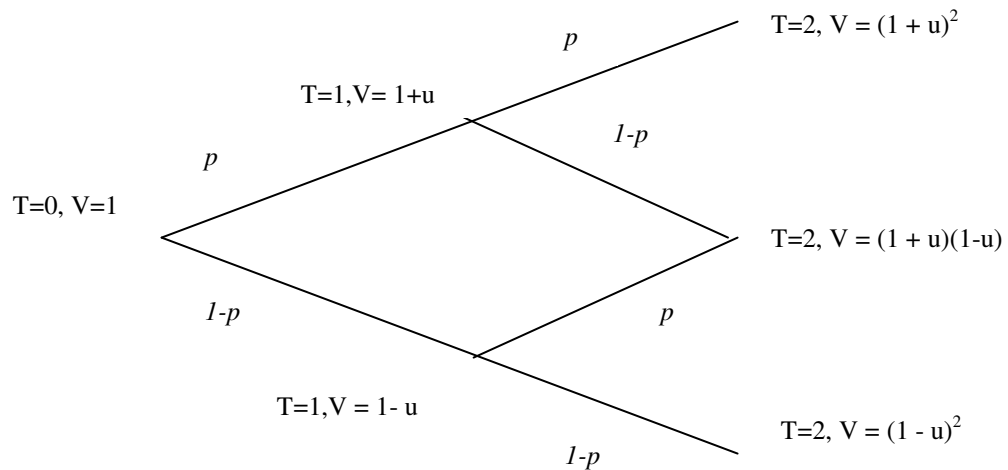
Figure1: A Binomial Model of Firm Value Process

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The owner-manager continues to operate the firm after date zero. The market for capital provision by outside investors is perfectly competitive so that the *market values* of outsiders' stakes in the firm are equal to their investments. Hence, the owner-manager captures the surplus from the project. Alternatively, we could view the owner-manager as representing the "original" shareholders" or "insiders", while the "new" shareholders are the "outsiders". The assumption that the owner-manager has the bargaining power is made purely for simplicity. In fact, all our results hold in a setting where the owner-manager issues debt at its market value, but *bargains* with new shareholders to determine her resulting ownership stake in the firm so that the surplus from the project is shared between the owner-manager and the new shareholders. Hence, we use the term "owner-manager" for concreteness thereafter.

The *state variable* is the *market value* of the firm (equity + debt) at each date. In the absence of taxes, bankruptcy costs, or informational asymmetries, leverage does not affect firm value. However, the undiversified owner-manager's discounted expected utility *does* depend on the firm's leverage and the maturity of its debt so that she is not indifferent to the choice of financing.

For simplicity, we assume that all payout flows occur at the terminal date and we set the risk-free rate to zero. We normalize units so that the initial firm value $V(0) = 1$ and initial investment $I \in (0,1)$. In each period, firm value grows by the proportion $(1+u)$ with probability $p \in (0,1)$ and declines by the proportion $(1-u)$ with probability $1-p$ where $u \in [0,1]$. Hence, at date 1, firm value is $(1+u)$ or $(1-u)$ with probability p or $1-p$, respectively, and at date 2, firm value is $(1+u)^2, 1-u^2, (1-u)^2$ with probabilities $p^2, 2p(1-p), (1-p)^2$, respectively.

By the theory of *risk-neutral valuation* (see Duffie, 2001), the market value of the firm at any date is the expectation of its end-of-period value under the *risk-neutral* or "equivalent martingale" probability measure (recall that the risk-free rate is zero). Since the proportional change in firm value in each period is either $(1+u)$ or $(1-u)$, the risk-neutral probability of an "up-tick" in *each period* is 0.5. The *actual* up-tick probability $p \in (0,1)$ determines the expected return of the project and, therefore, its *risk premium*. In the following, we show that the actual probability p crucially affects the owner-manager's choice of leverage as well as the maturity and risk of the firm's debt.

Since the risk-free rate is zero and the proportional change in firm value in each period is either $1+u$ or $1-u$, the risk-neutral probability of an up-tick or down-tick in each period is 0.5 regardless of the value of u. This feature of the two-period model presented here is purely for simplicity because our objective in this section is to illustrate the intuition underlying the key insights of this study in the simplest possible setting. Our results hold in a more general model where the risk-free rate is nonzero and/or the proportional change in firm value in each period is $1+u_1 ; 1-u_2 ; u_1 \neq u_2$ so that the risk-neutral probabilities depend on u_1, u_2 (details available upon request). In the continuous time model presented in the next section, we consider a nonzero risk-free rate and allow for the risk-neutral distribution of the asset value process to vary.

At date zero, the owner-manager could finance the project through a combination of debt and equity. We restrict consideration to zero coupon debt for simplicity (we consider coupon-bearing debt in the continuous-time model presented in the next section). The manager either chooses *long maturity* debt that matures at date 2 or chooses *short maturity* debt that matures at date 1 and is *re-financed* for the second period (see Diamond, 1991). Let $P \leq I$ denote the portion of the initial required

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investment I that is financed through debt; the portion $I - P$ is raised through equity. In our perfect information world with rational expectations, P equals the *market value* of the firm's debt, $I - P$ is the *market value* of the firm's "outside" equity. By the theory of contingent claims valuation, the market values of the firm's debt and outside equity equal the *risk-neutral expectations* of future payouts to debt-holders and outside shareholders, respectively (recall that the risk-free rate is zero). Because the market for capital provision is perfectly competitive, the surplus $1 - I$ of the project accrues to the owner-manager. The owner-manager's equity stake in the firm is, therefore,

$$f(P) = \frac{1 - I}{1 - P}. \tag{1}$$

The argument of the equity stake explicitly indicates its dependence on the amount of capital debt P raised through debt financing; this dependence plays an important role in our analysis.

In addition to the payoffs from her equity stake in the firm, the owner-manager also derives observable, but *non-verifiable*, control benefits at date 1, which are proportional to the value of the firm's total equity (see Zwiebel, 1996, Dyck and Zingales, 2004). Specifically, the owner-manager's control benefits at date 1 are equal to $\varepsilon(\text{Value of Equity})$ where $\varepsilon \in (0,1)$. In addition, we assume that $\varepsilon < 1 - I$, which ensures that the manager's proportional control benefits cannot exceed her own equity stake in the firm. As in DeMarzo and Fishman (2003), the owner-manager has linear inter-temporal preferences with a discount rate that is set to zero for simplicity (we consider a nonzero discount rate in the continuous time model).

The Owner-Manager's Expected Payoff at Date 0 from Choosing Long-Maturity Debt:
Suppose that the owner-manager issues long-maturity debt with *face value* D_L due at date 2 (recall that all debt is zero-coupon). By the theory of risk-neutral valuation, the

market value of debt at date 0 (therefore, the amount raised through debt financing) is the risk-neutral expectation of the payoffs to bondholders. Due to the presence of limited liability, the market value of debt at date 0 is

$$P_L = 0.25 \inf\left[(1+u)^2, D_L\right] + 0.5 \inf\left[1-u^2, D_L\right] + 0.25 \inf\left[(1-u)^2, D_L\right] \qquad (2)$$

Note that, because the maximum possible value of debt is I, the face value D_L must be such that $P_L \leq I$. By (1) and (2), the owner-manager's equity stake is

$$f(P_L) = (1-I)/(1-P_L). \qquad (3)$$

In order to derive the owner-manager's control benefits at the intermediate date 1, we need the value of equity at date 1, which depends on the "state" at date 1, that is, whether the firm value at date 1 is $1+u$ or $1-u$. The equity values in these two states are equal to the risk-neutral expectations of the total payoffs to equity-holders (insiders + outsiders) and are given by

$$\begin{aligned}
E^{1+u} &= 0.5\left[(1+u)^2 - D_L\right]^+ + 0.5\left[(1-u^2) - D_L\right]^+; \\
E^{1-u} &= 0.5\left[(1-u^2) - D_L\right]^+ + 0.5\left[(1-u)^2 - D_L\right]^+
\end{aligned} \qquad (4)$$

The superscripts indicate the dependence of the equity value on the firm value at date 1.

By (2), (3), and (4), the manager's total expected payoff at date 0 from issuing long-maturity debt with face value D_L is

$$\begin{aligned}
U(D_L) = \varepsilon\left(pE^{1+u} + (1-p)E^{1-u}\right) + \\
f(P_L)\left(p^2\left[(1+u)^2 - D_L\right]^+ + 2p(1-p)\left[(1-u^2) - D_L\right]^+ + (1-p)^2\left[(1-u)^2 - D_L\right]^+\right)
\end{aligned} \qquad (5)$$

The first term on the right hand side of (5) is the manager's expected payoff from her control benefits while the second term is the expectation of the payoff at date 2 from her equity stake in the firm. The actual probability of an "up-tick" p appears in the expressions since the manager cares about her *actual* expected payoff.

The Owner-Manager's Expected Payoff at Date 0 from Choosing Short-Maturity Debt:

Suppose now that the owner-manager issues short-maturity debt at date 0 with face value D_S due at date 1. This debt is re-financed (if possible) at date 1, that is, the market value of newly issued one-period debt at date 1 equals D_S. Bankruptcy is declared at date 1 if $D_S > 1 - u$. In this scenario, existing debt obligations cannot be re-financed because the maximum possible proceeds from the issuance of new debt equal the firm value $1 - u$.

The market value P_S of the firm's debt at date zero (the amount raised through debt financing) is

$$P_S = 0.5 \inf\left[(1+u), D_S\right] + 0.5 \inf[(1-u), D_S]$$ (6)

Note that $D_S < 1 + u$ because $P_S \leq I < 1$. By (1), the owner-manager's equity stake is $f(P_S) = \dfrac{1-I}{1-P_S}$. The face value of newly issued one-period debt at date 1 depends on whether the firm value at date 1 is $1 + u$ or $1 - u$. If firm value is $1 + u$, the face value of newly issued debt D^{1+u} must be such that its market value at date 1 equals D_S (the superscript indicates the dependence of the face value of new debt on the current "state"), that is,

$$0.5 \inf\left[(1+u)^2, D^{1+u}\right] + 0.5 \inf\left[(1-u^2), D^{1+u}\right] = D_S$$ (7)

If $D_S > 1 - u$, bankruptcy is declared when firm value is $1 - u$ since existing debt obligations cannot be met. For subsequent notational convenience, we set $D^{1-u} = \infty$ in this scenario. If $D_S \leq 1 - u$, then the face value of newly issued debt D^{1-u} is given by

$$0.5 \inf\left[(1-u^2), D^{1-u}\right] + 0.5 \inf\left[(1-u)^2, D^{1-u}\right] = D_S$$ (8)

The values of equity at the intermediate date 1 are

$$E^{1+u} = \left[(1+u) - D_S\right]^+; \quad E^{1-u} = \left[(1-u) - D_S\right]^+$$ (9)

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The manager's expected payoff from choosing short maturity debt with face value D_S is

$$
\begin{aligned}
U(D_S) = {}& \varepsilon\left(pE^{1+u} + (1-p)\varepsilon E^{1-u}\right) + f(P_S)p^2\left[(1+u)^2 - D^{1+u}\right]^+ + \\
& f(P_S)p(1-p)\left(\left[(1-u^2) - D^{1+u}\right]^+ + \left[(1-u^2) - D^{1-u}\right]^+\right) + \\
& f(P_S)(1-p)^2\left[(1-u)^2 - D^{1-u}\right]^+
\end{aligned}
\tag{10}
$$

The Owner-Manager's Objective: At date 0, the owner-manager decides whether to issue long – maturity or short maturity debt and chooses the corresponding face values D_L, D_S, respectively, to maximize her total expected future payoffs. The following proposition describes the manager's optimal financing and debt maturity choices. Its statement is complicated somewhat by the fact that the amount of debt financing (the market value of debt at date zero) is bounded above by the initial investment I.

1.2.2. Results and Discussions

Proposition 1:   *Let $D_L^{\text{all debt}}$ be the face value of long term debt when the manager chooses long-term **all debt** financing and let $D_S^{\text{all debt}}$ be the face value of short term debt in the first period when the manager chooses short term **all debt** financing (the market value of debt at date zero in each of these scenarios is, therefore, equal to the initial investment I). There exist p_1, p_2, p_3 (that depend on ε, u, and I) with $0.5 < p_1 \le p_2 \le p_3$ such that the manager chooses*

(i) *all-equity financing for $p < p_1$,*

(ii) *long maturity risk-free debt with face value $\min((1-u)^2, D_L^{\text{all debt}})$ for $p \in (p_1, p_2)$,*

(iii) *short maturity debt with face value $\min(1-u, D_S^{\text{all debt}})$ for $p \in (p_2, p_3)$,*

(iv) *long maturity debt with face value $\min(1-u^2, D_L^{\text{all debt}})$ for $p > p_3$ (this debt is risky if $D_L^{\text{all debt}} > (1-u)^2$)*

Proof. See Appendix A.

Note: The inequalities $p_1 \le p_2 \le p_3$ are not strict indicating that, for some parameter values, the intervals (p_1, p_2) and/or (p_2, p_3) could be empty.

We observe that the market values of the firm's debt (hence, its leverage) progressively increase from case (i) to case (iv) above, while debt maturity varies non-monotonically in a U-shaped manner. Hence, the results of Proposition 1 lead to the following implications:

- Leverage increases monotonically with the actual "up-tick" probability p in each period and, therefore, the expected growth of firm/asset value (alternatively, the risk premium of the project).

- If the manager issues nonzero debt, its maturity varies *non-monotonically* in a U-shaped manner, in general, with the "up-tick" probability p and, therefore, the expected growth of firm/asset value.

- The risk of the firm's debt (therefore, its credit spread) is significantly affected by the "up-tick" probability p.

The manager's choice of the level of debt financing is the outcome of the tradeoff between the *positive* effect of the debt level on her equity stake in the firm (see (3)) and the *negative* effect of the debt level on the manager's expected control benefits. The manager's subjective valuation of the project increases with the up-tick probability p. By the theory of risk-neutral valuation, however, the *market values* of the firm's debt and equity only depend on the *risk-neutral* up-tick probability 0.5, *and not on the actual probability* p. For lower values of p, the effect of the manager's expected control benefits at date 1 dominates so that she chooses lower levels of debt. At higher values of p, the manager's high subjective valuation of the project causes the effect of the

manager's payoffs from her equity stake in the firm to dominate, thereby inducing her to choose higher levels of debt in order to increase her equity stake.

The manager's choice of debt maturity reflects the tradeoff between the probability of re-financing short maturity debt at more favorable terms at date 1 versus the higher liquidity risk due to the possibility of bankruptcy in state $1-u$ and the accompanying loss of control benefits. At lower values of p, the "liquidity risk" effect dominates so that the manager issues long maturity debt. At intermediate values of p, the "re-financing" effect increases so that the manager issues short maturity debt. The manager's choice of leverage, however, increases with p. When the probability p is above a threshold, the high debt levels cause the "liquidity risk" effect to dominate the "re-financing" effect thereby inducing the manager to issue long maturity debt.

In Table 1, we illustrate the results of Proposition 1 by deriving the owner-manager's choice of leverage and debt maturity for varying values of the up-tick parameter u and probability p. The notation is explained in the table's legend. An examination of the columns of the table reveals the following:

- For low values of u, the manager chooses all-equity financing when p is below a threshold (case (i) of Proposition 1) and long maturity risky debt with face value $1-u^2$ when it is above the threshold (case (iv) of Proposition 1). In other words, for low values of the up-tick parameter u, only two of the four possible "financing regions" described in Proposition 1 appear.

- For intermediate values of u, there exist two triggers such that the manager chooses all-equity financing when p is below the lower trigger, long maturity risky debt with face value $1-u^2$ when it is above the higher trigger, and short maturity debt with face value $(1-u)$ between the triggers. In other words, for

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intermediate values of the up-tick parameter u, three of the four possible financing regions described in Proposition 1 appear. In these scenarios, both leverage and debt maturity increase with p.

Table 1: Financing and Debt Maturity Choices generated by Two-Period Binomial Model

The table presents results of simulations of the two period binomial model. The initial investment outlay I is set to 0.9 and the proportional control benefits parameter ε is set to 0.25. We vary the "up-tick" parameter u and the "up-tick" probability p as shown in the table and indicate the manager's optimal choice of leverage and debt maturity. "E" indicates that the manager chooses all-equity financing, "SM" indicates that the manager chooses short maturity debt with face value $1-u$, "LM/RF" indicates that the manager chooses long maturity risk-free debt with face value $(1-u)^2$ and "LM/R" indicates that the manager chooses long maturity risky debt with face value $1-u^2$.

		0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
	0.5	E	E	E	E	E	E	E	E	E	E
	0.505	E	E	E	E	E	E	E	E	E	E
	0.51	E	E	E	E	E	E	E	E	E	E
	0.515	E	E	E	E	E	E	E	E	E	E
	0.52	E	E	E	E	E	E	E	E	E	E
	0.525	E	E	E	E	E	E	E	E	E	E
	0.53	E	E	E	E	E	E	E	E	E	E
	0.535	E	E	E	E	E	E	E	E	E	E
	0.54	E	E	E	E	E	E	E	E	E	E
	0.545	E	E	E	E	E	E	E	E	E	E
	0.55	E	E	E	E	E	E	E	E	E	E
	0.555	E	E	E	E	E	E	E	E	E	E
	0.56	E	E	E	E	E	E	E	E	E	E
	0.565	E	E	E	E	E	E	E	E	LM/RF	LM/RF
	0.57	E	E	E	E	E	E	E	LM/RF	LM/RF	LM/RF
p	0.575	LM/R	LM/R	E	SM	SM	SM	SM	SM	SM	SM
	0.58	LM/R	LM/R	LM/R	SM	SM	SM	SM	SM	SM	SM
	0.585	LM/R	LM/R	LM/R	LM/R	SM	SM	SM	SM	SM	SM
	0.59	LM/R	LM/R	LM/R	LM/R	LM/R	SM	SM	SM	SM	SM
	0.595	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	SM	SM	SM	SM
	0.6	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	SM	SM	SM	SM
	0.605	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	SM	SM	SM
	0.61	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	SM	SM
	0.615	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	SM
	0.62	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R
	0.625	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R
	0.63	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R
	0.635	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R
	0.64	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R
	0.645	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R
	0.65	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R	LM/R

- For high values of u, all the four possible financing regions described in Proposition 1 appear so that debt maturity varies in a U-shaped manner with p.

The results of Table 1 (which are robust to alternative choices of values for the initial investment I and the control benefits ε) suggest that, for *typical* parameter values, both leverage and debt maturity *increase* with the expected growth of firm value. These observations extend to the continuous-time model analyzed in Sections IV and V and are also supported by our empirical analysis of the financing choices of firms in Section VI.

We emphasize that, in Proposition 1, the NPV of the project is *fixed* at $1-I$. Hence, the owner-manager's leverage and debt maturity choices vary significantly with the up-tick probability p although the NPV of the project is fixed. As mentioned earlier, the up-tick probability determines the project's risk premium. If all investors are assumed to be risk-neutral (as in a large number of studies in the literature), risk premia are equal to zero so that the actual up-tick probability *coincides* with the risk-neutral probability 0.5. Hence, the risk aversion of investors, as reflected in the deviation of the actual probability p from the risk-neutral probability 0.5, is a key driver of the variations in the owner-manager's leverage and debt maturity choices described in Proposition 1. We also note that a change in the up-tick probability p affects the expected growth *and* volatility of firm value in this stylized two-period binomial model. In the more general continuous-time model developed in the next section, we are able to disentangle the effects of the expected growth and volatility on leverage and debt maturity.

The analysis of the two-period binomial model highlights the significant impact of the interplay between the *actual distribution* of payoffs from the project (determined by the parameter p), and the *risk-adjusted* or *risk-neutral* distribution of payoffs, on the

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owner-manager's leverage and debt maturity choices, the risk of the firm's debt, and its credit spread. In Chapter II, we show that these implications and the intuition underlying them extend to a more general, continuous time setting.

1.3 Conclusion

In this chapter, we propose a parsimonious two-period model to examine the financing and debt maturity choice by an undiversified utility-maximizing owner manager. We show that the manager chooses all-equity financing if the project quality is below a threshold level. Above this level, the manager prefers debt to equity. She chooses long maturity debt with a high or low quality project, short maturity debt with a medium quality project. Our model predictions can better explain the empirical evidence than existing discrete-time model based on the framework of information asymmetries.

This simple binomial model captures the essence of owner-manager's financing decision to maximizing her own utility. The mathematically tractable model enables us to obtain the analytical results. It illustrates the economic dynamics of the variations of financing and debt maturity choices with different underlying projects in an intuitive way. However, all these are achieved at the expense of the model sophistication. The dynamic behavior which we observed in the real world can not be fully represented in a two-period model. In our model, the payout flow occurs only in the second period. In the real world, businesses are run as going concerns. Second, we model default event to be automatically triggered when the market asset value goes down to the debt value. In reality, it is more plausible that default happens when existing shareholders are not willing to service the debt. In other words, default should be modeled as an endogenous event. Lastly, short of a more sophisticated structural model, it is difficult to yield

quantitative implications on risky debt credit spreads. In order to address those issues, we develop a continuous-time structural model in the following chapter.

CHAPTER II

CONTINUOUS TIME STRUCTURAL MODEL

2.1. Introduction

We develop a parsimonious two-period monomial model in the previous chapter to explain financing and debt maturity choices of an undiversified owner-manager. Our model yields insights in the interplay of manager's own utility-maximizing motivation and firm's project characteristics on firms' finance and debt maturity choice. However, the binomial model has limitations due to its two-period time setting. The firm ceases to exist after the second period. Clearly this assumption violates the observations that most firms operate in much longer period. Second, the default is automatically triggered when the market value of total assets falls to the debt value. In reality, a firm can remain in the shareholders' control as long as they are willing to raise new financing to service existing debt. Third, the binomial model does not yield quantitative implications on actual maturity and credit spreads. Lastly, the quality of the project is characterized by the probability of the up-tick in the project value binomial tree. This probability is hard to estimate unambiguously from empirical data, which hinders empirical testing on the validity of our model.

