Essays in Capital Structure

by

Jie Yang

Department of Business Administration
Duke University

Date: ______________________

Approved:

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John Graham, Advisor

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David Robinson

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Adriano Rampini

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Jules van Binsbergen

Dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Business Administration
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2010

ABSTRACT

(Finance)

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Abstract

The costs and constraints to financing, and the factors that influence them, play critical roles in the determination of corporate capital structures.

Chapter 1 estimates firm-specific marginal cost of debt functions for a large panel of companies between 1980 and 2007. The marginal cost curves are identified by exogenous variation in the marginal tax benefits of debt. The location of a given company's cost of debt function varies with characteristics such as asset collateral, size, book-to-market, intangible assets, cash flows, and whether the firm pays dividends. Quantifying, the total cost of debt is on average 7.9% of asset value at observed levels, reaching as high as 17.8%. Expected default costs constitute approximately half of the total ex ante cost of debt.

Chapter 2 uses the intersection between marginal cost of debt functions and marginal benefit of debt functions to examine optimal capital structure. By integrating the area between benefit and cost functions, net benefit of debt at equilibrium levels of leverage is calculated to be 3.5% of asset value, resulting from an estimated gross benefit of debt of 10.4% of asset value and an estimated cost of debt of 6.9%. Furthermore, the cost of being overlevered is asymmetrically higher than the cost of being underlevered. Case studies of several firms reveal that, for some firms, the cost of being suboptimally levered is small while, for other firms, this cost is large, suggesting firms face differing sensitivities to the capital structure choice.

Finally, Chapter 3 examines the role of financing constraints on intertemporal capital structure choices of the firm via a structural model of capital investment. In the model, firms maximize value by choosing the amount of capital to invest and the amount of debt to issue. Firms face a dividend non-negativity constraint that restricts them from issuing equity and a debt capacity constraint that restricts them from issuing non-secured debt. The Lagrange multipliers on the two constraints capture the shadow values of being constrained from equity and debt financing, respectively. The two financing constraint measures are parameterized using firm characteristics and are estimated using GMM. The results indicate that these measures capture observed corporate financing behaviors and describe financially constrained firms. Finally, between the two financing constraints, the limiting constraint is the debt restriction, suggesting that firms care about preserving financial slack.

To my parents

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Introduction

The debate on how a firm chooses its capital structure and the factors that influence this decision is important and ongoing. Much of the work studying leverage choice focuses on examining capital structure variation in a reduced form setting, contrasting the benefits and costs of debt theorized to influence the firm's trade off to make optimal leverage decisions. Although there has been much progress and insight, questions remain as to why some firms do not appear to use as much debt as the benefits from doing so would suggest. Better understanding of the cost of debt and financing constraints is necessary to gain perspective on these issues and ultimately into optimal capital structure.

Chapter 1, "The Cost of Debt," (joint work with Jules van Binsbergen and John Graham), explicitly estimates marginal cost of debt function using instrumental variables analysis. Firms make capital structure decisions that are observed empirically. These decisions reflect the joint consideration of benefits and costs to using debt. In our analysis, we use these observed equilibrium leverage decisions and the simulated marginal tax benefits of debt curves to map out a marginal cost of debt curve. The identification comes from holding the cost environment constant while allowing the marginal tax benefit curve of debt to shift. This allows us to identify a positively sloped marginal cost of debt curve for any firm in any year. This curve is an increasing function of the amount of debt interest. The location of a given company's cost of debt function varies with characteristics such as asset collateral, size, book-to-market, intangible assets, cash flows, and whether the firm pays dividends. By integrating the area between benefit and cost functions, we find that the equilibrium net benefit of debt is calculated to be 3.5% of asset value, resulting from an estimated gross benefit of debt of 10.4% of asset value and an estimated cost of debt of 6.9%. We find that the cost of being overlevered is asymmetrically higher than the cost of being underlevered. Finally, we find that the cost of default makes up approximately half of the total cost of debt, implying that the agency and other nondistress costs make up the other half of the cost of debt.

Chapter 2, "Optimal Capital Structure," (joint work with Jules van Binsbergen and John Graham), takes the estimated marginal cost of debt curves from the previous chapter and together with firm-specific marginal benefit of debt curves, determines the optimal capital structure. This optimal capital structure is defined as the intersection of the marginal benefit and marginal cost curves. By calculating the gross benefit of debt and cost of debt, we can determine the net benefit of debt, which captures the value added by using the optimal leverage. We can evaluate these firm-specific welfare measures for any level (actual or hypothetical) of leverage and calculate how much it cost firms to deviate from the optimal capital structure. We find that for some firms, the cost of being suboptimally levered is small while for other firms this cost is large suggesting firms face differing sensitivities to the capital structure choice. Finally, we provide some case examples using optimal capital structures.