Therefore, in this chapter, we develop a continuous-time structural model to with rational expectation to examine the financing and debt maturity choices of owner-managers. The undiversified owner-manager chooses the firm's capital structure, and the maturity of its debt, to maximize her discounted expected utility. . In a perfect information framework, we show that the interplay between the objective of the undiversified, self-interested owner-manager who controls the firm, and the valuation of the firm's claims from the perspective of *well-diversified* "outside" investors,

significantly influences leverage and debt maturity decisions as well as credit spreads. The impact of this interplay is particularly pronounced in a world where the *representative investor* (who determines asset prices in the economy) is *risk-averse* leading to nonzero *market prices of systematic risk* and *risk premia* of the firm's projects.

In a world with perfect information, no tax advantages of debt or bankruptcy costs, we show that the manager, in general, finances the firm's operations with nonzero proportions of debt and equity. Leverage increases with the *ex post* (after debt is in place) expected growth rate, and decreases with the standard deviation, of the firm's value. The credit spreads on the firm's debt are significantly higher than those predicted by traditional structural models where financing decisions are made by diversified, value-maximizing (original or current) shareholders. The maturity of the firm's debt varies in a *non-monotonic* manner with the expected ex post growth rate and declines with the ex post volatility of firm value. Our results reconcile empirical evidence on the relations between firm leverage and debt maturity with underlying firm characteristics that are not completely consistent with existing theoretical models

The significant variations of leverage, debt maturity, and credit spreads with the *actual* distribution of firm value (in particular, its expected growth rate), which depends on the *risk premia* of the firm's projects, are key predictions of our analysis. These predictions cannot be obtained in models in which financing decisions are made by *value-maximizing* shareholders because leverage, debt maturity, and credit spreads only depend on the *risk-neutral* (or *risk-adjusted*) distribution of firm value in these models (for example, Fischer et al, 1989, Leland and Toft, 1996). They cannot be obtained either in models where investors are assumed to be risk-neutral so that risk premia are zero (Zwiebel, 1996). We show significant support for the primary implications of our theory

in our empirical analysis of the financing of incremental investments by firms. Our theoretical and empirical analyses together suggest that undiversified large shareholders or owner-managers significantly influence firms' financing decisions.

Consider a cash-constrained entrepreneur or owner-manager approaches the capital markets to finance a project at the initial date (the owner-manager could also be viewed as representing the firm's *large, controlling shareholders*). The manager could finance the project through equity and debt. Since our focus is on the impact of the owner-manager's financing discretion, we assume that there are no taxes, firm-level bankruptcy costs, or informational asymmetries. Hence, the *market value of the firm* under the project (the market value of the claim to the project's payout flow), which is the *state variable* in our analysis, is unaffected by leverage. The market value of the firm evolves as a lognormal process with a drift and volatility that are common knowledge. Since there are no informational asymmetries between outside investors (the market) and the owner-manager, the project must have positive NPV to receive external financing.

The market for capital provision is competitive so that the *market values* of "outside" investors' stakes (debt and equity) in the firm are equal to their investments. Hence, the owner-manager (alternatively, the controlling shareholders) captures the surplus from the project and receives the project's residual payout flows after payouts to debt and outside equity. The manager also derives private control benefits at each date (Zwiebel, 1996), which are proportional to the payout flow to equity. For tractability, we adopt Leland's (1994) framework where debt has infinite maturity, but could be continuously retired at differing rates leading to different "average" debt maturities. In financial distress, debt is serviced through the issuance of additional equity. Bankruptcy occurs *endogenously* when the market value of equity falls to zero and control of the firm

transfers to creditors. As in DeMarzo and Fishman (2003), the manager has linear inter-temporal preferences with a subjective discount rate. She chooses the firm's capital structure and the maturity of its debt (alternatively, the debt retirement rate) to maximize the discounted expected utility she derives from her entire stream of future payoffs. We solve the manager's optimization problem using numerical methods to derive her optimal choice of leverage and debt maturity.

The owner-manager is inherently undiversified due to her controlling ownership stake, control benefits, and significant human capital investment in the firm so that her objective deviates, in general, from value maximization. In particular, although firm value is unaffected by leverage in our framework, the undiversified owner-manager is *not* indifferent to the choice of leverage. The owner-manager has linear inter-temporal preferences and chooses the proportion and maturity of debt in the financing of the project at the initial date to maximize the discounted expected payoffs from her ownership stake in the firm and her control benefits.

We first examine the variation of the manager's choice of leverage with the project drift, *ceteris paribus* (in particular, keeping the market value of the firm fixed). We find that leverage increases monotonically with the project drift. Specifically, when the project drift is extremely low, the manager chooses to finance the project exclusively with equity because the high probability of bankruptcy deters the manager from using debt financing. On the other hand, when the drift is very high, she finances the project exclusively with debt. When the drift is in the intermediate range, the manager chooses to finance the project with a combination of debt and equity.

The intuition for these results hinges on the fact that the manager's choice of leverage balances the tradeoff between two effects: increasing the debt level increases the

manager's equity stake in the firm thereby allowing her to obtain a larger share of residual cash flows; increasing the debt level, however, also increases the probability of bankruptcy. The key to understanding the interplay between these effects is the fact that, for a given debt structure, the *market values* of outside equity and debt and, in particular, the bankruptcy level (the value of the payout rate at which bankruptcy occurs) depends only on the *risk-adjusted* drift of the project that is constant in these simulations since the market value of the firm is fixed. For a given debt structure, the probability of bankruptcy declines with the project drift and the manager's expected utility increases, that is, the manager's *subjective* valuation of the project increases. The manager, therefore, has the incentive to increase the level of debt as the project drift increases so that she can obtain a larger proportion of the firm's residual cash flows. In our framework, the drift or expected growth of firm value under the project are conceptually different notion from firm's "growth opportunities" that relate to the NPV of the project. In our model, the market value of the firm and, therefore, its book-to-market ratio and the project's NPV, are fixed in these simulations.

Next, we demonstrate that the manager's choice of debt maturity varies in a *non-monotonic,* U-shape manner with the project drift, that is, the manager issues longer-maturity debt for low and high drifts than for intermediate drifts. The intuition for these results hinges on the fact that the manager's choice of debt maturity reflects the tradeoff between the possibility of refinancing the firm's debt at more favorable terms in the future with shorter maturity debt versus the higher probability of bankruptcy in the near term, *ceteris paribus*. At lower values of the project drift, the probability of favorable future realizations is low so that the second effect predominates and the manager issues longer maturity debt. As the project drift increases, the probability that the manager can

refinance the firm's debt in the future at more favorable terms due to good project realizations increases so that debt maturity initially declines. As the project drift increases further, however, the manager's choice of leverage also increases thereby increasing the probability of bankruptcy. The interplay between these effects leads to the non-monotonic variation of debt maturity with the project's drift. Our results suggest that the utility benefits to the manager due to the reduction of the probability of bankruptcy outweigh the benefits of possible interest cost savings from shorter-term debt when the drift is very high. Therefore we observe that the manager choose long debt maturities beyond a threshold value of the project drift.

Our results reconcile several empirical findings regarding the variation of debt maturity and leverage with project quality that are not completely consistent with existing models. Diamond (1991) predicts that low and high quality firms issue short-term debt whereas medium quality firms issue long-term debt. However, Mitchell (1991, 1993) documents a *positive* relation between debt maturity and *ex post* project quality measured by the growth of net operating income, and Guedes and Opler (1996) document that very high quality firms are dominant in the extremely long-maturity debt market. Johnson (2003) documents a *negative* relation between leverage and short debt maturity; a finding that cannot be explained within Diamond's "pure debt financing" framework. The empirical evidence documented by these studies is consistent with the predictions of our analysis that leverage increases with the project's expected growth rate or drift, and that debt maturity increases with the drift if it exceeds a threshold. Nevertheless, the non-monotonic variation of debt maturity predicted by our analysis suggest that more complex, non-linear, functional specifications are necessary to rigorously estimate the relation between debt maturity, leverage, and project quality.

The significant variation of leverage and debt maturity with the drift or expected ex post growth of firm value even though the market value of the firm and the initial investment outlay (therefore, the book-to-market ratio) are fixed are important implications of this study. In particular, these results cannot be obtained in traditional "contingent claims" capital structure models where financing decisions are made by *value-maximizing* shareholders (Fischer et al 1989, Leland and Toft 1996) so that only risk-adjusted drifts matter. They also cannot be obtained in models where all agents are assumed to be risk-neutral (Zwiebel 1996) so that actual and risk-adjusted drifts coincide since risk premia are zero. Our results, therefore, imply that when managers control financing decisions in a world with nonzero risk premia, the expected ex post growth rate of firm value is an important determinant of ex ante financing decisions. We confirm these implications in our empirical analysis.

We then examine the variations of leverage and debt maturity with the project volatility. We show that, *ceteris paribus*, leverage decreases monotonically with project volatility. The manager prefers all-debt financing when volatility is low. As the project volatility increases, the manager chooses a nonzero proportion of equity financing. Beyond a threshold value of volatility, the manager finances the project exclusively through equity. These predictions are consistent with considerable empirical evidence that documents a negative relation between leverage and risk (Bradley, et al. 1984, Friend and Hasbrouck 1988, and Friend and Lang 1988). The result that the project is financed exclusively through equity if its risk exceeds a threshold is consistent with the evidence documented by Guedes and Opler (1999) that high-risk firms finance investments primarily through equity.

We also show that debt maturity declines monotonically with project volatility in the parameter range where the manager issues a combination of debt and equity. This prediction is consistent with the evidence documented by Stohs and Mauer (1996) who find a significant negative relation between debt maturity and earnings variability. The intuition for these results is that, as the volatility increases, the possibility of bankruptcy causes the manager to lower leverage levels. However, higher volatility levels also increase the probability of refinancing the firm's debt at more favorable terms in the future due to "good" project realizations. The manager's choice of debt maturity reflects the tradeoff between these effects. Since the manager's payoff in each period is proportional to the project's payout flow, the second effect dominates the first so that the manager's choice of debt maturity declines with volatility.

We find that, in the region where the manager issues nonzero debt, credit spreads vary non-monotonically with the project's drift and volatility. These results reflect the fact that the risk of the firm's debt depends on the *level* of debt in the firm's capital structure as well as the probability of bankruptcy that are determined endogenously by the project's drift and volatility. For reasonable parameter values, the credit spreads predicted by our model are substantially higher than those predicted by earlier structural models where financing decisions are made by value-maximizing (original or current) shareholders (for example, Fischer, Heinkel, and Zechner 1989, Leland 1994, Leland and Toft 1996, Goldstein, Ju, and Leland 2001) and are closer to those observed in reality.

We also examine the variation of financing choices with the manager's subjective discount rate or "degree of myopia" and the project's payout ratio. The manager's choice of leverage decreases monotonically with her discount rate. In other words, the more "myopic" manager with a higher discount rate adopts a more conservative financing

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policy. On the other hand, the manager's leverage choices increase with the payout ratio. A higher payout ratio increases the manager's payoff in each period, *ceteris paribus*, thereby increasing her discounted expected utility and reducing the relative impact of her personal costs due to bankruptcy.

Following Diamond's (1991) theoretical study of firms' debt maturity choices, several subsequent empirical studies document a non-monotonic relationship between a firm's credit rating and debt maturity. In Diamond's "pure debt financing" model, there is a one-one correspondence between a firm's credit rating, and the probability that it undertakes a positive NPV project. Moreover, in his framework, negative NPV projects are also necessarily riskier than positive NPV projects. In our dynamic framework where firms can choose both equity and debt financing, a firm's default risk (or credit rating) depends on the expected growth rate and volatility of firm value since they determine the *level* as well as the *maturity* of the firm's debt. We disentangle the effects of drift and volatility on the quality of a firm's pool of projects instead of using a single, imperfect measure of firm quality such as its credit rating.

In summary, we examine the financing choices of a utility-maximizing owner-manager in a continuous time framework. Our analysis shows that, for reasonable parameter values, managerial incentives lead to nontrivial leverage and debt maturity choices in a perfect information framework without taxes and bankruptcy costs. [1] The complex dynamics of leverage and debt maturity predicted by our analysis are significantly different from those obtained in static models, and reflect the fact that financing choices are made by a manager with a long-term objective function. Our study

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[1] The literature is still divided on whether tax advantages and bankruptcy costs are important determinants of capital structure. Graham (2000), Hennessy and Whited (2004) examine whether the "tradeoff" theory can explain financing choices. These studies do not, however, examine debt maturity choices in

suggests a tractable framework to reconcile several empirical findings on the variation of leverage and debt maturity choices with firm quality. Our analysis suggests that managerial incentives significantly influence firms' financing decisions.

The rest of the chapter is organized as follows. We discuss related literature in more detail in Section II. In Section III, we present our model. In Section IV, we analyze several "comparative static" relationships predicted by our model, and discuss connections with existing empirical evidence. Section V concludes. Proofs and numerical procedure are provided in Appendices B and C.

2.2. Related Literature

To the best of our knowledge, this is the first study to simultaneously examine optimal leverage and debt maturity choices by a utility-maximizing owner-manager in a continuous time framework. Flannery (1986) and Diamond (1991) examine debt maturity choices by managers in two-period "asymmetric information" models where financing is restricted exclusively to debt. Flannery (1986) predicts that debt maturity declines monotonically with project quality whereas Diamond (1991) predicts a non-monotonic variation; specifically high and low quality projects are financed with shorter maturity debt compared with projects of intermediate quality. [1] Kale and Noe (1990) and Goswami, Noe and Rebello (1995) also examine debt maturity choices in a framework that deals with different distribution of information asymmetries.

In contrast with these predictions, however, Mitchell (1991, 1993) documents a *positive* relation between debt maturity and *ex post* project quality measured by the growth of net operating income, and Guedes and Opler (1996) document that very high

conjunction with capital structure decisions. Boyce and Kalotay(1979) and Brick and Ravid(1985) examine the impact of taxes on debt maturity choices.

quality firms are dominant in the extremely long-maturity debt market. Berger et al (2005) document that borrowers with low ratings are more likely to issue longer-term debt, a finding that is inconsistent with Diamond's (1991) predictions..

As mentioned earlier, these empirical findings can be reconciled within our framework where debt maturity varies in a non-monotonic manner with project characteristics (the expected growth rate and volatility of firm value under the project). The significant differences between our predictions and those of Flannery (1986) and Diamond (1991) arise due to important distinctions between our frameworks. First, ours is a "perfect information" model where the manager may issue *both* debt and equity. Therefore, leverage and debt maturity are simultaneously determined endogenously. This leads to predictions about the variation of leverage and debt maturity with project quality that cannot be obtained in these "pure debt financing" models. Second, in Diamond's (1991) framework, negative NPV projects are also riskier than positive NPV projects. In our "perfect information" model, however, all projects that are financed have positive NPV, and we make no assumptions about the relationship between the risk of a project and its NPV. Third, in our model, the project's drift, volatility, and the payout ratio affect the manager's financing choices since they affect her utility. We, therefore, obtain a richer set of implications regarding the variation of leverage and debt maturity choices with project characteristics.

Empirical evidence is inconclusive on whether signaling and information asymmetries play crucial roles in affecting financing and debt maturity choices. Barclay and Smith (1995) and Stohs and Mauer (1996) find that that the economic significance of the effect of abnormal earnings on debt maturity choice is negligible. Guedes and Opler (1996) find no substantial variation by maturity in pre-issue and post-issue stock returns.

In a study that restricts consideration to bank loans rather than publicly issued debt, Berger et al (2005) do find that asymmetric information may play an important role in debt maturity choices. The positive implications of our "perfect information" framework suggest that "information asymmetry" need not play an important role in explaining firms' leverage and debt maturity choices.

Zwiebel (1996) proposes a three-period model of dynamic financing where entrenched managers choose leverage and debt maturity trading off "empire building" ambitions with the need to ensure sufficient efficiency to prevent control challenges. He predicts that long-term debt should be preferred when the quality of the firm's investment opportunities is low. This prediction is not consistent with the empirical evidence described above. Similar to Zwiebel (1996), financing decisions are controlled by managers in our framework. In contrast, however, we do not assume private benefits of control or the presence of control challenges. Further, our analysis leads to a larger set of predictions regarding the variation of leverage and debt maturity choices with underlying project characteristics. Morellec (2004) extends Zwiebel's (1996) analysis to a continuous-time setting. He does not focus on debt maturity choices. Aghion and Bolton(1992), analyze incomplete long-term financial contracts between an entrepreneur and an outside investor under uncertainty and noisy signals. Hart and Moore(1994) develop a capital structure model under perfect certainty and characterize the optimal repayment path. DeMarzo and Fishman (2003), DeMarzo and Sannikov (2004), and Biais et al (2004) develop dynamic contracting models of a manager's financing choices. However, neither study focuses on, or derives implications, for *debt maturity* choices.

We adopt the modeling approach of continuous time "contingent claims" models of firms' financing decisions. From an economic standpoint, however, our perspective is

fundamentally different from "traditional" contingent claim models (for example, Fischer et al 1989, Leland and Toft 1996, Leland 1998, Goldstein et al 2001) in that the firm's financing choices are determined by a utility-maximizing owner-manager rather than by diversified value-maximizing (original or current) shareholders. Conceptually, this implies that the subjective *project drift* or *expected growth rate* plays a prominent role in our analysis. In contrast, in contingent claim models where financing choices are made by value-maximizing shareholders, the firm's financing choices depend only on the *risk-neutral drift* (the difference between the risk-free rate and the payout ratio) and the project volatility. Therefore, we are able to explain empirical evidence on the relationships between *ex post* project *quality* (that depends on drift as well as volatility), leverage and debt maturity. Leland and Toft (1996) and Titman and Tsyplakov(2002) develop capital structure models where debt maturity is *exogenous*. Fischer et al (1989) and Goldstein et al (2001) assume a consol bond in their models. Christensen (2002) and Flor and Lester(2002) develop dynamic models of capital structure with callable debts. Ericsson(2000) develops a continuous time model of optimal leverage and maturity. These studies are fundamentally different from ours in that financing choices are made by diversified, value-maximizing (original or current) shareholders rather than by a utility-maximizing manager. In particular, none of these studies predicts the variation of leverage, and the complex non-monotonic variation of debt maturity, with underlying project characteristics (expected growth and volatility) that we obtain in our framework.

2.3. The Model

2.3.1 The Payout Rate Process

We consider a continuous-time "perfect information" framework where a cash-constrained entrepreneur approaches the capital markets to finance a profitable project. The initial required investment is I, but the project's market value is $V(0) > I$ (in our rational world with perfect information, a necessary condition for the project to be financed is that it have nonnegative NPV). The entrepreneur manages the firm after the project is financed.

The market for capital provision by outside investors is perfectly competitive so that the *market values* of outsiders' stakes in the firm are equal to their investments and the entrepreneur captures the surplus or NPV $V(0) - I$ (in effect, the entrepreneur has all the bargaining power with outside investors). Alternatively, we could view the entrepreneur as representing the "original shareholders" or "insiders" who have the bargaining power with bondholders and the "new shareholders" or "outsiders". Henceforth, we refer to the entrepreneur or "insiders" as an *owner-manager* for expositional convenience. The assumption that the owner-manager has all the bargaining power is made purely for simplicity. All our results are qualitatively valid in a more general setting where the owner-manager issues debt that is fairly valued, but *bargains* with new shareholders to determine her resulting ownership stake in the firm so that the surplus from the project is shared between the owner-manager and the new shareholders. To illustrate the impact of the owner-manager's incentives on financing choices, we consider a world with no taxes or bankruptcy costs (losses in firm value due to bankruptcy).

The fundamental variable that we model is the project's payout rate before interest payments $\Delta(.)$ that evolves as follows:

$$\frac{d\Delta(t)}{\Delta(t)} = \mu dt + \sigma dw(t) \tag{1}$$

In the above, $w(.)$ is a standard Brownian motion. The drift μ and volatility σ are common knowledge. For future reference, we describe the evolution of the payout rate process under the *risk-neutral* or *pricing* measure. If the market price of risk corresponding to the Brownian motion $w(.)$ is a constant λ, the payout rate process evolves as follows under the risk-neutral measure:

$$\frac{d\Delta(t)}{\Delta(t)} = (\mu - \lambda\sigma)dt + \sigma d\overline{w}(t) = \overline{\mu}dt + \sigma d\overline{w}(t) \tag{2}$$

In (2), $\overline{w}$ is a Brownian motion under the risk-neutral probability and $\overline{\mu}$ is the risk-adjusted drift of the project. By the theory of contingent claims valuation (Duffie 2001), the *market value of the firm* $V(t)$ (the claim to the entire payout flow) at any date t is the discounted *risk-neutral expectation* of the payout flows from the project where the discounting is at the risk-free rate r, which is assumed to be constant. Therefore,

$$V(t) = \overline{E}_t[\int_t^\infty e^{-rs}\Delta(s)ds] = \frac{\Delta(t)}{r - \overline{\mu}}$$

$$V(0) = \frac{\Delta(0)}{r - \overline{\mu}} \tag{3}$$

In (3), $\overline{E}_t$ is the expectation (at date t) under the risk-neutral probability measure. The risk-free rate, that is assumed to be constant, is denoted by r. Since the denominator in the is a constant, $V(.)$ and $\Delta(.)$ share the same dynamics. Hence the "gains process" (see Duffie 2001) follows:

$$\frac{dV + \Delta(t)dt}{V} = \mu dt + \sigma dw(t) \tag{4}$$

Defining $\delta = r - \bar{\mu}$, which is he project's payout ratio, the market value of the firm evolves as follows:

$$\frac{dV}{V} = (\mu - \delta)dt + \sigma dw(t) \qquad (5)$$

For future reference, the market value of the firm evolves as follows under the *risk-neutral measure*:

$$\frac{dV}{V} = (r - \delta)dt + \sigma d\bar{w}(t) \qquad (6)$$

In our world with perfect information and no taxes or bankruptcy costs, the market value of the firm V is the sum of the market values of the stakes of all claimants to the firm's payout flow, that is, the owner-manager, outside equity-holders, and outside debt-holders. In our subsequent analysis, we use firm value V as the state variable whose evolution is described by (4). A project, therefore, is characterized by three parameters: μ, the drift, or the expected growth rate of the asset value, σ, the volatility, and δ, the payout ratio. This permits a characterization of a wide range of possible projects. For example, a high drift, high volatility and low payout project could be typical of a "high technology" growth firm; a low drift, low volatility and high payout project might characterize a firm in a mature industry with relatively few growth opportunities; a low drift, high volatility, and low payout project might characterize a firm facing significant uncertainty in a troubled industry.