These two chapters contribute to the literature by providing a formal estimation and formulation of the cost of debt and analysis on the resulting optimal capital structure. This adds insight into the question of why firms use so little debt by rephrasing the question to ask what the cost of debt would have to be to justify the observed choices. As the estimation contains both quantitative and qualitative interpretations, the cost of debt curve provides a useful benchmark for future research as well as the practice of making capital structure decisions in the business world.

Although questions relating to the benefits and costs of debt that determine capital structure are certainly important, the capital structure decision itself interacts with the broader environment of corporate investment. Under the famous Modigliani and Miller theorem, corporate financial structures are independent of real investment decisions and the choice between debt and equity is irrelevant. Frictions in the market can lead to circumstances in which the independence and irrelevance of capital structure no longer hold. In the presence of financial frictions, the environment is often such that firms are faced with the joint decision on investment and capital structure at each point in time. Understanding this relationship is important in understanding the role of financing constraints and capital structure.

Chapter 3, "Financing Constraints and Capital Structure", examines the joint relationship between investment and capital structure in the presence of financing constraints. I construct a structural model in which firms maximize value by choosing the amount of capital to invest and the amount of debt to issue. In the model, firms face a dividend non-negativity constraint that restricts them from issuing equity and a debt capacity constraint that restricts them from issuing unsecured debt, i.e., any risky financing. The Lagrange multipliers on the two constraints capture the shadow values of the financing constraints. Since there are two separate constraints, the model gives me two financing constraint measures, one for equity and one for debt. Given these constraints, relative to investing in the current period through equity, the firm considers two alternatives: defer investment by issuing equity in the next period or invest today through debt financing. This decision is captured by the relative financing constraint between equity tomorrow and equity today and the relative financing constraint between debt today and equity today.

Using GMM, I estimate the model and the shadow costs of the two financing constraints. I parameterize the constraints using observed variables based on existing research on financial constraints and find they load in intuitive ways. Testing the two estimated financial constraint measures, I find that they capture observed corporate financing behavior. Having estimated two separate measures for financing constraints, I propose one overall financing constraint measure and examine the contribution of each individual constraint on the overall measure. I find that the limiting constraint is the debt constraint, which is limited in the model via availability of debt capacity. This provides evidence that firms ultimately care about preserving debt capacity and financial flexibility.

1

The Cost of Debt

Hundreds of papers investigate corporate financial decisions and the factors that influence capital structure. Much theoretical work characterizes the choice between debt and equity in a trade-off context in which firms choose their optimal debt ratio by balancing the benefits and costs. Traditionally, tax savings that occur because interest is deductible have been modeled as a primary benefit of debt (Kraus and Litzenberger, 1973). Other benefits include committing managers to operate efficiently (Jensen, 1986) and engaging lenders to monitor the firm (Jensen and Meckling, 1976). The costs of debt include financial distress (Scott, 1976), personal taxes (Miller, 1977), debt overhang (Myers, 1977), and agency conflicts between managers and investors or among different groups of investors. For the most part, these theoretical predictions have been tested using reduced form regressions that attempt to explain variation in capital structure policies based on estimated slope coefficients for factors such as firm size, tax status, asset tangibility, profitability, and growth options (Rajan and Zingales, 1995; Frank and Goyal, 2007; Graham, Lemmon, and Schallheim, 1998).

In this chapter, we empirically estimate the marginal cost curve for corporate debt using an approach analogous to textbook supply/demand identification (Working, 1927; Hayashi, 2000). In our main analysis, we first simulate tax benefit functions using the approach of Graham (2000). We observe a firm's actual debt choice in a given year, which is represented by a single point on its tax benefit function, and assume for our estimation sample that this point represents the equilibrium intersection of the marginal cost and benefit of debt functions. As the benefit functions shift, the variation in the intersection points allows us to empirically map out the location of the cost of debt function. That is, we estimate what the (perceived) marginal cost of debt must be to rationalize the typical firm's capital structure choices.

These estimated marginal cost curves should capture ex ante costs that managers trade off against tax benefits as they choose their optimal capital structure. These factors include costs of financial distress and agency costs, among others.[1] Note that we do not distinguish actual costs from costs as they are perceived or responded to by managers. These perceived costs could potentially differ from actual costs due to biases in the managerial decision-making process. For example, a firm with ample potential tax benefits that uses very little debt may actually face very high costs of debt, or the company may use little debt due to managerial bias. Either way, the low debt choice would be captured as a high cost of debt in our estimation procedure.

To interpret the actual debt choice as representing the intersection of marginal cost and benefit curves, we focus on firms that appear able to make unconstrained (optimal) choices. In our main analysis we therefore set aside financially distressed companies (based on a measure of Altman's Z-score). We also set aside firms that may be financially constrained (e.g., zero debt firms) by only retaining firm-year observations in which a material rebalancing of capital structure occurs. We assume

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[1] As described in more detail below, because we start with marginal tax benefit functions, the estimated cost of debt functions also capture the non-tax benefits of debt. These non-tax benefits are effectively negative costs.

that the remaining firms make (close to) optimal debt choices, and we use these choices to back out what the (actual or perceived) costs of debt must be to justify observed debt ratios. We note that our results are robust to including these apparently distressed or constrained firms in the sample, and also to different definitions of financial constraint. Related to this issue, our analysis is robust to the presence of fixed adjustment costs. It has been argued (e.g., Fischer, Heinkel and Zechner, 1989; Leary and Roberts, 2005; and Strebulaev, 2007) that fixed adjustment costs prevent firms from responding instantaneously to changing conditions, leading to infrequent capital structure adjustments. By estimating our model on only those firm-year observations in which a substantial rebalancing of capital structure occurs, we mitigate the effect of fixed adjustment costs.

We use two different identification strategies which lead to qualitatively and quantitatively similar marginal cost of debt functions. Both of these strategies rely on variation in marginal tax benefits. In the first approach, we simulate a marginal tax benefit function for each firm-year observation. This allows us to use a panel of time series and cross-sectional benefit variation to identify the cost curve. For this approach to work, the cost curve must remain fixed as the benefit function varies. To hold the cost function fixed, we include in the specification control variables that have been used in the prior literature to capture costs. To the extent that these control variables hold the cost environment constant, we can use the remaining variation in marginal benefits to estimate the cost curve. One advantage of this method is that it can be used in any sample period, including periods when there are no tax regime changes. In particular, we show that our estimates are robust across different time subsamples and when including time dummies. Another advantage is that the inclusion of the control variables allows the cost curve to shift location conditional on firm characteristics. However, this identification method relies importantly on the assumption that the control variables are comprehensive and hold the cost environment constant. The second identification strategy deemphasizes cross-sectional variation, and the need to control for the cost environment, by relying only on time series variation in the benefit curves due to the 1986 Tax Reform Act (TRA).

Based on these identification approaches, the ex ante marginal cost of debt curves that we estimate are positively sloped (i.e., cost increases with interest expense), as expected. The positive slope is indicative of debt costs that increase directly with the amount of debt used, such as expected costs of financial distress. The location of the cost functions vary (i.e., shift) with firm characteristics such as asset collateral, size, book-to-market, intangible assets, cash flows, and dividend-paying status. That is, the location of the cost function varies with firm-specific features of the cost of debt. For example, the cost function shifts downward as a firm's collateral increases. In general, our approach produces an ex ante estimate of the net cost of debt function for a wide variety of firms. This expands upon previous research, much of which provides point estimates for the ex post cost of debt for small subsets of firms. We also produce easy-to-implement algorithms that allow researchers and practitioners to explicitly specify firm-specific debt cost functions.

As described above, we estimate the cost functions on a subsample of firms that appear not to be financially constrained or distressed. We subsequently use the estimated coefficients to compute a cost of debt curve for any firm, including those that are distressed or constrained. Armed with firm-specific simulated marginal tax benefit functions and estimated marginal cost of debt functions for thousands of companies, we can infer optimal capital structure for any given firm at the intersection of the benefit and cost curves, as illustrated in Figure 1.1.

Traditional debt cost studies examine small samples and focus on a subset of the ex post costs of debt. Warner (1977), for example, studies 11 bankrupt railroad