The difference between the initial firm value $V(0)$ and the investment I is the net present value (NPV) of the project. In a world with perfect information, it is necessary for the project to have positive NPV for it to be financed. Since the market for capital provision by outside investors is perfectly competitive, the surplus $V(0) - I$ accrues to the owner-manager. If $P \leq I$ denotes the amount of the initial investment that is financed

through debt so that $I - P$ is financed through "outside equity", the owner manager, therefore, effectively has an equity stake in the firm given by

$$f = \frac{V(0) - I}{V(0) - P} \tag{7}$$

The key aspect of our framework, however, is that the owner-manager is *undiversified* so that she cares about maximizing the discounted expected utility she derives from her ownership stake in the firm rather than its *market value*.

2.3.2 The Debt Structure and Bankruptcy

The debt structure is described by the *principal*, the *coupon rate*, and the *maturity*. Since we consider a firm with a single investment opportunity that arrives at date 0, we follow Flannery (1986) and Diamond (1991) in restricting consideration to dynamic *refinancing* of existing debt. For tractability, we adopt the framework of Leland (1994) where debt has infinite maturity, but is continuously retired at par and replaced by newly-issued debt. For simplicity, we restrict consideration to simple debt without call, convertible or any other complex features This leads to a finite "average" debt maturity. As in Leland (1994), debt is initially issued at par so that the principal P equals the amount raised through debt financing. Subsequently, however, new debt is issued at its market value that, in general, differs from the par value.

At any time t after date zero, a proportion $me^{-mt}dt$ of debt issued at $t = 0$ is retired and replaced with new debt. Therefore, the proportion of initially issued debt still outstanding at date t is e^{-mt}. Let $p(\tau,t), c(\tau,t)$ denote the principal and coupon of debt outstanding at time of t that is issued at time $\tau \leq t$. Since the debt principal is retired at constant rate of m continuously, we have:

$$\frac{\partial p(\tau,t)/\partial t}{p(\tau,t)} = -m \tag{8}$$

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The outstanding principal and coupon and the replacing principal and coupon have the following relationship:

$$p(\tau,t)=e^{-m(t-\tau)}P \tag{9}$$

$$c(\tau,t)=e^{-m(t-\tau)}C \tag{10}$$

If bankruptcy never occurs, the average maturity M of debt is

$$M = \int_0^\infty t\left(me^{-mt}\right)dt = \frac{1}{m} \tag{11}$$

Therefore, the average debt maturity M varies inversely with the debt "rollover rate" m. As discussed by Leland (1998), this constant rollover structure can be viewed as a sinking fund that continuously retires outstanding debt at par.

As in Leland (1994), shareholders service debt entirely as long as the firm is solvent. If the firm's cash flows are insufficient to meet debt payments, shareholders inject capital by issuing additional equity. Bankruptcy occurs endogenously when the value of equity falls to zero so that it is no longer optimal for shareholders to service debt. The control of the firm transfers to bondholders after bankruptcy.

2.3.3 The Debt Value Process

By the theory of contingent claims valuation, the market value of debt is the discounted risk-neutral expectation of cash flows to bondholders where the discounting is at the risk-free rate (see Duffie 2001). By (6), we can show that the value of debt issued at $t=0$, denoted by $D^0(V,t)$ satisfies the following partial differential equation(PDE):

$$\frac{1}{2}\sigma^2 V^2 D_{VV}^0 + (r-\delta)VD_V^0 - rD^0 + D_t^0 + e^{-mt}\left(C+mP\right)= 0 \tag{12}$$

where subscripts indicate partial derivatives. As discussed in Leland (1998), although the value of debt issued at date $t=0$ is explicitly time-dependent, the value of *total outstanding debt* at any date depends only on the value of the state variable V. If $D(V)$

denote the value process of total outstanding debt at any date , we have $D^0(V,t)=e^{-mt}D(V)$.

From (10), we have that $D(V)$ satisfies the following ordinary differential equation (ODE):

$$\frac{1}{2}\sigma^2 V^2 D_{VV} + (r-\delta)VD_V - (r+m)D + (C+mP) = 0 \tag{13}$$

The above ODE has a general solution of the form:

$$D(V) = \frac{C+mP}{r+m} + A_1 V^{\eta_-} + A_2 V^{\eta_+} \tag{14}$$

in which

$$\eta_+ = \frac{-\left(r-\delta-\dfrac{\sigma^2}{2}\right) + \sqrt{\left(r-\delta-\dfrac{\sigma^2}{2}\right)^2 + 2\sigma^2(r+m)}}{\sigma^2} \tag{15}$$

$$\eta_- = \frac{-\left(r-\delta-\dfrac{\sigma^2}{2}\right) - \sqrt{\left(r-\delta-\dfrac{\sigma^2}{2}\right)^2 + 2\sigma^2(r+m)}}{\sigma^2} \tag{16}$$

Since r and m are positive, it follows that $\eta_+ > 0, \eta_- < 0$. The constant A_2 must be zero to ensure that the value of debt remains bounded. Therefore, the value of outstanding debt is given by:

$$D(V) = \frac{C+mP}{r+m} + AV^{\eta_-} \tag{17}$$

The debt value satisfies three additional conditions. Since debt is issued at par at date zero:

$$D(V(0)) = P \tag{18}$$

The value of debt at bankruptcy is equal to firm value since absolute priority is enforced at bankruptcy:

$$D(V_B) = V_B \tag{19}$$

Finally, we have the *smooth pasting* condition signifying that bankruptcy is optimally declared by shareholders.

$$E'(V)|_{V=V_B} = 0 \qquad (20)$$

For a given capital structure (P, C, m), the following result describes the relationships between firm value, the debt principal, the coupon, and rollover rate, and the endogenous bankruptcy level.

Proposition 1: *The initial firm value $V(0)$, endogenous bankruptcy level V_B, the debt principal P, the rollover rate m, and the coupon rate, C, satisfy the following system of equations:*

$$V_B = (A\eta_-)^{\frac{1}{1-\eta_-}}$$

$$(21)$$

$$\frac{(rP-C)\eta_-(C+mP)^{\eta_- - 1}}{(r+m)^{\eta} V_0^{\eta} (1-1/\eta_-)^{\eta_- - 1}} = 1 \qquad (22)$$

$$A = \frac{rP - C}{(r+m)V_0^{\eta_-}} \qquad (23)$$

Proof: see Appendix B.

 Remark: Note that, since initial debt is issued at par, the debt principal P, coupon C, and retirement rate m are *not* independent of each other.

2.3.4 The Owner-Manager's Objective

Owing to the manager's equity stake in the firm given by (7), she receives a proportion of its payout flows over time. The manager also derives control benefits at each date that are a proportion ε of the payout flow to equity-holders. The self-interested owner-manager is undiversified due to her controlling ownership stake in the firm, control benefits, significant human capital investment in the firm, and the fact that her

income over time is tied to the firm so that her objective differs in general *from value-maximization* (Zingales, 2000).

As in studies such as DeMarzo and Fishman (2003) and Biais et al (2004), the manager has time-additive linear preferences with a subjective discount rate β. The discount rate β can be interpreted as the maximum expected return that the manager could obtain through outside investments and could also be viewed as her "degree of myopia". The manager chooses the firm's capital structure (P,C,m) to maximize her discounted expected stream of payoffs from her control benefits and her undiversified equity stake in the firm.

Since the firm continuously retires a fraction of its debt at par and replaces it with new debt, the cash outflow (per unit time) to debt holders at any instant is $C+mP$. Hence the cash flow to shareholders (per unit time) is the total payout rate δV plus the cash inflow rate from issuing new debt $mD(V,t)$, minus the cash outflow rate to the debt holders. The owner-manager receives a fraction, $f(P)$ (given by (15)) of the total cash flows to the shareholders. As in Leland (1998), we also introduce a re-issuance cost for replacing old debt, denoted by k. The re-issuance cost does not affect our results qualitatively, but is a parameter of the model that can potentially be calibrated to actual leverage and debt maturity data.

Hence, for a given capital structure (P,C,m) the owner-manager's payoff (per unit time) at any date t when the firm is solvent is given by

$$CF_{P,C,m}(t) = \varepsilon\big(\delta V + mD_{P,C,m}(V,t) - (C+[1+k]mP)\big) + f(P)\big(\delta V + mD_{P,C,m}(V,t) - (C+[1+k]mP)\big)$$
(30)

where the subscripts indicate the dependence of the cash flows on the firm's capital structure. The first term on the right hand side of (30) represents the manager's control

benefits (recall that they are a proportion ε of the payout to equity-holders) while the second term represents the manager's payoff from her ownership stake f. $D_{P,C,m}(t)$ is the debt value at date t with the subscripts indicating its dependence on the firm's capital structure.

$$E\left[\int_0^{\tau_{P,C,m}} \exp(-\beta t)CF_{P,C,m}(t)dt\right] \tag{25}$$

in which $\tau_{P,C,m}$ is the (stopping) time at which bankruptcy occurs when the capital structure is (P,C,m), and β is the manager's subjective discount rate.

2.3.5 The Owner-manager's Value Function and Optimal Capital Structure

For a given capital structure (P,C,m), the value function of the manager is

$$U_{P,C,m} = \int_0^{\tau_{P,C,m}} e^{-\beta t}CF_{P,C,m}(t)dt \tag{26}$$

The subscripts on the value function, the bankruptcy time, and the manager's cash flows explicitly indicate their dependence on the firm's capital structure. The manager's objective is to choose the firm's capital structure (P^*,C^*,m^*) to solve

$$(P^*,C^*,m^*) = \arg\max_{P,C,m} U_{P,C,m} \tag{27}$$

We solve (27) by first deriving the manager's value function for a given capital structure given by (25). Using well-known dynamic programming arguments (see Fleming and Soner p.140), we can show that the manager's value function (where we have dropped the subscripts denoting its dependence on the capital structure to simplify the notation) must satisfy

$$\beta U = \frac{1}{2}\sigma^2 V^2 U_{VV} + (\mu - \delta)VU_V + (f(P)+\varepsilon)V + (f(P)+\varepsilon)mD(V) - (f(P)+\varepsilon)(C+(1+k)mP)$$

$$\tag{28}$$

where f is the manager's equity stake given by (7).

Proposition 2: *The solution of the ordinary differential equation (28) has the functional form:*

$$U = BV^{\gamma_-} + A'V^{\eta_-} + C'V + D' \qquad (29)$$

where,

$$A' = \frac{-(f(P)+\varepsilon)mA}{\frac{1}{2}\sigma^2\eta_-(\eta_- - 1)+(\mu-\delta)\eta_- - \beta}; C' = \frac{(f(P)+\varepsilon)\delta}{\beta-\mu+\delta}; D' = \frac{-r(f(P)+\varepsilon)(C+mP)}{\beta(r+m)} - \frac{(f(P)+\varepsilon)kmP}{\beta};$$

and

$$\eta_- = \frac{-\left(r-\delta-\frac{\sigma^2}{2}\right)-\sqrt{\left(r-\delta-\frac{\sigma^2}{2}\right)^2+2\sigma^2(r+m)}}{\sigma^2}; \gamma_- = \frac{-\left(\mu-\delta-\frac{\sigma^2}{2}\right)-\sqrt{\left(\mu-\delta-\frac{\sigma^2}{2}\right)^2+2\sigma^2\beta}}{\sigma^2}$$

The coefficient B in (29) is determined by the boundary condition $U(V_B)=0$, i.e. manager's value function equals to zero when the firm is bankrupt.

Proof: see Appendix B

Although we can analytically characterize the manager's value function U, we are unable to solve the "optimal capital structure" problem (27) analytically. We, therefore, use numerical methods (described in Appendix B) to solve (27). By the result of Proposition 1 (see 21 ,22, 23), the principal, the coupon rate, and the rollover rate are not independent of each other. Therefore, in our numerical algorithm, we determine the principal amount and rollover rate (P^*, m^*) and then deduce the corresponding coupon rate C^* from (22). Since debt is issued at par, the principal P^* is the amount that is financed through debt.

2.4. The Manager's Leverage and Debt Maturity Choices

We solve (27) numerically to derive the manager's choice of capital structure. We describe our numerical procedure in detail in Appendix B. The tables in this section report the numerical results for different choices of the model parameters. When the principal amount P is close to zero, we interpret it as an "all-equity" capital structure[2]. When the principal is equal to the initial investment I, it indicates that the manager prefers all-debt financing.

We choose baseline values for the model parameters and examine several "comparative statics" by varying parameters about their baseline values. As in Leland (1998), the baseline values for the risk-free rate r and the payout ratio δ are set to 0.06 and 0.05, respectively. The drift μ and volatility σ are set to their median values in our sample of financing data (see Chapter 3: Empirical Analysis). The managerial discount rate is not observable. We choose the baseline rate to be 0.3, which is reasonably higher than the historical market returns for well-diversified investors. The re-issuance cost is set to 1%. Ritter et al (1996) report that the cost of issuance of a bond is between 1% and 2% of the principal.

2.4.1. Comparative Statics with Drift

Table 2 reports the variation of leverage, debt maturity, the coupon rate and the yield spread with the drift μ with all other parameters set to their baseline values. The drift μ ranges from 0.01 to 0.28, which are (roughly) the 12.5 and 87.5 percentiles of the sample distribution of drifts from the data for our subsequent empirical analysis (see

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[2] We categorize the financing choice with leverage below 1% as all-equity financing.

Chapter 3: Empirical Analysis). In the "instrument" column, "All-equity" signifies that the

Table 2: Comparative Statics for Optimal Capital Structure and Debt Maturity with Changing Drifts

Initial asset value is normalized to 100, initial investment is 90, risk free rate is 0.06, payout ratio is 0.05, asset volatility is 0.3, manager's discount rate is 0.3. If the optimal maturity approaches infinity, we indicate it as a "Consol" bond.

| Drift	Maturity	Coupon	Instrument	Debt Prop.	Yield Spread
0.01	N/A	N/A	All-equity	0.00	N/A
0.02	N/A	N/A	All-equity	0.00	N/A
0.03	N/A	N/A	All-equity	0.00	N/A
0.04	N/A	N/A	All-equity	0.00	N/A
0.05	N/A	N/A	All-equity	0.00	N/A
0.06	N/A	N/A	All-equity	0.00	N/A
0.07	N/A	N/A	All-equity	0.00	N/A
0.08	N/A	N/A	All-equity	0.00	N/A
0.09	N/A	N/A	All-equity	0.00	N/A
0.10	N/A	N/A	All-equity	0.00	N/A
0.11	16.67	0.43	Both	0.07	0.08%
0.12	9.09	0.92	Both	0.15	0.15%
0.13	6.67	1.44	Both	0.23	0.25%
0.14	5.26	1.98	Both	0.31	0.37%
0.15	4.35	2.55	Both	0.39	0.55%
0.16	4.00	3.20	All-debt	0.47	0.82%
0.17	3.70	3.95	All-debt	0.55	1.19%
0.18	3.85	5.00	All-debt	0.64	1.81%
0.19	4.35	6.50	All-debt	0.74	2.78%
0.20	9.09	9.03	All-debt	0.87	4.38%
0.21	16.67	9.51	All-debt	0.90	4.57%
0.22	20.00	9.43	All-debt	0.90	4.47%
0.23	25.00	9.34	All-debt	0.90	4.38%
0.24	consol	9.24	All-debt	0.90	4.27%
0.25	consol	9.14	All-debt	0.90	4.16%
0.26	consol	9.03	All-debt	0.90	4.03%
0.27	consol	9.03	All-debt	0.90	4.03%
0.28	consol	9.03	All-debt	0.90	4.03%
0.29	consol	9.03	All-debt	0.90	4.03%
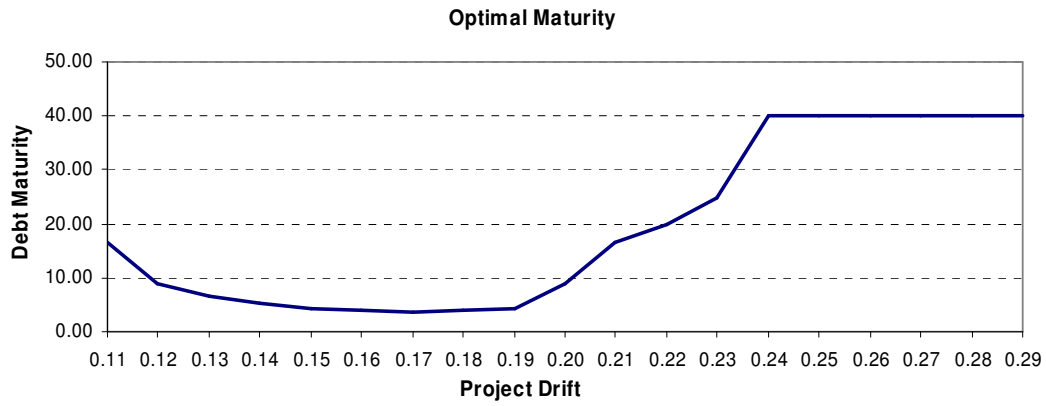
Figure 2: Optimal Leverage with Changing Project Drifts
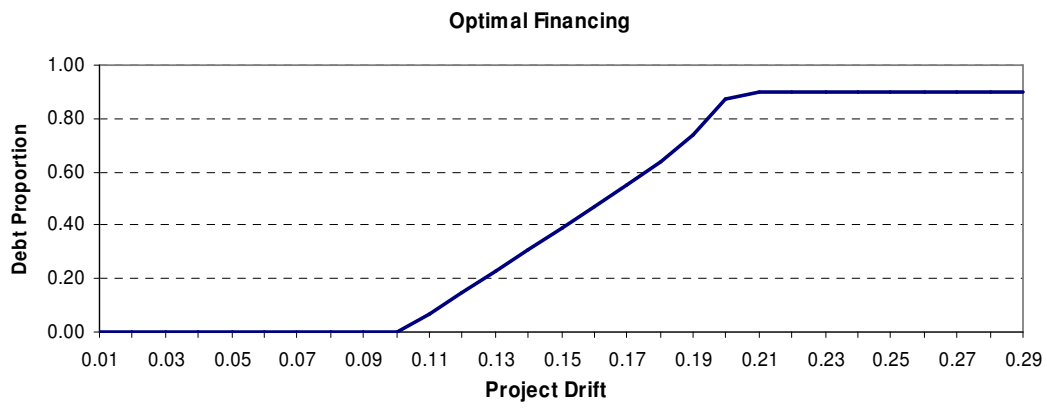
Figure 3: Optimal Maturity with Changing Project Drifts
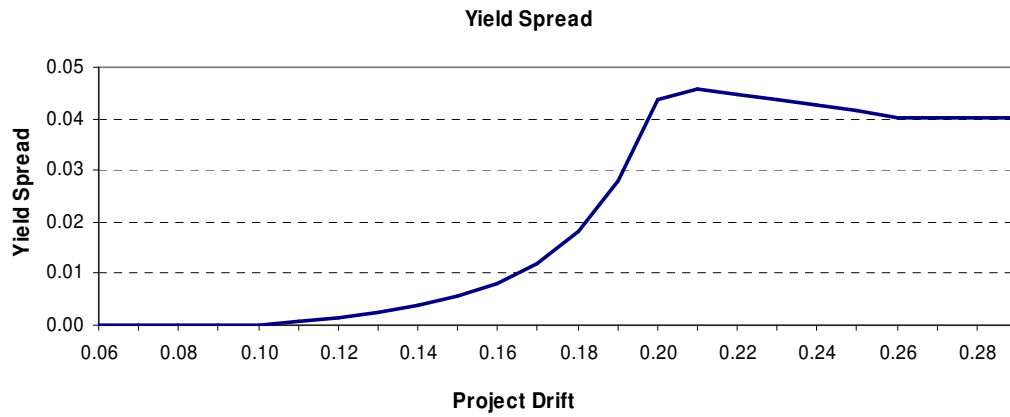
Figure 4: Yield Spreads with Changing Project Drifts

Parameters: V_0=100, I=90, r=0.06, δ=0.05, σ=0.3, β=0.3

manager chooses to finance the project entirely with equity; "All-debt" means that the optimal choice is all-debt financing; and "both" means that both debt and equity are issued. If the debt maturity exceeds 40 years, it is classified as a "Consol" bond.

Variation of Leverage with Drift

From Table 2, we see that the manager chooses all-equity financing for $\mu < 0.11$, issues debt and equity for $\mu \in [0.11, 0.15]$, and chooses all-debt financing for $\mu > 0.15$. All our simulations with differing choices of parameter values (not reported for brevity) lead to similar qualitative results; that is, there exist two trigger levels of the project drift such that the manager chooses all-equity financing below the lower trigger, all-debt financing above the higher trigger, and a combination of debt and equity between the triggers.

The intuition underlying these results is based on five important observations.

1. Since the initial market value $V(0)$ of the project and its NPV $V(0) - I$ are fixed, it follows from (6) that the manager's equity stake increases with the amount of money P raised through debt financing (recall that debt is initially issued at par so that P is also the debt principal).

2. In our "perfect information" world with rational expectations, the amount of money raised through debt financing equals the market value of debt at date zero.

3. By the theory of contingent claims valuation, the market value of debt is the discounted risk-neutral expectation of cash flows to bondholders where the discounting is at the risk-free rate. It follows from (14) and (15) that, for a given debt structure (P, C, m) does not depend on the parameter μ.

4. Further, by (14), (19), (20), (21), the bankruptcy level for a given debt structure (P, C, m) also does not depend on the parameter μ. Since the bankruptcy level

does not depend on μ, it follows from (5) that the probability of bankruptcy decreases with μ.