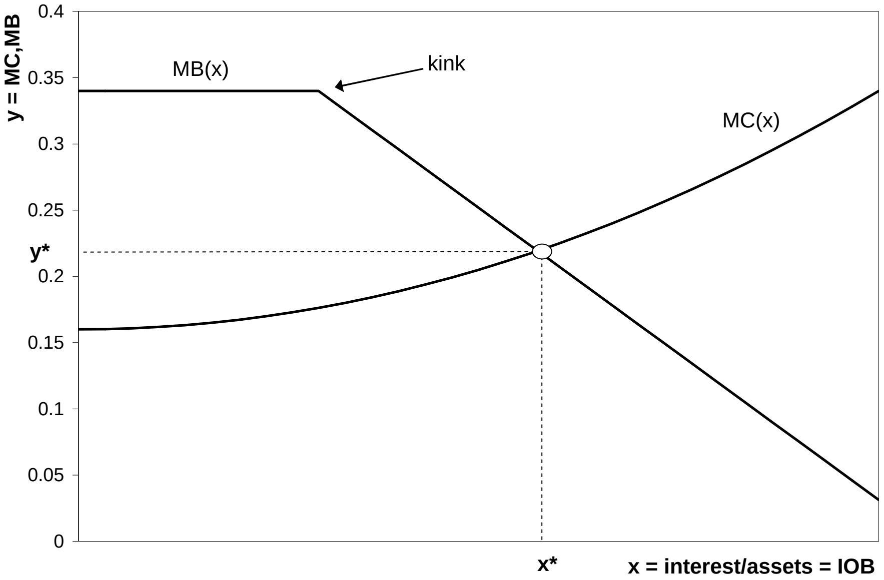

FIGURE 1.1: Capital structure equilibrium for a financially unconstrained, non-distressed firm. The figure shows the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, and the equilibrium amount of interest deductions over book value, x^*, where marginal cost and marginal benefit are equated. The equilibrium marginal benefit (which equals the equilibrium marginal cost) is denoted by y^*. Also, note that the benefit function becomes downward sloping at the point we refer to as the "kink."

companies, and estimates that ex post direct bankruptcy costs are about 5.3 percent of firm value. Weiss (1990) similarly estimates that direct bankruptcy costs are only 3.1 percent of firm value in a sample of 37 companies. Bris, Welch and Zhu (2006) estimate ex post legal costs for 212 firms filing for bankruptcy in New York and Arizona. In their sample, direct Chapter 11 expenses average about 9.5 percent of asset value. Andrade and Kaplan (1998) estimate that for a sample of 31 highly levered firms, when distress occurs the cost of financial distress is no more than 10 to 20 percent of firm value. Miller (1977) and others note that once one considers the relatively low probability that financial distress will occur, the ex ante costs of debt appear to be small. One conclusion from these traditional papers is that there must be other reasonably large costs of debt to justify the debt choices that firms make.

While these traditional papers are instructive, our analysis contributes by directly estimating ex ante all-in costs of debt, and by examining a broad cross-section of firms rather than a small ex post sample.

Recent research argues that thorough consideration leads to costs of debt that roughly equal the marginal (tax) benefits of debt in equilibrium.[2] For example, in Green and Hollifield's (2003) model, bankruptcy costs equal to three percent of firm value, combined with a personal tax disadvantage to interest income, are sufficient to justify an interior optimal debt ratio. Berk, Stanton and Zechner (2006) conclude that higher wages due to increased labor risk associated with greater corporate leverage should be modeled as a cost of debt. Carlson and Lazrak (2006) argue that increased firm risk due to asset substitution produces costs sufficient to offset the tax benefits of debt. Our approach captures these and other costs of debt that drive observed (equilibrium) corporate debt choices. The resulting cost curve is a positive function of the level of debt and its location is conditional on firm characteristics related to the theorized factors just discussed, among others.

Our approach is related to three other recent papers. Almeida and Philippon (2007) derive risk-neutral probabilities of default that capture the fact that the marginal utility of money is high in distress states. (Chen (2008) and Bhamra, Kuhn and Strebulaev (2008) make a similar point.) Using these probabilities, they estimate that the expected cost of distress is approximately equal to the tax benefits of debt estimated in Graham (2000), suggesting that on average observed capital structure is consistent with optimal choices. More specifically, the authors provide a point estimate of the cost of default that is about four percent of firm value for investment grade firms and about nine percent for speculative debt. We estimate that the all-in cost of debt is about six (seventeen) percent of firm value for invest-

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[2] In addition, see Parrino and Weisbach (1999).

ment (speculative) grade firms. Therefore, our estimates are in the same ballpark but larger than Almeida and Philippon's, which makes sense because their estimates capture default costs while ours include default as well as other costs of debt (such as agency costs). Overall, our analysis shows that default costs, as estimated by Almeida and Philippon (2007), amount to approximately half of the total costs of debt, leaving about half of the costs to be explained by other factors and theories.[3]

Korteweg (2009) estimates the net benefits to leverage from a data set of about 30,000 firm-months between 1994 and 2004. By generalizing the Modigliani-Miller beta levering and firm valuation formulas, he estimates how the net benefits of debt must vary with leverage and other covariates to explain the observed variation in stock and bond betas and valuations. For identification he assumes within-industry homogeneity with respect to asset betas, but he allows the net benefit function to vary on a firm-by-firm basis, based on individual firm characteristics. Even with this different approach, he estimates median net benefits to leverage of about 4% relative to total firm value, close to our results.

Finally, Morellec, Nikolov and Schuerhoff (2008) argue that, from a manager's point of view, debt is constraining to the extent that it can justify observed capital structure levels. As mentioned before, our framework captures costs as they are perceived or responded to by managers to the extent they are reflected in debt choice.

The rest of the chapter proceeds as follows. In Section 1.1, we explain the main intuition and econometric issues underlying our instrumental variables approach and provide details for our identification strategies. In Section 1.2, we describe the data and our sample selection process. In Section 1.3, we present and discuss our results,

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[3] We also benchmark the reasonableness of our numbers by showing that our estimated cost of debt for firms in the 90th to 99th percentile range are very similar to the costs estimated by Andrade and Kaplan (1998) for highly levered firms.

and in Section 1.4 we describe how to compute firm-specific marginal cost of debt functions. In Section 1.5, we use the marginal cost of debt function to quantify the total cost of debt and compare to benchmarks in the literature. Section 1.6 discusses several robustness checks. Finally, Section 1.7 summarizes the main points of the chapter.

1.1 Estimating Marginal Cost Curves

The main objective of this chapter is to estimate the marginal cost curve of debt, given in equation (1.1). In particular, we estimate a linear parametrization in which the marginal cost of debt for firm $i \in 1, ..., N$ at time $t \in 1, ..., T$ is linear in the amount of leverage, $x_{i,t}$, and a set of control variables, C:

$$MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} + \xi_{i,t}. \tag{1.1}$$

In this parametrization, a denotes the intercept of the marginal cost curve of debt and b denotes the slope.[4] Each θ_c is a coefficient for the firm specific control variables in C. The variable $\xi_{i,t}$ is an orthogonal shock.[5]

In Section 1.1.1, we present the general methodology and equations we use to estimate the marginal cost of debt. Section 1.1.2 details two separate identification strategies. Section 1.1.3 compares and contrasts the two strategies.

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[4] Note that linearity of the marginal cost of debt implies that the total cost of debt is a quadratic function of interest ($x_{i,t}$). Further, a positive slope on $x_{i,t}$ in the marginal cost function implies that the total cost curve is convex.

[5] We explore a generalization of equation (1.1) in which we include interaction terms between leverage and each of the control variables. In this generalization both the slope and the intercept of the marginal cost curve depend on the control variables. We find that this generalization adds little to the fit of the model, nor does it change any of our main conclusions. The results are available upon request.

1.1.1 General Method

We use exogenous variation of the marginal benefit curve of debt to identify the marginal cost curve of debt. To obtain a firm-year panel of benefit curves, we simulate the tax benefit for each dollar of incremental interest deduction using the method of Graham (2000). More generally, let $MB_{i,t}$ denote the marginal benefit curve of debt of firm i at time t as a function of the amount of leverage and an orthogonal shock $\eta_{i,t}$:

$$MB_{i,t} = f_{i,t}(x_{i,t}) + \eta_{i,t}. \tag{1.2}$$

The shock $\eta_{i,t}$ represents a shift of the marginal benefit curve.

We assume that financially unconstrained, non-distressed firms choose their equilibrium debt level optimally. Therefore, the observed level of debt of firm i in year t is the value of $x^*_{i,t}$ where the marginal benefit curve and the marginal cost curve intersect. Henceforth, for firms in our main sample, we refer to this observed level of debt as the "equilibrium amount of interest" or the "equilibrium level of debt," denoted by $x^*_{i,t}$. We refer to the corresponding "equilibrium marginal benefit/cost of debt" as $y^*_{i,t}$. In equilibrium, at $x_{i,t} = x^*_{i,t}$, it holds that:

$$y^*_{i,t} = MC_{i,t}\left(x^*_{i,t}\right) = MB_{i,t}\left(x^*_{i,t}\right). \tag{1.3}$$

To estimate the marginal cost curve of debt, one can not simply perform an OLS regression of $y^*_{i,t}$ on $x^*_{i,t}$ and the controls, as in equation (1.1). Since leverage and marginal costs/benefits are determined jointly, there is an endogeneity problem. If we use OLS, this endogeneity problem can lead to biased estimates.[6] Based on equilibrium $(x^*_{i,t}, y^*_{i,t})$ choices, OLS is unable to distinguish whether variation in these choices is due to shifts in the marginal cost or benefit curves, and hence is unable

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[6] The classic illustration of biases created by endogenous regressors is Working (1927), who explores this problem in the context of supply and demand curves. See also Hayashi (2000).