5. For a given debt structure (P, C, m) it follows from (5), (6), (22), and (23), that the *utility-maximizing* manager's discounted expected utility increases with μ, that is, her *subjective valuation* of the firm increases with μ.

The manager's optimal choice of capital structure trades off the beneficial effect of raising the level of debt through the increase in her equity stake with the detrimental effect of increasing the probability of bankruptcy. If the project drift is below a threshold, the manager resorts to all-equity financing due to the very high probability of bankruptcy with any nonzero level of debt. As the project drift increases and the probability of future bankruptcy declines, however, the manager issues more debt so that she can increase her equity stake in the firm thereby increasing her expected utility. Beyond a threshold value of the project drift, the manager resorts to all-debt financing so that her equity stake in the firm is maximized.

Variation of Debt Maturity with Drift

Next, we examine the variation of debt maturity with project drift. From Table 2, we see that debt maturity declines with the project drift when it is less than 0.11 and increases with the project drift when it exceeds 0.11. These results, which are qualitatively robust for different choices of underlying parameter values, suggest that debt maturity varies in a *non-monotonic U-shape* manner with the project drift.

The intuition for these results hinges on the fact that shorter maturity debt has two opposing effects on the manager's discounted expected utility, *ceteris paribus*. On the one hand, the manager may refinance the firm's debt at more favorable terms if future realizations of the firm value are high (recall that new debt is issued at its market value

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and that the market value of the firm's debt depends on the *current* firm value V, its *risk-neutral drift* $r - \delta$ and volatility σ). On the other hand, for the same leverage level, shorter maturity debt increases the probability of bankruptcy in the near term since principal and interest payments are larger. For lower values of the project drift where the manager chooses nonzero leverage, the second effect predominates so that the manager issues longer maturity debt. As the project drift increases, the probability that the manager can refinance the debt at more favorable terms due to good project realization increases so that the debt maturity declines. However, as the project drift further increases, the leverage increases substantially as well, thereby increasing the probability of bankruptcy, *ceteris paribus*. Beyond a threshold value of the drift, the manager, therefore, chooses longer-maturity debt.

Our results regarding the variation of debt maturity for lower values of the project drift are generally consistent with existing empirical evidence that debt maturity declines as project quality improves (see for example, Barclay and Smith(1995), Stohs and Mauer (1996), etc.). In addition, our results reconcile several other empirical findings that are not completely consistent with predictions of earlier models such as Flannery (1986) and Diamond (1991). Guedes and Opler (1996) find that "fully 99 percent of debt issues with a term to maturity of 30 years or more are made by investment grade firms". They also find that investment grade firms are more likely to issue *long-term* debt. Our results also shed light on the findings of Mitchell (1991, 1993) who documents a negative relation between the odds of issuing short-term debt and *ex post* project quality. She measures ex post project quality using the variable 'NOIG', the two-year change in annual net operating income measured from the year before the bond issue to the year following the issue and normalized by annual sales. These findings are not consistent with Diamond's

(1991) prediction that high quality firms issue short-term debt. Furthermore, Guedes and Opler (1996) do not find substantial variation by maturity in pre-issue and post-issue stock returns and conclude that "it appears difficult to argue that the debt maturity choice is primarily driven by exploitation of information asymmetry or by signaling." The positive implications of our "perfect information" framework suggest that information asymmetries may not play an important role in debt maturity choices.

Our predictions that, beyond a threshold value of the project drift, leverage as well as debt maturity increase monotonically are also consistent with the findings of Barclay and Smith (1995), Stohs and Mauer(1996), and Johnson (2003). Barclay and Smith (1995) and Stohs and Mauer (1996) document that firms with longer maturity debt also have higher leverage levels. Johnson (2003) documents that the proportion of short maturity debt decreases as firms' leverage increases.

The variations of leverage and debt maturity with the expected growth of firm value are, to the best of our knowledge, *novel* predictions of our theory. As the market values of the firm and equity depend on the risk-neutral drift of firm value, and not its actual drift, these predictions cannot be obtained in traditional contingent claims models where financing choices are made by *diversified value-maximizing* shareholders a(for example, Fischer et al 1989, Leland and Toft 1996). In our empirical analysis in Chapter 3, we find significant support for these predictions of our theory.

Variation of Yield Spreads with Drift

Finally, Table 2 shows that our model generates significant yield spreads. The yield spread generally increases with the leverage level. Compared to some traditional contingent claim models (see Merton(1974), Longstaff and Schwartz(1995), Leland and

Toft(1996), Leland(1998)), the predicted yield spreads, with range from 8 bps to nearly 457 bps, are broadly in line with those observed in reality.

Broadly, our results and the intuition underlying them emphasize the important role played by the fact that financing choices are made by an owner-manager with a *long-term* objective function, that is, her leverage and debt maturity choices rationally incorporate their effect on her stream of future payoffs. Our results regarding the variation of leverage and debt maturity with project drift help to reconcile several empirical findings that are not completely consistent with earlier theories of debt maturity.

2.4.2 Comparative Statics with Volatility

Next, we examine the variation of leverage and debt maturity with the firm volatility σ. Table 3 reports the optimal debt maturity and leverage with volatility σ ranging from 0.2 to 0.55, which are (roughly) the 12.5 and 87.5 percentiles of the sample distribution of volatilities from the data for our subsequent empirical analysis (see chapter 3, Table 6 and 9).

From the Table 3, we see that, the manager's choice of leverage decreases monotonically with the project (firm) volatility. The intuition for these results is that, as the project volatility increases, *ceteris paribus*, the higher probability of bankruptcy leads the manager to choose lower leverage levels. These results are consistent with the findings of a number of empirical studies that document a negative relationship between leverage and the firm risk (Bradley et al 1984, Friend and Hasbrouck 1988, and Friend and Lang 1988).

Table 3 also demonstrates that debt maturity declines monotonically with the project volatility in the range where the manager issues debt. Higher volatility increases

Table 3: Comparative Statics for Optimal Capital Structure and Debt Maturity with Changing Volatilities

Initial asset value is normalized to 100, initial investment is 90, risk free rate is 0.06, payout ratio is 0.05, asset drift is 0.15, manager's discount rate is 0.3. If the optimal maturity approaches infinity, we indicate it as a "Consol" bond.

Volatility	Maturity	Coupon	Instrument	Debt Prop.	Yield Spread
0.20	7.69	4.74	Both	0.69	0.87%
0.21	7.14	4.52	Both	0.66	0.85%
0.22	6.67	4.21	Both	0.62	0.78%
0.23	6.25	3.99	Both	0.59	0.76%
0.24	5.88	3.77	Both	0.56	0.73%
0.25	5.56	3.55	Both	0.53	0.70%
0.26	5.26	3.33	Both	0.50	0.67%
0.27	5.00	3.12	Both	0.47	0.63%
0.28	4.76	2.90	Both	0.44	0.59%
0.29	4.55	2.69	Both	0.41	0.56%
0.30	4.35	2.55	Both	0.39	0.55%
0.31	4.35	2.42	Both	0.37	0.55%
0.32	4.17	2.21	Both	0.34	0.50%
0.33	4.00	2.07	Both	0.32	0.48%
0.34	4.00	1.94	Both	0.30	0.48%
0.35	3.85	1.81	Both	0.28	0.45%
0.36	3.70	1.74	Both	0.27	0.46%
0.37	3.70	1.61	Both	0.25	0.45%
0.38	3.57	1.48	Both	0.23	0.42%
0.39	3.45	1.41	Both	0.22	0.42%
0.40	3.45	1.28	Both	0.20	0.39%
0.41	3.33	1.21	Both	0.19	0.39%
0.42	3.23	1.15	Both	0.18	0.39%
0.43	3.23	1.09	Both	0.17	0.39%
0.44	3.23	0.95	Both	0.15	0.36%
0.45	3.13	0.89	Both	0.14	0.34%
0.46	3.13	0.82	Both	0.13	0.34%
0.47	3.03	0.76	Both	0.12	0.33%
0.48	2.94	0.76	Both	0.12	0.35%
0.49	2.94	0.70	Both	0.11	0.34%
0.50	2.86	0.63	Both	0.10	0.32%
0.51	2.86	0.57	Both	0.09	0.30%
0.52	2.86	0.50	Both	0.08	0.29%
0.53	2.78	0.50	Both	0.08	0.31%
0.54	2.78	0.44	Both	0.07	0.28%
0.55	2.63	0.44	Both	0.07	0.29%
0.56	2.70	0.38	Both	0.06	0.27%
0.57	2.56	0.38	Both	0.06	0.28%

Optimal Financing
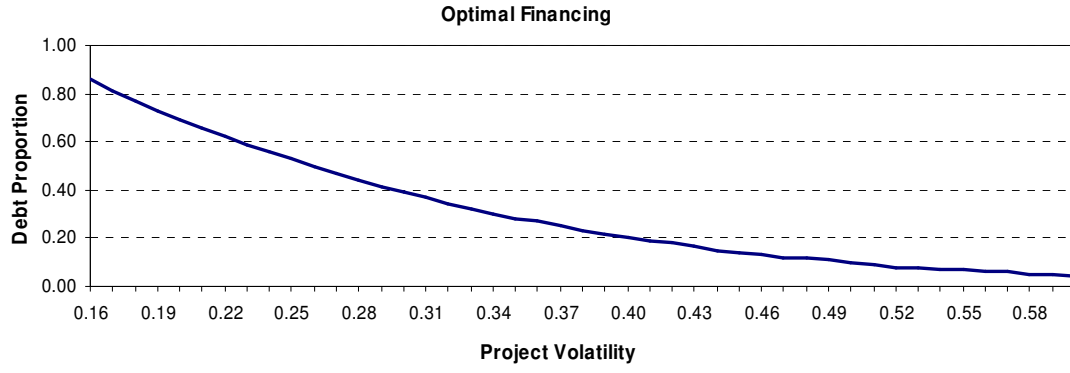
Figure 5: Optimal Leverage with Changing Project Volatilities
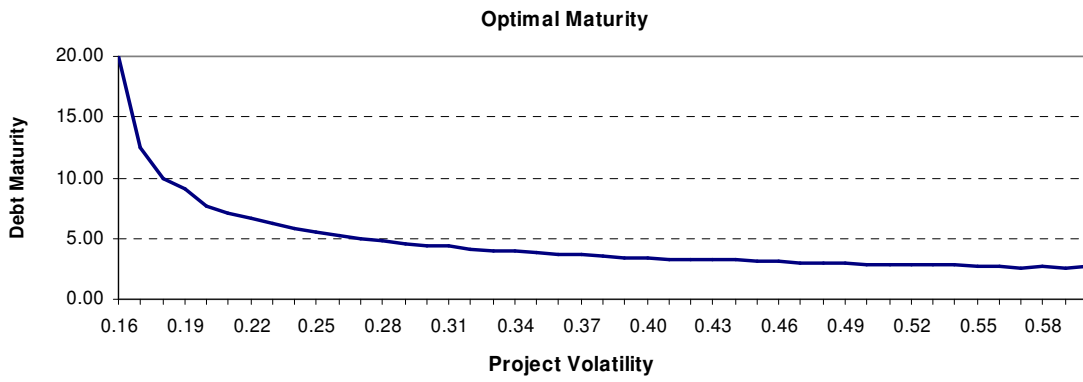
Optimal Maturity

Figure 6: Optimal Maturity with Changing Project Volatilities
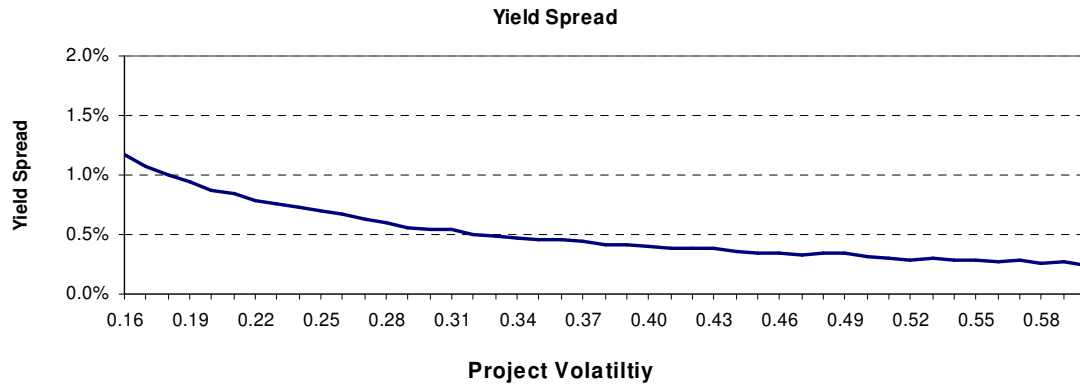
Yield Spread

Figure 7: Yield Spreads with Changing Project Volatilities

Parameters: V_0=100, I=90, r=0.06, δ=0.05, μ=0.15, β=0.3

the probability of refinancing the firm's debt at more favorable terms in the future due to high project value realizations. As project volatility increases, the decline of the firm's leverage implies that the relative benefits of future favorable refinancing outweigh the costs from the increased possibility of financial distress under short-term financing. Therefore we observe that the debt maturity declines as the project volatility increases. This prediction is consistent with the findings of Stohs and Mauer (1996) who document a significant negative relation between debt maturity and earnings variability. In Chapter 3: Empirical Analysis, we document significant empirical support for the predictions of our model regarding the variations of leverage and debt maturity with volatility.

From Table 3, we see that the yield spread generally decreases with the debt maturity (and leverage). These predictions are consistent with the findings of Mitchell (1993) who documents a *negative* relationship between debt maturity and credit spreads.

Table 4 demonstrates the variation of debt maturity, coupon rate and leverage with drift and volatility in a panel form. The chosen values for the other parameters are r=0.06, δ=0.05 and β=0.3. We display the results for volatilities equal to 0.25 and 0.35. We can see that the pattern in Table 4 is qualitatively identical to Table 2. Table 5 demonstrates the effect of changing project volatility with different drift on the optimal debt maturity, coupon rate and optimal leverage in a panel form. Similarly, we choose to present the cases with drifts equal 0.12, 0.18, which are approximately the mean and median drifts of our empirical samples. The results with other parameters exhibit a similar pattern. If the project drift is sufficiently high, the manager prefers all-debt financing when the volatility is below a threshold. For example, in the case of μ=0.18, the manager chooses all-debt when σ is below 0.23. It is not surprising to observe that the

Table 4: Comparative Statics for Optimal Capital Structure and Debt Maturity
with Changing Drifts and Different Volatilities

Initial asset value is normalized to 100, initial investment is 90, risk free rate is 0.06, payout ratio is 0.05, managerial discount rate is 0.3. If the optimal maturity approaches infinity, we indicate it as a "Consol" bond.

Drift	Volatility 0.25			Volatility 0.35		
	Maturity	Coupon	Debt Prop.	Maturity	Coupon	Debt Prop.
0.01	N/A	N/A	0.00	N/A	N/A	0.00
0.02	N/A	N/A	0.00	N/A	N/A	0.00
0.03	N/A	N/A	0.00	N/A	N/A	0.00
0.04	N/A	N/A	0.00	N/A	N/A	0.00
0.05	N/A	N/A	0.00	N/A	N/A	0.00
0.06	N/A	N/A	0.00	N/A	N/A	0.00
0.07	N/A	N/A	0.00	N/A	N/A	0.00
0.08	N/A	N/A	0.00	N/A	N/A	0.00
0.09	N/A	N/A	0.00	N/A	N/A	0.00
0.10	N/A	N/A	0.00	N/A	N/A	0.00
0.11	20.00	0.79	0.13	14.29	0.18	0.03
0.12	11.11	1.48	0.24	7.69	0.55	0.09
0.13	7.69	2.13	0.34	5.56	0.93	0.15
0.14	6.25	2.84	0.44	4.55	1.39	0.22
0.15	5.56	3.55	0.53	3.85	1.81	0.28
0.16	5.00	4.28	0.61	3.45	2.33	0.35
0.17	5.26	5.41	0.71	3.13	3.00	0.43
0.18	7.14	6.88	0.81	2.94	3.79	0.51
0.19	16.67	8.41	0.90	2.94	4.76	0.59
0.20	14.29	8.46	0.90	3.33	6.52	0.70
0.21	14.29	8.46	0.90	5.26	9.10	0.82
0.22	14.29	8.46	0.90	16.67	10.74	0.90
0.23	16.67	8.41	0.90	25.00	10.52	0.90
0.24	16.67	8.41	0.90	consol	10.28	0.90
0.25	20.00	8.34	0.90	consol	10.14	0.90
0.26	25.00	8.28	0.90	consol	10.14	0.90
0.27	25.00	8.28	0.90	consol	10.14	0.90
0.28	33.33	8.20	0.90	consol	10.14	0.90
0.29	consol	8.12	0.90	consol	10.14	0.90
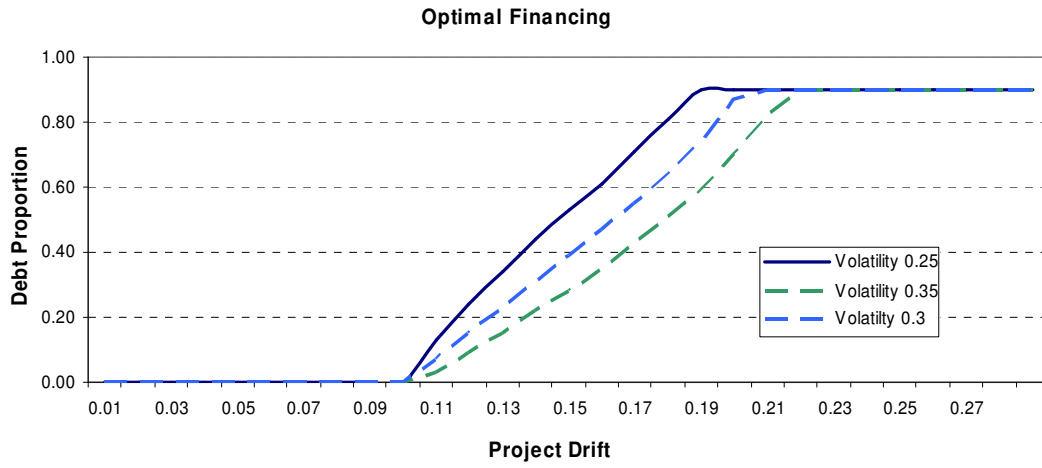
Optimal Financing

Figure 8: Optimal Leverage with Changing Project Drifts
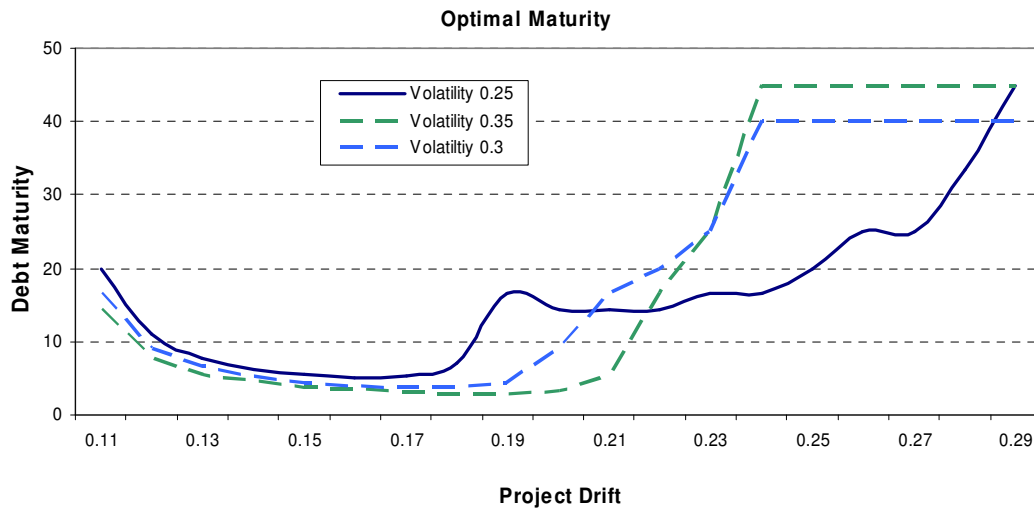
Optimal Maturity

Figure 9: Optimal Maturity with Changing Project Drifts

Parameters: V_0=100, I=90, r=0.06, δ=0.05, β=0.3

range of drifts for all-debt financing is larger when the project volatility is lower. The uncertainty associated with higher volatility deters the manager from choosing high leverage for a wider range of project drifts.

The results of Tables 2-5 clearly demonstrate the significant impact of the project's actual drift or expected growth rate on the manager's financing choices. As mentioned earlier, this feature of our framework differs significantly from traditional "contingent claims" models that assume that the manager behaves in the interests of *market value maximizing* (original or current) shareholders (for example, Merton 1973, Fischer et al 1989, Leland 1994). In these models, financing choices only depend on the risk-neutral drift of the project. Hence, the fact that the utility-maximizing owner-manager makes financing choices in our model allows us to understand a large number of empirical findings regarding the relationships between leverage, debt maturity, and *ex post* project quality that depends on the drift or *growth* of firm value as well as its volatility.

2.4.3 Comparative Statics with Respect to the Manager's Discount Rate β

Figure 12-14 reports the comparative statics of the manager's subjective discount rate or "degree of myopia". Since a manager's "degree of myopia" is unobservable, it is difficult to compare these results with empirical findings. Our results, however, are consistent with intuitive arguments. From Figure 12, we see that the manager's choice of leverage declines monotonically with her discount rate, *ceteris paribus*. When the manager's discount rate is smaller than 0.21, the manager prefers all debt financing. When the discount rate is greater than 0.21, she chooses both debt and equity financing. Intuitively, a more myopic manager with a higher subjective discount rate behaves more conservatively in her financing decisions.

Table 5: Comparative Statics for Optimal Capital Structure and Debt Maturity with Changing Volatilities and Different Drifts

Initial asset value is normalized to 100, initial investment is 90, risk free rate is 0.06, payout ratio is 0.05, managerial discount rate is 0.3. If the optimal maturity approaches infinity, we indicate it as a "Consol" bond.