to identify either curve unambiguously. Furthermore, shifts of the marginal benefit curve ($\eta_{i,t}$) are potentially correlated with shifts of the marginal cost curve ($\xi_{i,t}$). By using instrumental variables that proxy for benefit shifts and that are uncorrelated with cost shifts, we can identify the cost curve.[7]

Suppose that we have an instrument z. As described above, this instrument needs to satisfy two criteria. It needs to be correlated with shifts of the marginal benefit curve, and it needs to be uncorrelated with shifts of the marginal cost curve:

$$\begin{aligned} corr\left(z,\eta\right) &\neq 0 \qquad (1.4) \\ corr\left(z,\xi\right) &= 0. \qquad (1.5) \end{aligned}$$

Identification thus requires *exogenous* variation in the marginal benefit curve; that is, the marginal benefit curve of debt must shift while the marginal cost curve remains constant. The exogenous benefit variation may result from time series shifts of the marginal benefit curve of firm i, e.g., tax regime shifts, or, alternatively, from cross-sectional variation in the location of the marginal benefit curve of debt at some time t. See Figure 1.2 for an illustration.

With an instrument, z, that satisfies the two conditions above, one can use two stage least squares (2SLS) to estimate the marginal cost curve depicted in equation (1.1). The first stage regression consists of regressing x on z and C control variables, and obtaining fitted values, $\hat{x}$. In the second stage regression, y is regressed on the fitted value of the first stage, $\hat{x}$, and the C control variables. The standard errors of the second stage of a 2SLS regression do not reflect the uncertainty of the first stage estimation and should therefore not be used to compute the t-statistics of estimated coefficients. Instead, we report GMM standard errors. These standard errors are

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[7] In unreported analysis, we use OLS (without instruments) to directly estimate equation (1.1). The estimated slopes are negative, small, and insignificant, implying that the OLS estimates result in a line that lies somewhere between the marginal benefit and marginal cost curves.

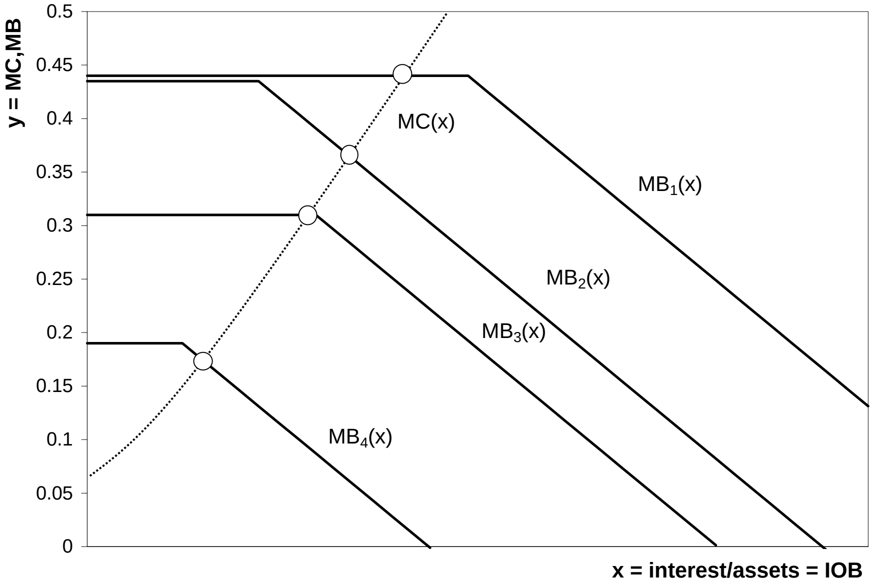

FIGURE 1.2: Identifying the cost function using shifts in the marginal benefit function. The figure shows four marginal benefit curves of debt, each intersected by the marginal cost curve of debt. The four marginal benefit curves can represent the same firm at four different points in time. The marginal benefit curves can alternatively represent four different firms at the same point in time. Empirically, we use both cross-sectional and time-series variation in marginal benefit curves to identify the marginal cost function of debt. Notice that the area under the marginal benefit curve, A, is a good proxy for the location of the curve: $MB_1(x) \geq MB_2(x) \geq MB_3(x) \geq MB_4(x)$ implies that $A_1 \geq A_2 \geq A_3 \geq A_4$.

double clustered by both firm and year as in Thompson (2006) and Petersen (2008). The moments corresponding to the estimation procedure are given by:

$$g_a(a, b, \{\theta_c\}) = \frac{1}{NT}\sum_i \sum_t \left(y_{i,t} - a - bx_{i,t} - \sum_{c \in C} \theta_c c_{i,t} \right), \tag{1.6}$$

$$g_z(a, b, \{\theta_c\}) = \frac{1}{NT}\sum_i \sum_t \left(y_{i,t} - a - bx_{i,t} - \sum_{c \in C} \theta_c c_{i,t} \right) z_{i,t}, \tag{1.7}$$

$$g_c(a, b, \{\theta_c\}) = \frac{1}{NT}\sum_i \sum_t \left(y_{i,t} - a - bx_{i,t} - \sum_{c \in C} \theta_c c_{i,t} \right) c_{i,t}, \quad \text{for } c \in C. \tag{1.8}$$

Apart from these standard errors, we present our results in terms of 2SLS to facilitate exposition. See Appendix 1.A for a detailed discussion of the 2SLS procedure as well as the first stage regression results.

1.1.2 Identification Strategies

In this section, we detail two separate identification approaches that we use to identify the marginal cost curve of debt. These approaches can broadly be characterized as follows: (i) Panel Approach, (ii) 1986 Tax Reform Act. Both identification strategies use variation in marginal tax benefits of debt to identify the cost curve. The set of control variables C is the same for each strategy. The identifying instrument, $z_{i,t}$, that we use in each identification strategy is given by:

(i) the area under the marginal benefit curve: $\mathrm{A}_{i,t}$. (See Section 1.1.2.)

(ii) the implementation of the 1986 TRA: $\mathrm{TRA86}_{i,t}$. (See Section 1.1.2.)

Identification Strategy (i): Panel Approach

Our panel of simulated marginal benefit curves exhibits substantial variation both in the time series and in the cross-section. The time series variation is mainly due to tax regime changes, such as the Tax Reform Act (TRA) of 1986. The cross-sectional variation in benefit curves is related to (but not limited to) the occurrence of taxable losses and the ability to carry those losses backwards or forward. We use this variation of the marginal benefit curves to identify the marginal cost curve of debt.

As noted above, we have the advantage of observing a simulated version of the *whole* marginal benefit curve of debt. This allows us to observe the variation in (or shifts of) these benefit curves. To measure these shifts, we first compute for each firm in each year the total potential tax benefit of debt, $A_{i,t}$, which is equal to the area under the marginal tax benefit curve:

$$A_{i,t} = \int_{0}^{\infty} f_{i,t}\left(x_{i,t}\right) dx_{i,t}. \tag{1.9}$$

Since the area under the curve measures the total potential tax benefits, $A_{i,t}$ provides a natural description of the location of the marginal benefit curve and accommodates non-linearities in benefits. If the marginal benefit curve shifts upward (downward), then the area under the curve increases (decreases) in tandem. Henceforth, we interpret variation in this area measure as variation (shifts) of the marginal benefit curve.[8] That is, for this specification, $z \equiv \{A\}$.

As conveyed in equations (1.4) and (1.5), to obtain unbiased cost estimates we should only use variation of the marginal benefit curve that is uncorrelated with variation in the marginal cost curve. To accomplish this, we include in the specification a set of control variables C that are theorized to be correlated with the location of the debt cost curve: a measure for firms' collateralizable assets ($COL_{i,t}$), the log of total assets ($LTA_{i,t}$), the book-to-market ratio ($BTM_{i,t}$), a measure for firms' intangible assets ($INTANG_{i,t}$), cash flow ($CF_{i,t}$), and whether the firm pays dividends ($DDIV_{i,t}$). These variables represent the standard measures of debt costs extensively used in the literature (Frank and Goyal, 2007).[9] In summary, C denotes the set of cost control variables that drive the location of the MC curve:

$$C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}. \tag{1.10}$$

Assuming that these control variables adequately hold the cost environment constant, the remaining variation of the marginal benefit curves can be used to identify the cost curve.

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[8] We explore alternative definitions that capture shifts of the marginal benefit curve, such as partitions of the area measure, or including as a second instrument the location of the kink in the marginal benefit curve. We repeat the analysis and all results hold. For ease of exposition, we focus on the area measure.

[9] These variables are defined in Section 1.2 and in Appendix 1.B.

We estimate this specification both with and without year dummies in both stages of the regression. Including year dummies ensures that the identification of the slope of the cost curve is driven by the *cross-sectional* variation of the marginal benefit curves and not by time series variation. Reassuringly, we estimate similar cost curves in both cases.