Volatility	Drift 0.12			Drift 0.18		
	Maturity	Coupon	Debt Prop.	Maturity	Coupon	Debt Prop.
0.20	12.50	2.16	0.35	16.67	7.43	0.90
0.21	12.50	1.98	0.32	16.67	7.61	0.90
0.22	12.50	1.79	0.29	20.00	7.75	0.90
0.23	11.11	1.67	0.27	16.67	7.80	0.89
0.24	11.11	1.48	0.24	10.00	7.36	0.85
0.25	10.00	1.35	0.22	7.14	6.88	0.81
0.26	10.00	1.23	0.20	5.88	6.40	0.77
0.27	10.00	1.11	0.18	5.00	6.07	0.74
0.28	9.09	1.05	0.17	4.55	5.61	0.70
0.29	9.09	0.92	0.15	4.17	5.30	0.67
0.30	8.33	0.86	0.14	3.85	5.00	0.64
0.31	8.33	0.80	0.13	3.57	4.70	0.61
0.32	8.33	0.68	0.11	3.33	4.41	0.58
0.33	7.69	0.61	0.10	3.23	4.24	0.56
0.34	7.69	0.55	0.09	3.03	3.96	0.53
0.35	7.69	0.49	0.08	2.94	3.79	0.51
0.36	7.14	0.49	0.08	2.86	3.52	0.48
0.37	7.14	0.43	0.07	2.70	3.35	0.46
0.38	7.14	0.37	0.06	2.63	3.19	0.44
0.39	7.14	0.31	0.05	2.56	3.03	0.42
0.40	6.67	0.31	0.05	2.50	2.87	0.40
0.41	6.67	0.24	0.04	2.44	2.71	0.38
0.42	6.25	0.24	0.04	2.38	2.55	0.36
0.43	6.67	0.18	0.03	2.33	2.39	0.34
0.44	6.25	0.18	0.03	2.27	2.24	0.32
0.45	5.88	0.18	0.03	2.22	2.17	0.31
0.46	6.67	0.12	0.02	2.17	2.01	0.29
0.47	6.25	0.12	0.02	2.13	1.86	0.27
0.48	5.88	0.12	0.02	2.08	1.79	0.26
0.49	5.56	0.12	0.02	2.04	1.72	0.25
0.50	5.26	0.12	0.02	2.04	1.57	0.23
0.51	6.25	0.06	0.01	2.00	1.50	0.22
0.52	5.88	0.06	0.01	1.96	1.43	0.21
0.53	5.56	0.06	0.01	1.92	1.36	0.20
0.54	5.26	0.06	0.01	1.89	1.28	0.19
0.55	5.26	0.05	0.01	1.85	1.21	0.18
0.56	5.26	0.04	0.01	1.82	1.14	0.17
0.57	5.26	0.04	0.01	1.82	1.07	0.16

Optimal Financing
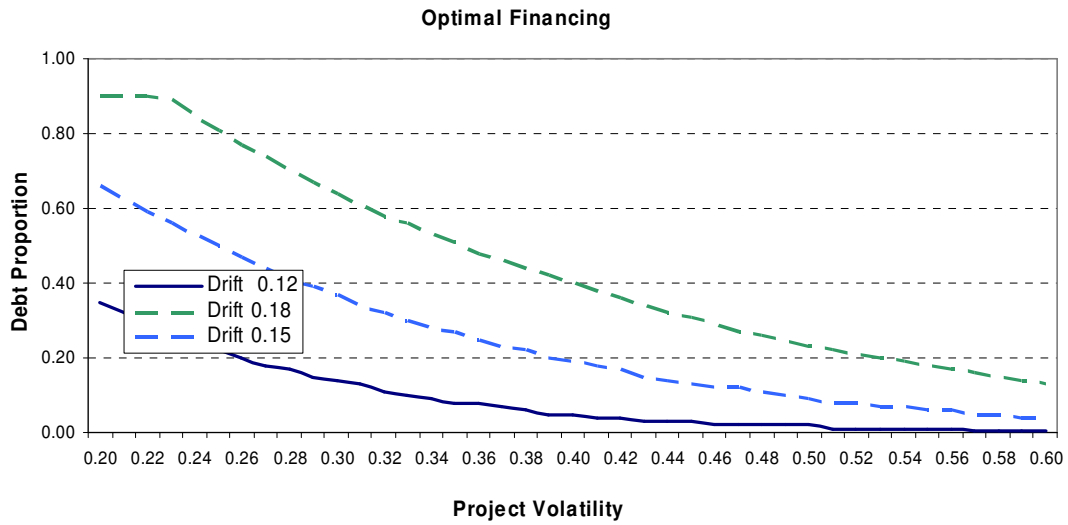
Figure 10: Optimal Leverage with Changing Project Volatilities
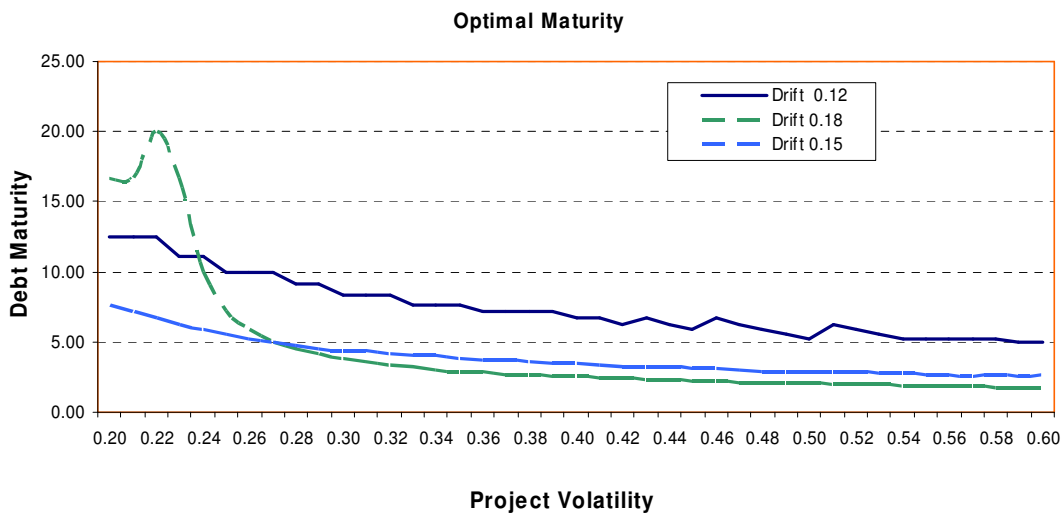
Optimal Maturity

Figure 11: Optimal Leverage with Changing Project Volatilities

Parameters: V_0=100, I=90, r=0.06, δ=0.05, β=0.3

2.4.4 Comparative Statics with Respect to Payout Ratio δ

Figure 15-17 reports the comparative statics with regard to the payout ratio δ. The manager's choice of leverage increases monotonically with the payout ratio, *ceteris paribus*. The intuition for these results is that, as the payout ratio increases, the total payout to all claimants, including the manager, increases. Therefore, for the same leverage level, the manager's discounted expected utility increases. The effect of the manager's personal costs due to bankruptcy, therefore, declines so that the manager is more willing to take on higher levels of debt.

2.4.5 Comparative Statics with Respect to Risk Free Rate R

Figure 18-20 shows the comparative statics with respect to the risk free rate R. The risk free rate ranges from 1% to 8% with a step of a quarter of percent. As anticipated, we see that debt financing is preferred when the risk free rate is low and equity financing is preferred when the risk free rate is high. If R is high, the cost of debt financing is high, *ceteris paribus,* hence the manager prefers equity. If R is low, *ceteris paribus*, low cost of debt induces the manager to issue debt for financing.

2.5. Conclusions

In this chapter, we develop a continuous-time "perfect information" model to examine financing and debt maturity choices by an undiversified, utility-maximizing owner-manager. We differ significantly from traditional "contingent claim" models of capital structure where financing decisions are made by diversified, value-maximizing (original or current) shareholders. In a perfectly competitive market for capital provision by outside investors, the owner-manager receives the surplus from the firm's operations. The manager chooses the firm's capital structure to maximize the discounted expected

Optimal Financing
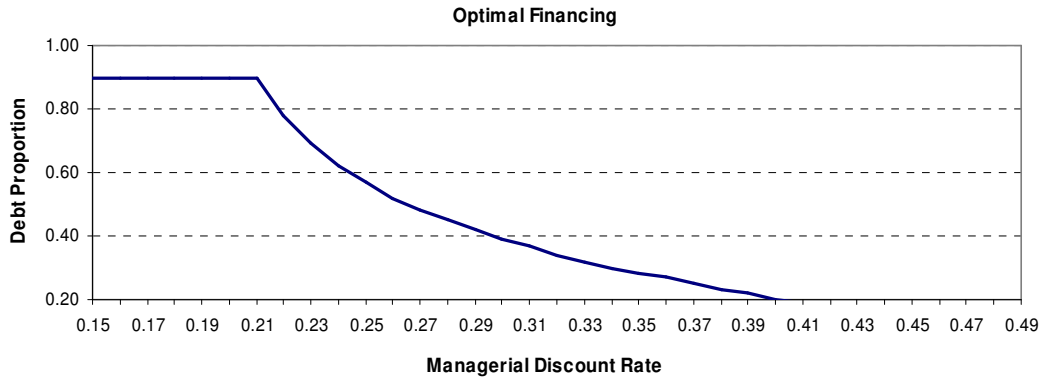
Figure 12: Optimal Leverage with Changing Managerial Discount Rate
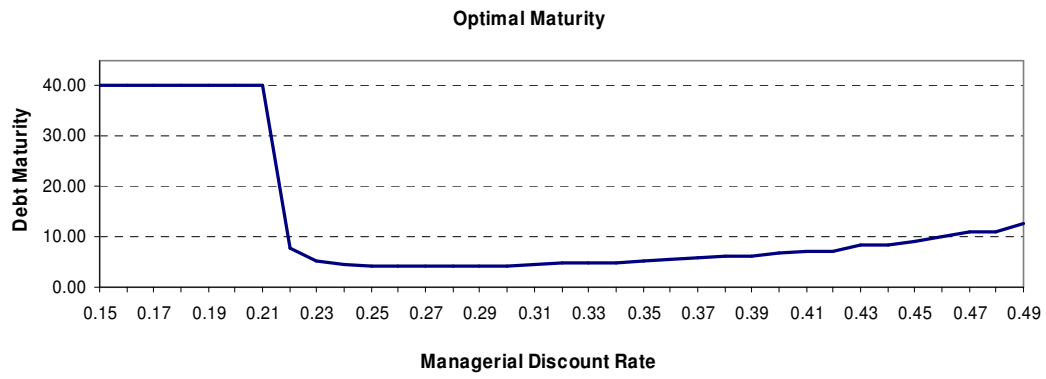
Optimal Maturity

Figure 13: Optimal Maturity with Changing Managerial Discount Rate
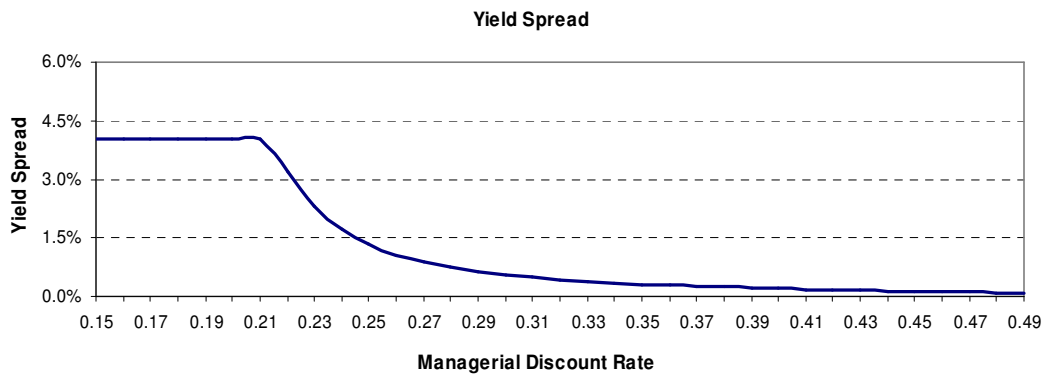
Yield Spread

Figure 14: Yield Spread with Changing Managerial Discount Rate

Parameters: $V_0=100$, I=90, r=0.06, $\delta=0.05$, $\mu=0.15$, $\sigma=0.3$

Optimal Financing
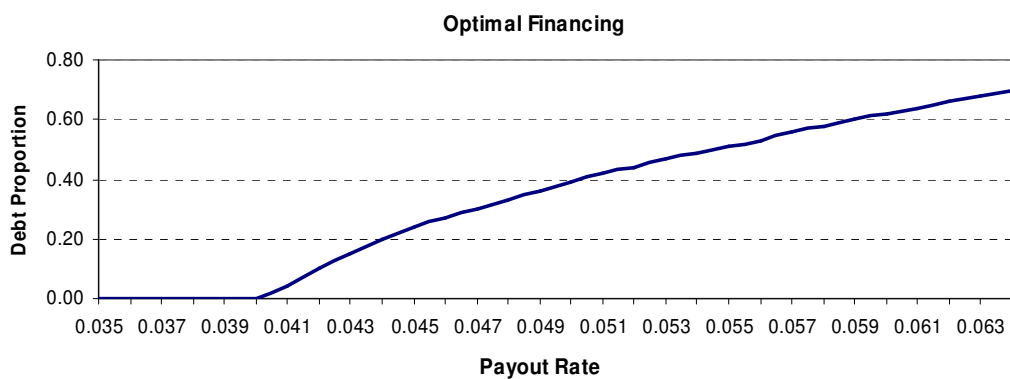
Figure 15: Optimal Leverage with Changing Payout Ratio
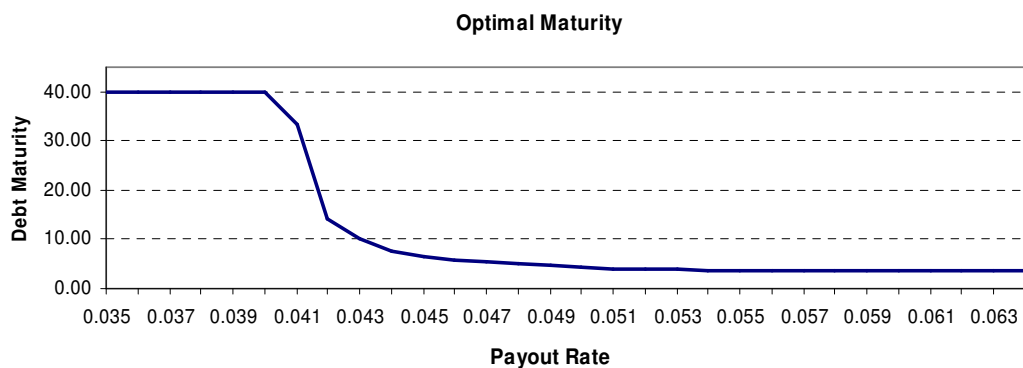
Optimal Maturity

Figure 16: Optimal Maturity with Changing Payout Ratio
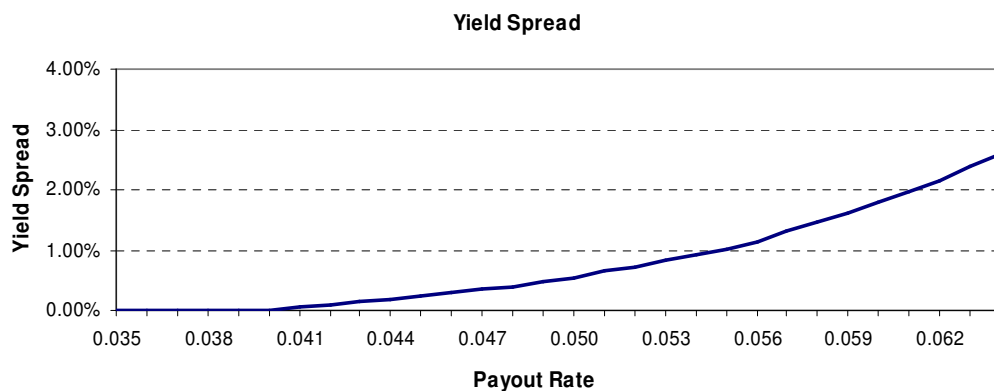
Yield Spread

Figure 17: Yield Spread with Changing Payout Ratio

Parameters: $V_0=100$, $I=90$, $r=0.06$, $\beta=0.3$, $\mu=0.15$, $\sigma=0.3$

Optimal Financing
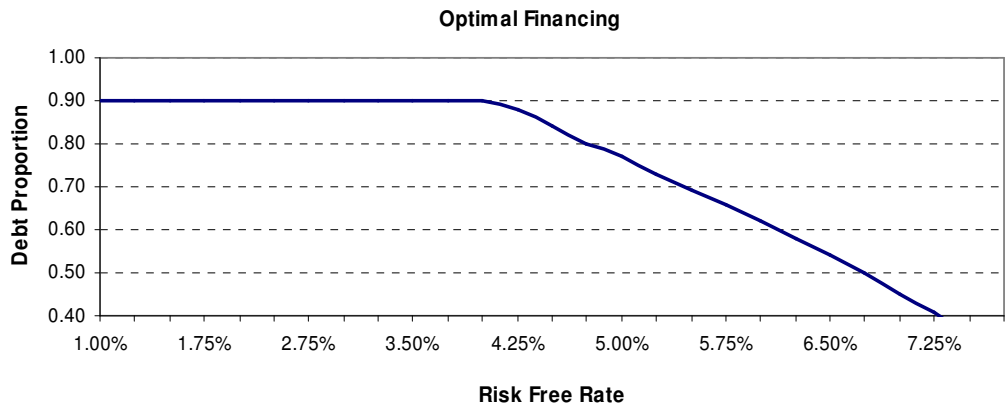
Figure 18: Optimal Leverage with Changing Risk Free Rate
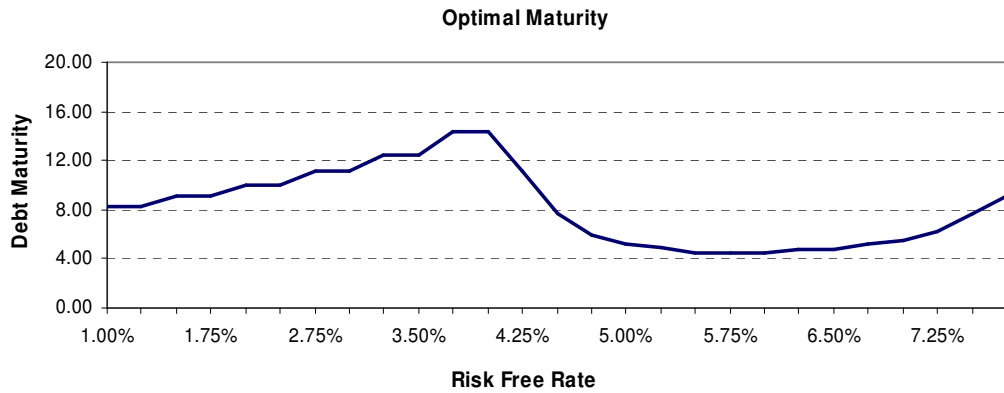
Optimal Maturity

Figure 19: Optimal Maturity with Changing Risk Free Rate
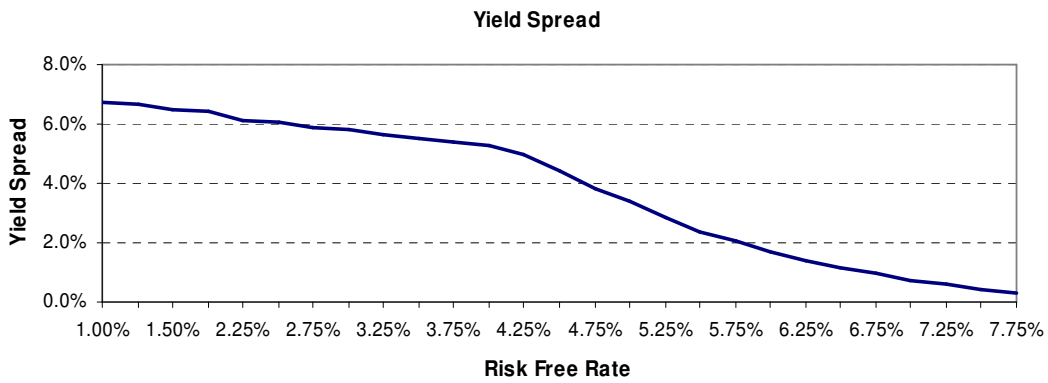
Yield Spread

Figure 20: Yield Spread with Changing Risk Free Rate

Parameters: V_0=100, I=90, β=0.3, μ=0.15, σ=0.3

utility she derives from her entire stream of future cash flows. We numerically derive the manager's optimal financing policy and examine the comparative static relationships between the firm's leverage, debt maturity, and credit spreads with underlying project characteristics.

We show that leverage increases (decreases) monotonically with the project's drift (volatility). In general, there exist two trigger levels of the project's drift (volatility) such the manager chooses all-equity (all-debt) financing below the lower trigger and all-debt (all-equity) financing above the higher trigger. Between the triggers, the firm's capital structure reflects a nonzero proportion of debt and equity. In the region where the manager chooses nonzero debt financing, debt maturity declines monotonically with project volatility, but varies in a non-monotonic manner with the project's drift. The manager's choice of leverage decreases monotonically with her subjective discount rate or "degree of myopia" and increases monotonically with the project's payout ratio. For reasonable parameter values, the credit spreads on corporate debt predicted by our model are significantly higher than those predicted by traditional structural models that do not incorporate manager-firm agency conflicts, and closer to those observed in reality.

Our results help to reconcile several empirical findings that are not consistent with earlier models of capital structure and debt maturity. However, the dynamics of leverage, debt maturity, and credit spreads predicted by our analysis suggest that more complex functional specifications are probably necessary to empirically estimate the relationships between variables. Further, the fact that these variables are endogenously determined suggests that a structural approach may be required to examine their relationships.

CHAPTER III
EMPIRICAL ANALYSIS

3.1 Introduction

In the previous chapter, we develop a unified theoretical framework to examine the impact of managerial discretion on firms' financing and debt maturity choices. Since leverage and debt maturity decisions are made by an undiversified, *utility-maximizing* owner-manager rather than *market value maximizing* shareholders, our model leads to novel implications for the relationships between firms' financing and debt maturity choices and the drift and volatility of their asset values. We predict a positive relationship between leverage and the drift or *ex post* expected growth of firm value, and a negative relationship between leverage and the volatility of firm value. Debt maturity varies in a U-shaped manner with the drift of firm value, and declines with the volatility of firm value. In this chapter, we empirically examine the relationships between firms' financing and debt maturity choices, and the expected growth rates and volatilities of their asset values. We document significant empirical support for our theoretical predictions regarding these relationships.

The data for our tests are obtained from the CRSP, COMPUSTAT and FISD databases. We use financial reporting data from the COMPUSTAT database to examine firms' financing choices. We collect firms' net equity and debt issuance data from cash flow statements to calculate the amount of debt financing as a proportion of total external financing. We construct monthly time series of firms' market asset values using stock return data from CRSP and COMPUSTAT balance sheet data, and estimate the volatility of firm's value directly from the monthly time series of asset value. Direct estimation of drifts of diffusion process proves to be econometrically extremely challenging and

existing time series of financial data appear not long enough to yield reliable estimations.[3] Instead, we first estimate firms' equity betas from daily stock returns from CRSP. We then calculate firms' asset betas and use CAPM to calculate the *ex ante* expected return of firms' total asset. For the tests on debt maturity, we obtain data on the maturity structure of publicly issued debt from the FISD database. In addition, we also include control variables that are found to be significant determinants in financing and debt maturity choices from previous empirical studies. Most of these variables are collected from the COMPUSTAT database.

Our model predicts a positive relationship between leverage and the drift or expected *ex post* growth rate of firm value, and a negative relationship between leverage and the volatility of firm value. We empirically examine the relationships between firms' financing of *incremental new* investments, and the expected growth rates and volatilities of their asset values. By using Tobit analysis, we find that the relation between the proportion of debt financing of incremental investments and the *ex post* expected growth rate of firm value is positive and significant, and that the relation between the proportion of debt financing and the *ex post* volatility of firm value is negative and significant. In all our tests, we control for the variables that have been identified by previous literature as significant determinants of financing choices. In particular, as predicted by our theory, leverage varies significantly with the expected ex post growth rate of firm value after *controlling* for the market-to-book ratio, a widely used proxy for firm's growth opportunity.

Next, we test our hypotheses regarding the relationships between firms' debt maturity choices and the expected *ex post* growth rate and volatility of firm values. In

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[3] Recent advances in estimating drifts of diffusion process with discrete time data, readers are referred to for example, Ait-Sahalia(2002).

our data sample obtained from the Fixed Investment Securities Database (FISD), we find that the expected growth rates of firm value primarily lie in the region where our theory predicts that debt maturity increases with drift. Using our data sample, therefore, we test the hypotheses that the relation between debt maturity and drift is positive, and the relation between debt maturity and volatility is negative. We perform the tests using both OLS and panel regressions. We include control variables that have been identified as important determinants of debt maturity such as taxes, existing leverage, the Book-to-Market ratio, asset tangibility, credit rating, profitability, asset maturity and firm size. Consistent with our hypotheses, we find a positive and significant relation between debt maturity and the *ex post* expect growth of firm value, and a negative relation between debt maturity and the *ex post* volatility of firm value controlling for all economic variables that have been identified by prior literature as important determinants of debt maturity.

We closely mirror our theoretical framework (and those of earlier theoretical studies) in our empirical analysis by examining how firms finance *incremental* investments (see also Mayer and Sussman 2004). Consistent with the findings of Frank and Goyal (2003) and Mayer and Sussman (2004), we document that equity financing is used more widely than previously thought.

Following Diamond's (1991) theoretical study of firms' debt maturity choices, several subsequent empirical studies document a non-monotonic relationship between a firm's credit rating and debt maturity. In Diamond's "pure debt financing" model, there is a one-one correspondence between a firm's credit rating, and the probability that it undertakes a positive NPV project. Moreover, in his framework, negative NPV projects are also necessarily riskier than positive NPV projects. In our dynamic framework where

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firms can choose both equity and debt financing, a firm's default risk (or credit rating) depends on the expected growth and volatility of firm value since they determine the *level* as well as the *maturity* of the firm's debt. We empirically examine the relationships between a firm's debt maturity choices and the *drift* as well as the *volatility* of its value. Therefore, we disentangle the effects of drift and volatility on the quality of a firm's pool of projects instead of using a single, imperfect measure of firm quality such as its credit rating.

In summary, this is the first empirical study (to the best of our knowledge) to analyze the relationships between firms' financing and debt maturity choices and the ex post drift and volatility of their asset values. We document significant support for our theoretical predictions regarding these relationships.

3.2 Related Literature

A large part of empirical literature is devoted to explain the leverage of public-traded firms. In those studies, the dependent variable under scrutiny is the observed *level* of market leverage. However, many theoretical studies on corporate finance aim to explain *incremental* financing behavior for cash-constrained firms. Recently, a series of empirical papers are directed to examine firms' incremental financing choices, which we briefly review in the following.

Shyam-Sunder and Myers(1999) test pecking order theory by checking whether *changes* in debt are a linear function of the financing deficit. If firms follow the pecking order for their financing needs, a regression of the issuance of debt on financing deficit should have a significant coefficient of one. They document strong support for this prediction in a sample of 157 firms from 1971 to 1989. However, Chirinko and

Singha(2000) shows that this is neither a necessary nor a sufficient condition for the pecking order theory to be valid.

Frank and Goyal(2003) examine a much larger sample with 768 firms from 1971 to 1998. They show that net equity issues track the financing deficit more closely than do net debt issues and financing deficit is less important in explaining net debt issues over time for firms of all sizes. Mayer and Sussman(2004) use a filtering technique to identify large investment spikes. They find that the spikes are predominantly financed with debt by large firms and by new equity by small loss-making firms.

In the debt maturity literature, existing empirical evidence is inconclusive on Diamond's (1993) model prediction. Mitchell(1991)'s study shows that the odds of issuing short term debt is in a negative relation with the ex post project quality, which is inconsistent with Diamond's prediction. Mitchell (1993) also shows a positive relationship between debt maturity and credit quality using the same data source. This result suggests that low risk firms have longer maturities than high-risk firms, inconsistent with both Flannery's and Diamond's models. Barclay and Smith(1995)'s study indicates that lower-rated firms issue more long-term debt than higher-rated firms and that non-rated firms have more short-term debt. Their evidence suggests a nonmonotonic relation between credit rating and debt maturity as predicted by Diamond's model. Guedes and Opler(1996) examines the maturity of incremental debt issues rather than the maturity of all liabilities on a firm's balance sheet. Their main finding is that large firms with investment grade credit ratings typically borrow both very short term and long term debt, while firms with speculative grade credit ratings borrow medium term debt. They also find that smaller and riskier firms rarely issue short-term debt and never issue long-term debt. Stohs and Mauer(1996)'s paper tests the maturity

hypotheses by computing the weighted average maturity of a firm's liabilities including all debt, debt-like obligations and current liabilities. Their regression shows that firms with low-quality ratings tend to lengthen debt maturity structure, but that this trend diminishes as credit rating deteriorates, which is supportive of Diamond's prediction of nonmonotonic relation between bond rating and debt maturity.

Similarly, empirical research has not provided conclusive support on whether signaling and information asymmetries play a crucial role in determining debt maturity choices. Barclay and Smith(1995) investigate the relation between debt maturity and ex post abnormal earnings. The regression shows statistical significance but not economic significance. Stohs and Mauer(1996)'s study confirms Barclay and Smith(1995)'s finding that the economic significance of abnormal earnings is negligible: one standard deviation increase in abnormal earning reduces debt maturity structure by only 3.5%. Guedes and Opler (1996) find no substantial variation by maturity in pre-issue and post-issue stock returns. In contrast, Berger et al.(2003) use a unique set of data on bank loans and find that information asymmetries appear to affect firms' maturity choices of bank loans.

Barclay et al. (2003) argue that previous empirical studies on debt maturity suffer from the endogeneity arising from the joint determination of leverage and maturity. Johnson(2003) uses simultaneous equations approach to control for endogenous effects. He finds strong support for an economically significant attenuation effect of short debt maturity on leverage. Datta et al. (2005) document a significant and robust inverse relation between managerial ownership and corporate debt maturity, after controlling for previously identified determinants of debt maturity and modeling leverage and debt maturity as jointly endogenous. Both Johnson and Datta's paper use the proportion of short debt to proxy for firms' debt maturity.

3.3 Empirical Methodology

In the previous theory chapters, we presented a unified theory of the financing and debt maturity choices of a firm that is controlled by an undiversified utility-maximizing owner-manager. It would be ideal to test our model's implications using a single dataset that includes financing and debt maturity data. Because such a comprehensive database is not available, we use data from COMPUSTAT and CRSP to test our hypotheses regarding firms' financing choices. [4] We then use public debt maturity data from FISD (Fixed Investment Securities Data) to test our hypotheses regarding firms' debt maturity choices.

A number of recent studies were directed to investigate the managerial compensation and entrenchment with firms' financing and debt maturity policies. Berger et al (1997) show that leverage levels are lower when CEOs do not face pressure from either ownership and compensation incentives or active monitoring. Datta et al (2005) show that managerial stock ownership plays an important role in determining corporate debt maturity. They document a significant and robust inverse relation between managerial stock ownership and corporate debt maturity. These studies empirically establish a direct link between managerial compensation and firms' financing and debt maturity choices, and confirm that managerial incentives are significant determinants in shaping corporate financing policies. Our theoretical model in investigating the impact of managerial incentives on corporate financing policy is partly motivated by these robust empirical findings. However, in our empirical investigations, we focus on testing the relationship between observable firms' characteristics and their financing policies.

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[4] COMPUSTAT reports the amount of debt maturing within 2, 3, 4 and 5 years for some firms. However, these data are not very helpful to construct the average debt maturity a firm issues in a given year.

Therefore, our study adds another dimension, namely, the interplay of firms' characteristics and managerial incentives, to the existing literature.

The arguments of Barclay, Marx and Smith (2003) on the endogeneity of leverage and maturity choices motivate Johnson (2003) and Datta et al. (2005) to use two-stage least square regressions in their analyses of firms' debt maturity choices. These studies examine the level and maturity of firms' existing debt on their balance sheets. In contrast, we closely follow our theoretical framework (and most prior theoretical studies) in examining how firms finance *new* investments. In other words, we examine the proportion of debt in a firm's *incremental* financing choices and the maturity of *incremental* debt issues.

As shown in the previous chapter, the proportion and maturity of debt in the financing of a firm's project are *both endogenously* determined as functions of the fundamental parameters of the model, specifically, the project's market value, the required investment or book value, the actual drift, the volatility, the risk-free rate, and the payout ratio. More precisely,

$$\text{Incremental Leverage} = L(V(0), I, \mu, \sigma, r, \delta)$$
$$\text{Incremental Debt Maturity} = M(V(0), I, \mu, \sigma, r, \delta)$$

In our empirical analysis, we examine *incremental* leverage and debt maturity choices by *separately* estimating the functions $L(.)$ and $M(.)$ above. Since leverage and debt maturity are separately estimated, the endogeneity problems arising from the simultaneous estimation of the proportion and maturity of *total* existing debt, which are cumulative outcomes of *past* financing decisions, are avoided (see Barclay et al, 2003). It is, therefore, econometrically appropriate to separately estimate these functions. Second, the endogeneity problem arises in simultaneously estimating the *concurrent* leverage level and maturity, which are cumulative outcomes of past financing and maturity

decisions. Since our empirical analysis focuses on *incremental* financing and debt maturity choices, this endogeneity problem is not a concern for our study.

Our theory does not incorporate market frictions such as taxes, transaction costs, and informational asymmetries in our model in order to directly focus on the effects of managers' incentives on firms' financing choices. In our empirical analysis, however, it is necessary to control for these variables since they have been identified by earlier theoretical and empirical studies as important determinants of firms' financing choices. We discuss these control variables in more detail in the following.

3.4 Empirical Tests on Firms' Financing Choices

Based on our theory, we test the following hypotheses regarding firms' financing choices.

A. The proportion of debt financing of an investment is positively related to the expected ex post growth rate of firm value

B. The proportion of debt financing of an investment is negatively related to the ex post volatility of firm value

3.4.1 Data and Empirical Implementation

We collect financing data from the COMPUSTAT Industrial Annual North America database. Our sample period begins from 1971 when the U.S. started to report cash flow statement. The sample period ends in 2000. As is standard in the empirical capital structure literature, we exclude financial firms (SIC 6000 – 6999) and regulated utilities (SIC 4900 – 4999). Next, we collect the external financing data: net issuance of long-tem debt (data114) and net issuance of common stocks and preferred stocks (data115). A negative value for the net issuance of debt and equity during a particular

Table 6: Descriptive Statistics for Financing Data

Debtfrac is the dollar proportion of debt financing out of total external financing. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks. *B/M* is the book-to-market ratio of the value of total assets. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets.

	Mean	*Median*	*Lower Quartile*	*Upper Quartile*	*Standard Devation*
Debtfrac	0.640	0.895	0.132	1.000	0.415
Mu	0.188	0.149	0.103	0.225	0.166
Mktlev	0.407	0.392	0.180	0.611	0.261
B/M	0.778	0.772	0.481	1.031	0.422
Tangibility	0.335	0.285	0.150	0.483	0.233
Sigma	0.358	0.295	0.203	0.447	0.228
Profit	0.075	0.123	0.052	0.181	0.330
Logasset	18.220	18.056	16.800	19.490	2.007

Table 7: Correlation Matrix for Financing Data

 Debtfrac is the dollar proportion of debt financing out of total external financing. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks. *B/M* is the book-to-market ratio of the value of total assets. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets.

	Debtfrac	*Mu*	*Mktlev*	*B/M*	*Tangibility*	*Sigma*	*Profitability*	*Logasset*
Debtfrac	1.000							
Mu	-0.307	1.000						
Mktlev	0.570	-0.352	1.000					
B/M	0.359	-0.287	0.692	1.000				
Tangibility	0.273	-0.154	0.219	0.171	1.000			
Sigma	-0.406	0.839	-0.459	-0.337	-0.221	1.000		
Profitability	0.160	-0.234	0.115	0.137	0.099	-0.287	1.000	
Logasset	0.240	-0.253	0.327	0.219	0.228	-0.396	0.260	1.000

fiscal year implies that the firm effectively buys back outstanding securities during that year. Since our theory focuses on the financing of new investments, we restrict consideration to firm-year samples where the net issuance of equity and debt are both nonnegative. The sample formation in this manner focuses our attention on firm-year samples that resort to external financing and exclude those who engage in securities buy-backs.

We estimate the *ex post* volatility of firm value by merging CRSP stock return data with COMPUSTAT data. We use CRSP monthly data to calculate the market value of common stock. For every firm-year sample, we compute market value of equity by multiplying the year-end value of equity (the stock price multiplied by the number of shares outstanding) with one plus the holding period return including distributions. As it is difficult to estimate the market value of debt because the trading data for corporate debt are scarce and unreliable, we follow earlier empirical studies by using the book value of reported total liabilities from a firm's balance sheet as the estimate of the market value of debt. For a firm in good financial health, the book value of debt is a reasonable approximation for its market value. We add the book value of debt to the market value of equity to compute the market value of the firm. In this manner, we construct the monthly time series of the market value of total assets for all sample firms.

We estimate the *ex post* annual volatility of asset value from the above constructed monthly time series. For each firm-year observation, we calculate the returns of the monthly market value of total assets for the 36-month period starting from the beginning of the following fiscal year. The drift and volatility of firm value are estimated as follows:

$$SIGMA = \sqrt{\frac{1}{35}\left(\sum_{i=1}^{i=36}\left(\Delta\,ln(\,V_{ASSET}^{i}\,) - \overline{\Delta\,ln(\,V_{ASSET}\,)}\right)^{2}\right)} * \sqrt{12}$$

(1)

In the above formula, $\overline{\Delta\ln(V_{ASSET})}$ is the average of the logarithm returns of the monthly market value of a firm's total assets over the subsequent three-year period. As a robustness check, we also estimate the volatility for a two-year period after the sample year. The results with alternative volatility are qualitatively very similar.

It is an econometric challenge to precisely estimate the drifts of diffusion processes with discrete time data. Interested readers are referred to Ait-Sahalia's (2002) seminal paper. Several recent papers extend Ait-Sahalia's method and provide detailed estimation procedure. However, standard errors of drift estimators are invariably high in those procedures (see, for example, Li 2006). Direct estimation by MLE from realized firm value data may introduce too much noise in the estimator. We therefore use CAPM to estimate the *ex ante* expected growth of firm value. This approach is also closer to our theory that examines the effect of the *ex ante* expected growth of firm value due to a new investment on the manager's choice of financing the investment.

First, we employ market model to estimate equity beta. We run regression of daily stock excess returns on value-weighted market excess index returns. Throughout this chapter, we present the results with *ex post* three-year estimation period (using two-year estimation period does not change our empirical results). [5]We then calculate the asset beta in the following way, adjusting the asset beta with market leverage and the effects of debt tax shield:

(2)

$$\beta_{ASSET} = \frac{\beta_{EQUITY}}{1 + V_{Debt}/V_{Equity} * (1 - T_{c})}$$

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[5] We also use ex ante three-year and six-year daily returns with the sample-year being the middle to calculate equity betas, the empirical results are very similar to what we report in the following.

in which V_{Debt} and V_{Equity} are market values of debt and equity, Tc is the statutory corporate tax rate, which we choose 34% uniformly. We use the *ex post* three-year average of realized market risk premium and treasury bill rates to proxy for expected market risk premium and risk-free rate. The expected annual asset return, R, can be calculated by standard CAPM. Thus, the estimate of the drift of firm value is:

$$MU = \log(1 + R) + \frac{SIGMA^2}{2} \qquad (3)$$

We calculate the ratio of book value of total liabilities to market value of total assets (market value of equity plus book value of total liabilities) as *market leverage*. As in earlier empirical studies, we use the *book-to-market ratio*, defined as the book value of total assets divided by the market value of total assets, to proxy for the firm's growth opportunities. We also control for the tangibility of the firm's assets. Tangible assets are easy to collateralize thereby reducing the agency costs of debt and increasing firms' incentives to issue debt. We calculate the *asset tangibility* as the ratio of tangible asset to the book value of total assets. We use the logarithm of asset value to proxy for *firm size*. Small firms tend to be more vulnerable to economic shocks than large ones and are, therefore, likely to have higher probabilities of financial distress. In addition, transaction costs of recurring debt issuance may be small for large firms compared with small firms. Finally, informational asymmetries between insiders in a firm and the capital markets are lower for large firms.

The tradeoff theory of capital structure highlights the importance of tax shields on debt as a crucial determinant of firms' financing choices. We use several variables to proxy for tax effects. We define a dummy variable equal to one for firms with net operating loss carryforwards and zero otherwise. Similarly, we define another dummy

variable equal to one for firms with investment tax credits and zero otherwise. As an alternative, we calculate non-debt tax shields as in Titman and Wessels (1988). Non-debt tax shields are calculated from observed federal income tax payments(T), operating income(OI), interests payments(i), and the statutory corporate tax rate(TR): $NDT = OI – I – T/TR$. We then scale non-debt tax shields with book value of total assets. We use the operating income before depreciation scaled by total assets to measure the profitability of the firm. The profitability measure can also be regarded as a rough proxy for the *payout ratio* in our model.

3.4.2 Empirical Results

Table 6 reports the descriptive statistics: number of observations, mean, standard deviation, lower and upper quartile, as well as median for the dependent and explanatory variables. We observe that debt plays a dominant role in firms' financing: *Debtfrac*, the amount of debt financing as a proportion of total external financing, has a mean of 0.64 and median of 0.895. In fact, nearly a quarter of the firm-year samples issue all-debt for financing. The drift of firm value, *Mu*, has a mean of 0.188 and a median of 0.149. The volatility of firms' asset value, *Sigma*, has a mean 0.358 and a median of 0.295.

We report the correlation matrix of independent variables in Table 7. Most pairs exhibit fairly low correlations. B/M ratio and market leverage (*Mktlev*) have a high correlation of 0.699, consistent with the existing finding that low B/M ratio firms, regarded as firms with high growth opportunities, tend to have less debt in their capital structures. As anticipated, volatility is negatively correlated with variables such as asset tangibility *(Tangibility)*, market leverage (*Mktlev*), and firm size (proxied by *Logasset*).

Table 8: Tobit Analysis of Firms' Financing Choices

Debtfrac is the dollar proportion of debt financing out of total external financing. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks*B/M* is the book-to-market ratio of the value of total assets. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets. *Losscarry* is the dummy for operating loss carryforward, taking value of one if loss carryforward is greater than zero, and zero otherwise. *Invcr* is the dummy for investment tax credit, taking value of one if investment tax credit is greater than zero, zero otherwise. Columns (1) to (6) report the estimates of coefficients and t-statistics (in parentheses) for different model specifications.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	1.128***	0.330***	0.479***	0.333***	0.533***	0.534***
	(154.666)	(31.924)	(38.678)	(29.463)	(15.045)	(15.087)
Mu	0.402***	0.179***	0.356***	0.150***	0.119***	0.122***
	(9.647)	(4.978)	(9.069)	(4.178)	(3.313)	(3.374)
Mktlev		1.309***		1.430***	1.427***	1.427***
		(88.543)		(72.754)	(72.428)	(72.441)
B/M			0.432***	-0.107***	-0.134***	-0.134***
			(47.104)	(-9.291)	(-11.688)	(-11.710)
Tangibility			0.506***		0.408***	0.408***
			(32.351)		(28.636)	(28.672)
Sigma	-1.490***	-0.627***	-1.064***	-0.557***	-0.493***	-0.494***
	(-48.551)	(-22.694)	(-36.035)	(-19.833)	(-16.882)	(-16.926)
Profitability				0.136***	0.117***	0.118***
				(10.855)	(9.413)	(9.468)
Logasset					-0.020***	-0.020***
					(-11.020)	(-11.033)
Losscarry					0.099***	0.136***
					(14.076)	(6.187)
Invcredit						-0.039*
						(-1.795)
N	30467	30467	30402	30409	30378	30378

***,** and* indicate statistical significance at 1,5,and 10 percent levels, respectively.

Although our data show that a large number of firms raise funds through debt, equity financing also plays a significant role in our samples. In our sample, firms exclusively issue equity more than twenty percent of the time (over twenty percent of the firm-year observations correspond to pure equity issues). Over fifty percent of the firm-year observations correspond to issues of both debt and equity. This evidence is consistent with the findings of Frank and Goyal (2003) and Mayer and Sussman (2004).

Tobit Analysis

In our tests on firms' financing choice, the dependent variable is *Debtfrac*, the amount of debt financing for the firm as a proportion of total external financing for the fiscal year. For firms issue only debt or equity in the sample year, the variable *Debtfrac* takes values of one or zero. Since the dependent variable is censored above one and below zero, we employ Tobit analysis to test our hypotheses.

Table 8 reports the results of Tobit analysis for various model specifications. Across all model specifications, the coefficients on *Mu,* the *ex post* expected growth rate of firm value, are positive and statistically significant at the one percent level, which is consistent with our hypothesis A. The coefficients on *Sigma,* the *ex post* volatility of market asset value are negative and statistically significant at the one percent level, which is consistent with our hypothesis B. [6] Moreover, the impact of volatility on firms' debt financing choices is also economically significant. A one standard deviation change in the volatility leads to a ten percent change in the proportion of debt financing. Our control variables include proxies for tax shields, firm size, asset tangibility, growth opportunities, profitability as well as current leverage. While the negative relation between leverage and past earnings volatility has been documented in prior empirical

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[6] We also use repeated sub-samples to test these hypotheses controlling for firm fixed effects since it is computationally extremely cumbersome for the full samples. The results are the same.

studies, this paper is the first (to the best of our knowledge) to examine the relation between leverage and the *ex post* expected growth rate and volatility of firm value.

The estimators for tangible assets show that the firms issue more debt if they have more tangible assets, which is consistent with Rajan and Zingales(1995). The *B/M ratio*, a proxy for growth opportunities, is significantly negatively related with debt financing. In our sample, firms raise substantial funds from external resources. The negative coefficients indicate that firms with high growth opportunity prefer debt to equity, if they do need external financing.

Market leverage (that is, the existing leverage) is positively related with the proportion of debt financing. *Profitability*, the proxy for profitability, is positively related with debt financing, although the magnitude is fairly small. Highly profitable firms prefer debt to equity if they are in need of external funds for investment, which is consistent with the pecking order theory of capital structure. The coefficient on the tax dummy *Losscarry* is significantly positive. *Invcr*, the dummy for investment tax credit, has a negative sign with only marginal significance. We also run regressions including *NDTTA*, on-debt tax shield scaled by total assets. *NDTTA* is not statistically significant in almost all specifications, although its signs are consistent with Titman and Wessels (1988).

The Tobit analysis shows strong support for our model predictions on firms' external financing choice with regard to the characteristics of firm value. The signs on *Mu* and *Sigma* are consistent with our hypotheses, at the one percent statistical significance level, after controlling the effects of firm size, growth opportunity, size effect and profitability.

3.5 Empirical Tests on Debt Maturity Choices

In this subsection, we present the results of empirical tests of the predictions of our model that

C. Debt maturity varies in a U-shape manner with the ex post expected growth rate of firm value.

D. Debt maturity is negatively related to the ex post volatility of firm value.

3.5.1 Data and Empirical Implementation

We obtain the debt maturity data from the FISD database. Consistent with earlier empirical studies that examine firms' debt maturity choices, we exclude financial service firms (SIC 6000-6999) from our sample. However, we include regulated firms (SIC 4900-4999) in these tests for two principal reasons. First, the empirical literature on debt maturity invariably includes regulated firms. Second, regulated firms constitute a considerable portion of the FISD data; they increase our sample size by about 10 percent. We include a regulated firm dummy variable in our regression analysis to control for the effect of regulation.

The FISD database contains detailed information on publicly issued debt including offering date, maturity date, offering yield, issue type, issue amount, coupon information, etc. For each debt issue, we infer its maturity by the difference between issue date and maturity date. However, FISD data does not include domestic commercial paper and bank loan data. Many sample firms have multiple public debt issues in a given calendar year. We calculate the weighted average maturity for these firm-year samples. Hence, in our analysis, the dependent variable is the weighted average maturity of the public debt firms issued in a given year. We use both pooled OLS and fixed effect panel regressions to test our hypotheses regarding firms' debt maturity choices. FISD data does

Table 9: Descriptive Statistics for Debt Maturity Data

Myear is the weighted average debt maturity. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks. *B/M* is the book-to-market ratio of the value of total assets. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets. *Rating* is the S&P Long-term Debt Domestic Credit Rating, assigned zero is non-rated. *Assetmat* is gross property, plant and equipment (PPE) divided by depreciation expense.

	Mean	Median	Lower Quartile	Upper Quartile	Standard Devation
Myear	16.059	10.000	10.000	25.000	11.003
Mu	0.151	0.126	0.083	0.172	0.222
Mktlev	0.498	0.496	0.327	0.656	0.219
B/M	0.779	0.781	0.568	0.978	0.317
Tangibility	0.431	0.399	0.227	0.631	0.251
Sigma	0.250	0.201	0.147	0.281	0.212
Profit	0.129	0.131	0.095	0.171	0.096
Logasset	21.190	21.207	20.109	22.270	1.597
Rating	7.554	9.000	0.000	12.000	6.275
Assetmat	16.683	14.784	10.210	20.172	10.808

Table 10: Correlation Table for Debt Maturity Data

Myear is the weighted average debt maturity. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks. *B/M* is the book-to-market ratio of the value of total assets. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets. *Rating* is the S&P Long-term Debt Domestic Credit Rating, assigned zero is non-rated. *Assetmat* is gross property, plant and equipment (PPE) divided by depreciation expense.

	Myear	*Mu*	*Mktlev*	*B/M*	*Tangibility*	*Sigma*	*Profit*	*Logasset*	*Rating*	*Assetmat*
Myear	1.000									
Mu	-0.022	1.000								
Mktlev	-0.040	-0.106	1.000							
B/M	0.050	-0.070	0.782	1.000						
Tangibility	0.153	-0.069	0.103	0.153	1.000					
Sigma	-0.109	0.797	-0.176	-0.143	-0.204	1.000				
Profit	0.116	-0.040	-0.242	-0.192	0.135	-0.117	1.000			
Logasset	0.101	0.016	-0.020	-0.035	0.086	-0.079	0.141	1.000		
Rating	-0.092	-0.029	0.021	0.000	0.074	0.003	0.014	0.268	1.000	
Assetmat	0.161	-0.115	0.149	0.217	0.590	-0.197	-0.048	0.010	0.045	1.000

not include the data of privately issued debt. Consequently, simple regression on this censored data with only public debt will produce inconsistent estimates of explanatory variables. To correct this selection bias, we use the maximum likelihood estimator (Nawata, 1994) in the spirit of Heckman (1979)'s selection model. We include the variables that are statistically significant predictors of the public/private issues in MacKie-Mason (1990) to control for the selection bias.

As in the test on financing choice, we estimate the *ex ante* expected growth of firm value by CAPM and the volatility of firm value of assets from the monthly time series of asset value. As in our earlier tests, we include control variables for market leverage, the Book-to-Market ratio, asset tangibility, firm size, profitability, non-debt tax shields, investment credit and loss carry-forward dummies. In addition, we add control variables that have been identified as important determinants of debt maturity. We now describe the computation of these variables.

We compute the *asset maturity* as gross property, plant and equipment (PPE) divided by depreciation expense. Myers (1977) argues that firms can match the maturities of their assets and liabilities to reduce underinvestment problems. We assign one to the dummy (*Regulate*) for a regulated firm (SIC 4900-4999) and zero otherwise to control for the effect of regulation.

Brick and Ravid (1985) show that the tax-shields on long-term debt are higher when the yield curve is upward sloping. Therefore, as in Johnson (2003), we also include a term structure variable, defined as the 30-year U.S. treasury yield minus the six-month U.S. treasury yield (treasury yield data are obtained from the Federal Reserve Bank website).

We use the S&P domestic long-term debt credit rating extracted from the COMPUSTAT database as a measure of the firm's credit risk. It is a cardinal number system, 16 is the highest rating number while 1 is the lowest. For all non-rated firms, we assign zero as their credit rating.

3.5.2.Empirical Results

Table 9 reports the descriptive statistics for firms in our sample: the number of observations, mean, median, standard deviation, lower and upper quartile, for the dependent and explanatory variables. The maturity variable, *Myear* has a mean and a median of 10 years. The drift of firms' asset value, *Mu*, has a mean of 0.117 and a median of 0.085. The volatility of firm value, *Sigma*, has a mean of 0.265 and a median of 0.203. While the mean and median values of *Mu* correspond closely to the corresponding values for the sample of firms used in our earlier tests of firms' financing choices, the mean and median values of *Sigma* are significantly lower. This suggests that the FISD database contains a higher percentage of large and stable firms. We also report the Pearson correlation matrix of independent variables in Table 10. Most pairs of correlation are similar to those in our earlier sample.

OLS Regressions

Table 10. Panel A reports the results of pooled OLS regressions for different model specifications. The dependent variable is *Myear*, the value weighted average maturity of public debt issued by the firm in a given calendar year. Across all model specifications, the coefficients on *Mu,* the *ex post* expected growth rate of firm value, are positive and statistically significant with *p*-values below 0.0001. The coefficients on *Musqr*, the square of the drift, are negative but only marginally significant. The coefficients of *Mu* and *Musqr* suggest that debt maturity attains its maximum when *Mu* is

greater than 5, well outside the range of values of *Mu* in the sample. The overall empirical evidence suggests that debt maturity increases with the drift of firm value. Consistent with our hypothesis D, the coefficients on *Sigma* are negative and significant at the one percent level in all specifications. Not only these coefficients are statistically significant, they are economically significant as well. An increase by one standard deviation in *Mu* lengthens the debt mature by over two years. Likewise, an decrease by one standard deviation in *Sigma* increases the debt maturity similar magnitude.

The empirical evidence that debt maturity increases with the drift of firm value is, in fact, also consistent with the theory. Table 9 indicates that the values of *Mu* for a majority of firms in the sample are greater than 0.08. Moreover, the sample *Mu* is skewed toward right (higher value of *Mu*).An examination of Table 6 in the previous chapter reveals that debt maturity is likely to increase with drift over this range. In other words, the range of values of firm drifts in our sample corresponds to the "right half" of the predicted U-shaped relation between debt maturity and drift. Therefore, as we empirically document, debt maturity should increase with drift in this range. The fact that the FISD database includes data on publicly issued debt implies that firms with low drifts do not issue public debt to finance their investment needs. This observation, combined with our earlier findings that firms with low growth rates are less likely to issue debt, are consistent with our theory.

Debt maturity increases with the Book-to-Market ratio, a proxy for growth opportunities, confirming the findings of Johnson (2003) and Guedes and Opler (1996). The coefficients on *Mktlev* are significantly negative indicating that firms with higher existing leverage levels choose shorter debt maturities. The coefficients of *Logasset*, the proxy for firm size, are positive and significant, which is also consistent with Johnson

(2003). The coefficients of *Profitability*, the proxy for profitability, are positive and significant suggesting that more profitable firms issue longer-term debt.

The coefficient of *Regulate*, the dummy for regulated firms is positive and significant at five percent significant level, supporting Barclay and Smith (1995)'s argument that regulated firms can borrow longer-term because with less discretion in investment decisions, debt agency problem are less severe. This finding is also consistent with Guedes and Opler (1996) and Johnson (2003). The coefficients of asset maturity are positive and significant, which is also consistent with existing literature. Myer (1977)'s argue that firms can match the maturities of their assets and liabilities to reduce the underinvestment problems.

The coefficient of the tax dummy *Invcr* are significantly positive, confirming Johnson (2003)'s findings. However, *NDTTA*, non-debt tax shield scaled by total assets, and *Losscarry*, the dummy for operating loss carryforward, are generally not statistically significant. We, therefore, do not report them for the sake of brevity. The term structure variable is statistically insignificant and we do not report it either.

Our dataset is an unbalanced panel data with over 45% of sample firms have repeated observations. As a robustness check, we also perform fixed effect panel regression, reported in Table 11, Panel B. As the table shows, the results are similar to those of pooled OLS regressions for most variables. The coefficients of *Mu* and *Musqr* are close to those reported in Panel A, with similar statistical significance. The coefficient of *Sigma* remains negative as we expect, but with lower statistical significance.

Heckman Correction

In previous sub-section, we test our hypothesis on the maturity data of publicly issued debt. We do not have maturity information on privately placed debt including bank

Table 11: Empirical Analysis of Firms' Debt Maturity Choices

Myear is the weighted average debt maturity. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets.. *Invcr* is the dummy for investment tax credit, taking value of one if investment tax credit is greater than zero, and zero otherwise. *Assetmat* is gross property, plant and equipment (PPE) divided by depreciation expense. *Rating* is the S&P Long-term Debt Domestic Credit Rating, assigned zero is non-rated. *Regulate* is the dummy variable, taking value of one if regulated firm, zero otherwise. Columns (1) to (4) report the estimates of coefficients and t-statistics (in parentheses) for different model specifications.

	A. Pooled Regression		B. Fixed Effects	
	(1)	(2)	(3)	(4)
Intercept	13.49***	-2.43	N/A	N/A
	(14.35)	(-0.84)	N/A	N/A
Mu	14.20***	10.75***	9.59***	10.09***
	(5.59)	(4.33)	(3.04)	(3.10)
Musqr	-1.33***	-1.14***	-1.24***	-1.32***
	(-4.62)	(-3.89)	(-3.33)	(-3.42)
Mktlev	-9.78***	-8.21***	-7.80***	-6.86***
	(-6.80)	(-6.09)	(-3.61)	(-2.82)
Sigma	-12.96***	-9.44***	-3.56*	-3.33*
	(-8.80)	(-6.63)	(-1.63)	(-1.50)
B/M	6.48***	4.84***	3.30**	2.93**
	(5.40)	(4.32)	(2.31)	(1.89)
Tangibility		0.50***		-4.89**
		(0.51)		(-1.62)
Profitability	10.63***	6.84***		4.97**
	(4.96)	(3.49)		(1.78)
Logasset		0.79***	-1.62***	-1.67***
		(5.75)	(-4.95)	(-5.15)
Invcredit		4.36***	1.27**	1.24**
		(10.91)	(1.95)	(1.90)
Assetmat	0.14***	0.09***		0.08**
	(5.88)	(3.53)		(1.96)
Regulate		1.15**		7.84
		(1.66)		(1.07)
Rating		-0.16***		-0.08
		(-6.16)		(-0.38)
Adjusted R2	0.07	0.12	0.20	0.20
N	3154	3153	3198	3153

***,** and* indicate statistical significance at 1,5,and 10 percent levels, respectively.

Table 12:Empirical Analysis of Firms' Debt Maturity Choices with Heckman Correction

Myear is the weighted average debt maturity. *Mu* is the drift of the market value of total assets. *Mktlev* is the market leverage, computed by book value of total liabilities divided by the sum of book value of total liabilities and market capitalization of common stocks. *Tangibility* is the ratio of the fixed assets to the book value of total assets. *Sigma* is the volatility of the market value of total assets. *Profitability* is the operating income before tax and amortization scaled by book value of total assets. *Logasset* is the logarithm of book value of total assets.. *Invcr* is the dummy for investment tax credit, taking value of one if investment tax credit is greater than zero, and zero otherwise. *Assetmat* is gross property, plant and equipment (PPE) divided by depreciation expense. *Rating* is the S&P Long-term Debt Domestic Credit Rating, assigned zero is non-rated. *Regulate* is the dummy variable, taking value of one if regulated firm, zero otherwise. Columns (1) to (2) report the estimates of coefficients and t-statistics (in parentheses) for different model specifications.

	(1)	(2)
Intercept	-1.72	-2.42
	(-0.43)	(-0.55)
Mu	11.26***	10.60***
	(5.41)	(5.05)
Musqr	-1.15***	-1.12***
	(-3.82)	(-3.74)
Mktlev	-9.12***	-8.62***
	(-6.30)	(-5.88)
Sigma	-10.25***	-9.33***
	(-4.70)	(-3.92)
B/M	4.87***	5.02***
	(4.73)	(4.88)
Tangibility		0.51
		(0.53)
Profitability		6.71***
		(3.23)
Logasset	0.83***	0.80***
	(6.82)	(6.52)
Invcredit	4.67***	4.37***
	(7.38)	(6.25)
Assetmat	0.11***	0.09***
	(5.90)	(3.76)
Regulate		1.17*
		(1.57)
Rating	-0.15***	-0.16***
	(-4.84)	(-5.09)
Rho	-0.02	-0.009
	(-0.09)	(-0.04)
N	3159	3153

***,** and* indicate statistical significance at 1,5,and 10 percent levels, respectively.

loans, which takes a considerable portion of corporate liabilities. Hence, the dataset may be subject to sample selection bias (Heckman, 1979). We implement Nawata (1994)'s method to correct for potential sample bias. Nawata (1994) proposes a maximum likelihood estimator for standard Heckman selection model, which improves estimation efficiencies from two-step method.

We show the results after the correction of sample selection bias in Table 12. In the selection-part estimation, we include the variables that are found to be significant in predicting whether firm chooses public or private issuance in Makie-Mason(1990). These variables include existing ones *Sigma, Losscarry, Invcr, Tangibility, Mktlev,* plus *Dividend*, dummy variable of one if the firm paid dividends, *RND,* research and development scaled by total assets, and *Advertising*, expenditure on advertising scaled by total assets. Our main results still hold after the Heckman correction. The coefficients and statistical significance are consistent with previous model specifications without Heckman correction. The model parameter *Rho* is not significant in both specifications, which suggests that sample selection bias may not be a problem in our dataset.

3.6 Conclusion

We test the predictions of our theory on the impact of managerial incentives on the financing and debt maturity choices of firms. In our empirical analysis, we use financial report data from COMPUSTAT, stock return data from CRSP, and debt maturity data from FISD. We examine the relations between the level and maturity of debt in a firm's financing of *incremental* investments, and the *ex post* growth rate and volatility of its value. We estimate directly the volatility of firm value by constructing monthly time series of firms' total asset value. We use CAPM to infer the *ex ante* drift of

firm value. In our tests, we include control variables that have been identified as important determinants of firms' financing and debt maturity decisions by previous studies, such as firm size, growth opportunity, profitability, tax effects. We perform Tobit analysis, OLS and panel regressions in our empirical tests. The empirical results broadly support the predictions of our theory regarding the relations between firms' financing and debt maturity choices, and the drift and volatility of their asset values.

APPENDIX A

ANALYSIS OF THE TWO-PERIOD MODEL

In this Appendix, we prove Proposition 1. Because the proof is rather involved, we present it in several intermediate steps. We use the following lemma frequently in the proof.

Lemma A1: *The function* $G(D) = \dfrac{A - \alpha D}{B - \beta D}; A, B, \alpha, \beta > 0$ *is increasing and strictly convex over* $D \in \inf(A/\alpha, B/\beta)$ *if* $A/\alpha > B/\beta$, *is decreasing if* $A/\alpha < B/\beta$, *and is constant if* $A/\alpha = B/\beta$.

Proof. The assertions follow directly from differentiating the function G.

The following result establishes the optimality of all-equity financing when the up-tick probability $p \leq 0.5$.

Proposition A1: *If* $p \leq 0.5$, *it is optimal for the owner-manager to choose all-equity financing.*

Proof. The manager's expected payoff from issuing long-term debt with face value D_L is given by (5). By (4) the manager's expected control benefits, described by the first term on the right hand side of (5), decrease with D_L. Because $f(P_L) = (1 - I)/(1 - P_L)$, the second term can be rewritten as

$$(1 - I) \frac{\left(p^2 \left[(1+u)^2 - D_L \right]^+ + 2p(1-p) \left[(1 - u^2) - D_L \right]^+ + (1-p)^2 \left[(1-u)^2 - D_L \right]^+ \right)}{\left(0.25 \left[(1+u)^2 - D_L \right]^+ + 0.5 \left[(1 - u^2) - D_L \right]^+ + 0.25 \left[(1-u)^2 - D_L \right]^+ \right)}$$

For $p \leq 0.5$, we can use Lemma A1 to show that the above expression decreases with D_L so that the second term on the right hand side of (5) also decreases with D_L. Hence, *within the class of long-term debt financing*, the manager's expected payoff is maximized

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when $D_L = 0$, which corresponds to all-equity financing. We can similarly use Lemma 1 to show that (details omitted for brevity) the manager's expected payoff from issuing short-term debt with face value D_S decreases with D_S for $p \leq 0.5$.

<div align="right">Q.E.D.</div>

We now analyze the manager's financing choices in the region $p > 0.5$. The following proposition describes the possible face values of the manager's optimal (long-term or short-term) debt choices.

Proposition A2: *a) If it is optimal for the manager to issue long-term debt, the corresponding face value D_L^* must belong to the set $\left\{(1-u)^2, 1-u^2, D_L^{\text{all debt}}\right\}$ where $D_L^{\text{all debt}}$ is the face value of debt when the manager chooses long-term all-debt financing.*

b) If it is optimal for the manager to issue short-term debt, the corresponding face value D_S^* must belong to the set $\left\{1-u, D_S^{\text{all debt}}\right\}$ where $D_S^{\text{all debt}}$ is the face value of debt when the manager chooses short-term all-debt financing.

Proof. a)   To simplify the exposition, we make the standing assumption that $D_L^{\text{all debt}} \geq 1 - u^2$. The arguments are similar for the case where $D_L^{\text{all debt}} < 1 - u^2$. By (2), (4) and the result of Lemma A1, the owner-manager's expected utility $U(D_L)$ from issuing long-term debt with face value D_L (given by (5)) is *piecewise convex,* that is, it is convex for $D_L \in [0, (1-u)^2), D_L \in ((1-u)^2, 1-u^2), D_L \in ((1-u^2, D_L^{\text{all debt}})$. It follows that the face value D_L^* at which the function $U(.)$ is maximized must be one the boundary points $\left\{(1-u)^2, 1-u^2, D_L^{\text{all debt}}\right\}$ of these intervals.

b) We assume that $D_S^{\text{all debt}} \geq 1 - u$ (this, in fact, follows from our assumption that $D_L^{\text{all debt}} \geq 1 - u^2$; see part a)). By (6), (7), (8), (9), and the result of Lemma A1, the owner-

manager's expected utility $U(D_S)$ from issuing short-term debt with face value D_S (given by (10)) is convex for $D_S \in [0, 1-u); D_S \in (1-u, D_S^{\text{all debt}})$. Hence, its optimum D_S^* must be one of the boundary points of these intervals.

<div align="right">Q.E.D.</div>

Proposition A2 substantially simplifies the analysis of the owner-manager's optimal financing choice because it is sufficient to restrict consideration to face values of debt at the "boundary" points $\{(1-u)^2, 1-u^2, D_L^{\text{all debt}}\}$ for long-maturity debt and $\{1-u, D_S^{\text{all debt}}\}$ for short-maturity debt. In order to simplify the subsequent analysis, we assume that $D_L^{\text{all debt}} \geq 1 - u^2$. We can use similar arguments to prove Proposition 1 in the case where $D_L^{\text{all debt}} < 1 - u^2$ (details available upon request).

Proposition A3: *a) The manager's expected payoff from choosing long maturity **all debt** financing equals her expected payoff from choosing short maturity **all debt** financing.*

*b) The manager's expected payoff from issuing long maturity debt with face value $1 - u^2$ strictly exceeds her expected payoff from choosing long-term **all debt** financing.*

Proof. a) We begin by noting that the market value of debt in any state is the *risk-neutral expectation* of its future payoffs and that the risk-neutral probability of an "up-tick" in firm value in each period is 0.5 (recall that the risk-free rate is zero). Since $D_L^{\text{all debt}} \geq 1 - u^2$, the market value at date 1 of long-term debt with face value $D_L^{\text{all debt}}$ is equal to $0.5 D_L^{\text{all debt}} + 0.5(1 - u^2)$ when firm value is $1 + u$, and is equal to $1 - u$ when firm value is $1 - u$. Since the market value of this debt at date 0 must be I (by definition, $D_L^{\text{all debt}}$ is the face value of debt when the manager chooses all debt financing), we must have

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$$0.5\left(0.5D_L^{\text{all debt}} + 0.5(1-u^2)\right) + 0.5(1-u) = I \qquad (A1)$$

It follows from (A1) that $I \geq 1-u$. Let $D_S^{\text{all debt}}$ be the face value of debt when the manager chooses short maturity all debt financing. We must have

$$0.5D_S^{\text{all debt}} + 0.5\inf(D_S^{\text{all debt}}, 1-u) = I \qquad (A2)$$

Since $I \geq 1-u$, it follows from (A2) that $D_S^{\text{all debt}} \geq 1-u$. Comparing (A1) with (A2), it then follows that

$$0.5D_L^{\text{all debt}} + 0.5(1-u^2) = D_S^{\text{all debt}} \qquad (A3)$$

By (A3), the face value of *re-financed* short term debt in period 2 is equal to $D_L^{\text{all debt}}$ when firm value is $1+u$. Since $D_S^{\text{all debt}} \geq 1-u$, bankruptcy is declared when the firm value at date 1 is $1-u$. It now follows from (9) and (10) that the manager's expected payoff from issuing short-term debt with face value $D_S^{\text{all debt}}$ is identical to her expected payoff from issuing long-term debt with face value $D_L^{\text{all debt}}$.

b) Since $D_L^{\text{all debt}} \geq 1-u^2$, it follows from (4) that the owner-manager's expected control benefits (the first term on the right hand side of (5)) are strictly greater when she issues long maturity debt with face value $1-u^2$ than when she chooses all debt financing with face value $D_L^{\text{all debt}}$. By (1) and (2), the manager's expected payoff from her equity stake in the firm (the second term on the right hand side of (5)) if she issues long-term debt with face value $D_L \in [1-u^2, D_L^{\text{all debt}}]$ is

$$\frac{1-I}{0.25[(1+u)^2 - D_L]}\left(p^2[(1+u)^2 - D_L]\right) = (1-I)4p^2 \qquad (A4)$$

By (A4), the owner-manager's expected payoff from her equity stake in the firm *does not vary* with $D_L \in [1-u^2, D_L^{\text{all debt}}]$. The result of the proposition, therefore, follows from the

fact that her expected control benefits are greater when she chooses $D_L = 1 - u^2$.

<div align="right">Q.E.D.</div>

By the results of Proposition A3, the manager always prefers to issue long-term debt with face value $1 - u^2$ to either long-term or short-term all debt financing. The following result compares the manager's expected payoff from issuing long maturity debt with face value $1 - u^2$ to short-term debt with face value $1 - u$.

Proposition A4: *Set* $p_3' = \dfrac{1 + \left(\dfrac{\varepsilon}{1-I}\right) u}{2}$. *The manager's expected payoff from issuing short maturity debt with face value $1 - u$ is strictly greater than her expected payoff from issuing long maturity debt with face value $1 - u^2$ for $p < p_3'$, and is strictly smaller for*

$p > p_3'$.

Note: Since $\varepsilon < 1 - I$ by assumption, $p_3' < 1$.

Proof. By (6)-(10), we can show that the manager's expected payoff at date zero from issuing short maturity debt with face value $1 - u$ is

$$U(D_S = 1 - u) = p\varepsilon(2u) + \frac{1-I}{u}\left[p^2\left((1+u)^2 - (1-u)\right) + p(1-p)(u - u^2)\right] \quad (A5)$$

By (2) – (5), the manager's expected payoff at date zero from issuing long maturity debt with face value $1 - u^2$ is

$$U(D_L = 1 - u^2) = p\varepsilon(u + u^2) + 4(1 - I)p^2 \quad (A6)$$

From (A5), (A6), and after some algebraic manipulations,

$$U(D_S = 1 - u) - U(D_L = 1 - u^2) = \left[4(1 - I) - 2(1 - I)(u + 1)\right]p^2 + \left[\varepsilon(u^2 - u) - (1 - I)(1 - u)\right]p$$

Hence, $U(D_L = 1 - u^2) > U(D_S = 1 - u)$ if and only if $p > p_3' = \dfrac{1 + \left(\dfrac{\varepsilon}{1 - I}\right)u}{2}$.

<div align="right">Q.E.D.</div>

The following proposition compares the manager's expected payoff from issuing long-term debt with face value $(1 - u)^2$ and long-term debt with face value $1 - u^2$.

Proposition A5: *There exists $p^* < p_3'$ (defined in Proposition A4) such that the manager's expected payoff from issuing long maturity debt with face value $1 - u^2$ strictly exceeds her expected payoff from issuing long maturity debt with face value $(1 - u)^2$ if and only if $p > p^*$.*

Proof. By (2)-(5), the manager's expected payoffs at date zero from issuing long maturity debt with face value $(1 - u)^2$ and long maturity debt with face value $1 - u^2$, respectively, are

$$U(D_L = (1 - u)^2) = \varepsilon[p(1 + u - (1 - u)^2) + (1 - p)(1 - u - (1 - u)^2)] +$$
$$\frac{1 - I}{1 - (1 - u)^2}\left(p^2[(1 + u)^2 - (1 - u)^2] + 2p(1 - p)[(1 - u^2) - (1 - u)^2]\right)$$
$$U(D_L = 1 - u^2) = \varepsilon p((1 + u) - (1 - u^2)) + 4(1 - I)p^2$$
(A7)

From (A7) and some algebraic simplification, we obtain

$$U(D_L = (1 - u^2)) - U(D_L = (1 - u)^2) = 4(1 - I)p^2[1 + \frac{u^2}{1 - (1 - u)^2}] - 4(1 - I)p\frac{u(1 - u)}{1 - (1 - u)^2} - \varepsilon(p + 1)u(1 - u)$$
(A8)

Differentiating the right hand side above with respect to p and using the fact that $\varepsilon < 1 - I$ by assumption, we can show that $U((1 - u^2)) - U((1 - u)^2)$ is increasing in p for $p > 1/2$. Further, we can check that $U((1 - u^2)) - U((1 - u)^2) < 0$ for $p = 1/2$, and $U((1 - u^2)) - U((1 - u)^2) > 0$ for $p = 1$. It follows that there exists $p^* \in (1/2, 1)$ such that the

manager's expected payoff from issuing long maturity debt with face value $1 - u^2$ strictly exceeds her expected payoff from issuing long maturity debt with face value $(1 - u)^2$ if and only if $p > p^*$.

It remains to show that $p^* < p_3' = \dfrac{1 + \left(\dfrac{\varepsilon}{1-I}\right)u}{2}$. To show this, it follows from the arguments in the previous paragraph that it suffices to show that $U((1 - u^2)) - U((1 - u)^2) > 0$ for $p = p_3'$. Setting $p = p_3'$ in (A7) and after some algebra, we obtain

$$U((1 - u^2)) - U((1 - u)^2)|_{p=p_3} = \left(\frac{\varepsilon}{1-I}\right)^2 \left(\frac{u^2}{2} + u^3(\frac{u}{1-(1-u)^2} + \frac{1}{2})\right) + \left(\frac{\varepsilon}{1-I}\right)\left(2u(1 + \frac{u^2}{1-(1-u)^2})\right)$$

The expression on the right hand side is clearly strictly positive for all $\varepsilon > 0, u \in (0,1)$.

Q.E.D.

Proposition A6: *There exists p_2' such that the manager's expected payoff from issuing short maturity debt with face value $1 - u$ exceeds her expected payoff from issuing long maturity debt with face value $(1 - u)^2$ if and only if $p > p_2'$.*

Proof. The proof follows using arguments similar to those used to prove Proposition A5 and is omitted for brevity.

By the results of Propositions A4, A5, and A6, the manager's expected payoff from issuing short maturity debt with face value $1 - u$ strictly exceeds her expected payoff from issuing long maturity debt with face value $(1 - u)^2$ when $p = p_3'$ It follows that $p_2' < p_3'$. The following proposition compares the manager's expected payoffs from

all-equity financing and her payoffs from issuing long-term debt with face values $(1-u)^2$

and $1-u^2$, respectively.

Proposition A7: *a) There exists $p_1' \in (0.5,1)$ such that the manager's expected payoff*

from issuing long maturity debt with face value $(1-u)^2$ strictly exceeds her expected

payoff from all equity financing if and only if $p > p_1'$. Further, we have $p_1' < p_3'$ (defined

in Proposition A4) if $\dfrac{\varepsilon}{1-I} > \dfrac{2u-3u^2}{u^4}$, which is always true if $u > 2/3$ because $\varepsilon > 0$.

b) There exists $p_3'' \in (0.5,1)$ such that the manager's expected payoff from issuing long

maturity debt with face value $1-u^2$ strictly exceeds her expected payoff from all equity

financing if and only if $p > p_3''$.

Proof. a) From (2)-(5) and some algebra, we can show that the difference between the

manager's expected payoffs from issuing long-term debt with face value $(1-u)^2$ and all

equity financing is

$$U(D_L = (1-u)^2) - U(D_L = 0) = -\varepsilon(1-u)^2 + (1-I)(1-u)^2 \frac{[1+(2p-1)u]^2 - 1}{1-(1-u)^2}$$

(A9)

The right hand side of (A9) is an increasing function of p. Further, it is strictly negative

for $p = 0.5$ and strictly positive for $p = 1$. Hence, there exists $p_1' \in (0.5,1)$ such that the

manager's expected payoff from issuing long-maturity debt with face value $(1-u)^2$

strictly exceeds her expected payoff from all-equity financing if and only if $p > p_1'$.

It remains to show that $p_1' < p_3'$ if $\dfrac{\varepsilon}{1-I} > \dfrac{2u-3u^2}{u^4}$. Because the right hand side

of (A9) is an increasing function of p, it suffices to show that it is strictly positive for

$p = p_3'$ when this condition holds. Setting $p = p_3'$ in the right hand side of (A9), we

obtain

$$(1-I)(1-u)^2 \left(\frac{[1+\left(\frac{\varepsilon}{1-I}\right)u^2]^2 - 1}{1-(1-u)^2} - \frac{\varepsilon}{1-I} \right) = \left(\frac{(1-I)(1-u)^2}{1-(1-u)^2} \right) \left(\left(\frac{\varepsilon}{1-I}\right)^2 u^4 + \left(\frac{\varepsilon}{1-I}\right)(3u^2 - 2u) \right)$$

The right hand side above is positive if and only if $\dfrac{\varepsilon}{1-I} > \dfrac{2u - 3u^2}{u^4}$.

b) This is proved using arguments similar to those used in part a); the details are omitted

for brevity.

Q.E.D.

Setting $p_1 = \min(p_1', p_3'')$, $p_3 = \max(p_3', p_3'')$, and $p_2 = \max(p_1, p_2')$, it follows

from the results of Propositions A2 - A7 that the manager chooses

- all-equity financing for $p < p_1$,

- long maturity debt with face value $(1-u)^2$ for $p \in (p_1, p_2)$

- short maturity debt with face value $(1-u)$ for $p \in (p_2, p_3)$

- long maturity debt with face value $1 - u^2$ for $p > p_3$.

We could have $p_1 = p_3$ in which case the interval (p_1, p_3) is empty if. If (p_1, p_3) is *non-

empty*, however, it follows from Remark A1 that the interval (p_2, p_3) is also nonempty.

Hence, the triggers p_1, p_2, p_3 satisfy the statements of Proposition 1.

APPENDIX B

ANALYSIS OF CONTINUOUS TIME MODEL

Proof of Proposition 1

From the requirement of selling debt at part at the initial date: $D(V0)=P$, we have

$$\frac{C+mP}{r+m} + AV_0^\eta = P \qquad (B.1)$$

By the same way, we obtain from the bankruptcy requirement:

$$\frac{C+mP}{r+m} + AV_B^\eta = (1-\alpha)V_B \qquad (B.2)$$

From the smooth pasting condition:

$$E'(V)|_{V=V_B} = 0 \qquad (B.3)$$

substitute $E(V)= V-D(V)$, we have

$$D'(V)|_{V=V_B} = 1 \qquad (B.4)$$

i.e. $A\eta V_B^{\eta-1} = 1$ $\qquad (B.5)$

From (A.1), we solve for A:

$$A = \frac{rP-C}{r+m}V_0^{-\eta} \qquad (B.6)$$

(A.5) can be written as:

$$AV_B^\eta = \frac{V_B}{\eta} \qquad (B.7)$$

Substitute into (A.2), we solve V_B in terms of P:

$$V_B = \left(\frac{C+mP}{r+m}\right)\frac{1}{1-1/\eta} \qquad (B.8)$$

Combined with (A.3), we obtained P in the implicit function:

$$\frac{(rP - C)\eta(C + mP)^{\eta-1}}{(r + m)^{\eta} V_0^{\eta}(1 - 1/\eta)^{\eta-1}} = 1 \tag{B.9}$$

Proof of Proposition 2

Manager's value function satisfies the following ODE:

$$\beta U = \frac{1}{2}\sigma^2 V^2 U_{VV} + \mu V U_V + f[\delta V + mD(V) - (C + (1+k)mP)] \tag{B.10}$$

The homogeneous part of the above ODE is:

$$\frac{1}{2}\sigma^2 V^2 U_{VV} + \mu V U_V - \beta U = 0 \tag{B.11}$$

The roots of its characteristic equation are:

$$\gamma = \frac{-\left(\mu - \frac{\sigma^2}{2}\right) \pm \sqrt{\left(\mu - \frac{\sigma^2}{2}\right)^2 + 2\sigma^2\beta}}{\sigma^2} \tag{B.12}$$

It is obvious that one root is positive and the other is negative since β is always positive.

The general solution of the homogeneous ODE is in the form:

$$U_h = B_1 V^{\gamma_+} + B_2 V^{\gamma_-} \tag{B.13}$$

Manager's value must approach to the asset value asymptotically, so B_1 must be zero.

Henceforth we suppress the subscript. If we can find a particular solution for ODE

(A.12), then we can obtain the general solution, which is the linear combination of the

solution to the homogeneous part and the particular solution. By inspecting (A.12), we

conjecture that the particular solution is in the form of

$$A'V^{\eta} + C'V + D'$$

substitute into (A.10), we have:

$$\frac{1}{2}\sigma^2 V^2\left(A'\eta_-(\eta_- -1)V^{\eta_- -2}\right) + (\mu - \delta)V\left(A'\eta_- V^{\eta_- -1} + C'\right) - \beta\left(A'V^{\eta_-} + C'V + D'\right)$$

$$+ (f(P) + \varepsilon)\delta V + (f(P) + \varepsilon)m\left(\frac{C + mP}{r + m} + AV^{\eta_-}\right) - (f(P) + \varepsilon)(C + (1+k)mP) = 0$$

(B.14)

The subscripts are derivatives, develop the above equation on derivatives of V, we have

$$\left(\frac{1}{2}\sigma^2 V^2 A'\eta(\eta-1) + (\mu-\delta)A'\eta - \beta A' + (f(P)+\varepsilon)m)A\right)V^{\eta} + \left(\mu C' + (f(P)+\varepsilon)\delta\right) - C'\beta)V$$

$$- \beta D' + \left[\frac{(f(P)+\varepsilon)m(C+mP)}{r+m} - f(P)(C + (1+k)mP)\right] = 0$$

(B.15)

The coefficients must be zero to make the above left side equals to zero:

$$\frac{1}{2}\sigma^2 A'\eta(\eta-1) + (\mu - \delta)A'\eta - \beta A' + (f(P) + \varepsilon)m - A = 0 \tag{B.16}$$

$$(\mu - \delta)C' + (f(P) + \varepsilon)\delta - C'\beta = 0 \tag{B.17}$$

$$-\beta D' + \left[\frac{(f(P) + \varepsilon)m - (C + mP)}{r + m} - f(P)(C + (1+k)mP)\right] = 0 \tag{B.18}$$

Solve the above equations, we have:

$$A' = \frac{-(f(P) + \varepsilon)mA}{\frac{1}{2}\sigma^2\eta_-(\eta_- - 1) + (\mu - \delta)\eta_- - \beta} \tag{B.19}$$

$$C' = \frac{(f(P) + \varepsilon)\delta}{\beta - \mu + \delta} \tag{B.20}$$

$$D' = \frac{-r(f(P) + \varepsilon)(C + mP)}{\beta(r + m)} - \frac{(f(P) + \varepsilon)kmP}{\beta} \tag{B.21}$$

Hence we obtain the particular solution for (A.12). Combine the solution to the

homogeneous part and the particular solution, the general solution is in the form of

$$U = BV^{\gamma} + A'V^{\eta} + C'V + D' \tag{B.22}$$

in which *A', C'* and *D'* are stated above. B is to be decided by the boundary condition

$U(V_B)=0$, i.e. manager's value function equals to zero when the firm is bankrupt.

APPENDIX C

NUMERICAL PROCEDURE

We use simple search algorithm to find the pair of the principal amount P and the rollover rate m that optimizes the manager's value function (24). We choose the baseline parameters and parameter ranges according to the descriptive statistics from our empirical investigation of the second essay. The baseline drift and volatility are 0.1 and 0.3, which are the medians of our total samples. The ranges for the drift and volatility are -0.1 to 0.24 and 0.2 to 0.45, matching the lower and upper quartile for these parameters of our total samples.

Throughout the numerical procedure, the initial value V_0 is 100, the project investment is 90, and the risk free rate r is 6%. We use nested loops of P and m to carry out the search process. Our search range for P is from 0 to 90, since the principal amount must be less or equal the investment needs, I. The incremental steps are 0.1 for P from 0 to 1 and 1 for P from 1 to 90, Our search range for m from 0.01 to 5, corresponding to the average maturity range from less than 3 months to 100 years. The incremental steps are 0.01 for m from 0.01 to 0.1, 0.02 for m from 0.1 to 1 and 0.5 for m from 1 to 5.

For each loop iteration with known P and m , we calculate coupon rate C and endogenous bankruptcy level V_B by Proposition 1. We then calculate the manager's value function by Proposition 2. After running through all the iterations of P and m, we find the optimal capital structure *(P, C, m)* that achieves the maximum of manager's value function (24).

APPENDIX D

DESCRIPTION OF CONTROL VARIABLES

1. *NDTTA:* Non-debt tax shields scaled by total assets. Our calculation follows Titman and Wessels (1988):

$$NDTTA = \frac{OI - i - T/TR}{TotalAssets}$$

in which *OI* is operating income(data13) , *i* is interest expense(data15), *T* (data16)is federal income tax payments, *TR* is the statutory tax rate.

2. *Logasset*: the logarithm of the book value of firm's total assets(data6).

3. *B/M ratio*: Book to market ratio of total assets. Book value of total assets(data6). Market value of total assets is the sum of book value of liabilities(data181) and market capitalization.

4. *Tangibility*: the value of tangible assets(data8) scaled by total assets(data6).

5. *Mktlev*: the market leverage defined by total liabilities(data181) divided by the sum of total liabilities and market value of equity.

6. *Profitability*: the profitability is defined as operating income before depreciation scales by book value of total assets(data6);

7. *Invcr*: the dummy for investment tax credit, taking value of one if investment tax credit is greater than zero, and zero otherwise.

8. *Losscarry*: the dummy for operating loss carryforward, taking value of one if operating loss carryforward is greater than zero, and zero otherwise.

9. *Regulate*: the dummy variable, taking value of one if regulated firm, zero otherwise.

10. *Rating*: S&P Long-term Debt Domestic Credit Rating(SPDRC).

11. Term: 30-year U.S. treasury yield minus the six-month U.S. treasury yield.

12. Assetmat: Asset maturity, defines as gross property, plant and equipment (PPE) divided by depreciation expense.

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