Identification Strategy (ii): 1986 Tax Reform Act

Identification strategy (ii) uses the Tax Reform Act (TRA) of 1986 to identify the marginal cost of debt curve. Under the 1986 TRA, corporate tax rates were reduced by 12 percentage points for most firms. Furthermore, the 1986 TRA was phased-in in a manner that differentially moves firms with different fiscal year-ends into the new, lower tax regime. For example, firms with fiscal year-ends in June 1987 had all 12 months of income subject to tax rates at the old 46 percent tax rate that year (see Maydew 1997). Income for upper bracket July 1987 fiscal year-end firms was subject to a blended tax rate that was $\frac{1}{12}$ of the new 34 percent statutory tax rate and $\frac{11}{12}$ of the old 46 percent tax rate. Firms with a fiscal year end in August were exposed to $\frac{2}{12}$ of the new tax rate and $\frac{10}{12}$ of the previous tax rate for each income bracket, and so on. Firms with December fiscal year ends faced half of the old tax regime and half of the new tax regime (i.e., an upper bracket maximum tax rate of $\frac{1}{2}(0.46)+\frac{1}{2}(0.34)=0.40$). By June 1988, all firms had switched over to the new regime that had a maximum 34 percent tax rate. This phase-in offers the identification advantage of the tax rate change affecting otherwise similar firms at slightly different points in time.

Let $\text{fyr}_{i,t}$ denote the month of firm i's fiscal year end in year t and let $\text{TRA86}_{i,t}$ denote the variable that captures the phase-in of the new tax regime. $\text{TRA86}_{i,t}$ takes the value 0 in and before 1986 and takes the value 1 in and after 1989. For 1987 and

1988, the phase-in variable is defined as:

$$\mathrm{TRA86}_{i,t} = \begin{cases} 0, & \text{if } \mathrm{fyr}_{i,t} \leq 6 \text{ and } t = 1987, \text{ or } t < 1987 \\ (\mathrm{fyr}_{i,t} - 6)/12 & \text{if } \mathrm{fyr}_{i,t} > 6 \text{ and } t = 1987 \\ (\mathrm{fyr}_{i,t} + 6)/12 & \text{if } \mathrm{fyr}_{i,t} \leq 6 \text{ and } t = 1988 \\ 1, & \text{if } \mathrm{fyr}_{i,t} > 6 \text{ and } t = 1988, \text{ or } t > 1988. \end{cases} \tag{1.11}$$

In our second identification strategy, we use $\mathrm{TRA86}_{i,t}$ as our identifying instrument. This instrument allows identification from the Tax Reform Act of 1986 to come from two sources: 1) a general before and after time-series effect captured by the 0 before 1987 and 1 after 1988, and 2) an additional effect captured by the 1/12, 2/12, etc. phasing-in that affects different firms differently depending on their fiscal year-ends. In unreported analysis, we document that identification is possible based on either 1) or 2) above; however, we combine the two in the $\mathrm{TRA86}_{i,t}$ variable used in specification (ii).

1.1.3 Comparing the Two Identification Strategies

Both of the identification strategies above have advantages and disadvantages. Identification strategy (i) uses all of the variation in the marginal benefit curves available in the data panel. This includes both time series and cross sectional variation. Recall that a unique advantage of our data set is that we "observe" the *whole* simulated marginal benefit curve of debt, and not just the equilibrium points where the marginal cost and marginal benefit curves intersect.[10] In other words we observe a simulated proxy for shocks to the marginal benefit curve $\eta_{i,t}$, which we argue allows us to create an instrument, $\mathrm{A}_{i,t}$, that is highly correlated with these marginal benefit shifts, as required by equation (1.4). In identification method (ii), this advantage of knowing the whole benefit function is not exploited. Moreover, identification strategy (i) can

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[10] In many cases, including the Working (1927) example, one only observes equilibrium points. In Working (1927) these equilibrium points are equilibrium prices and quantities. We have the advantage of "observing" one of the two curves. In the Working (1927) analogy this implies observing the whole demand curve.

be used in periods in which there are no corporate tax regime shifts.

The downside of identification strategy (i) is that, in order for it to produce valid estimates, the potential correlation between marginal benefit shifts and marginal cost shifts needs to be captured fully by the cost control variables so as to fulfill the criteria in equation (1.5). As such, omitted variables might lead to biased cost curve estimates. Specification (ii) arguably relies less on this assumption, although we include cost control variables in both identification strategies. However, the associated cost of specification (ii) is that the information used for identification is more limited than the information used in specification (i). In addition to the variation of specification (ii), specification (i) also includes variation due to other tax regime changes as well as cross-sectional variation. Due to this trade-off between information and the need to control for the cost environment, we present the estimation results of both strategies. Reassuringly, we find similar results for both strategies.

1.2 Data and Summary Statistics

1.2.1 Marginal Tax Benefit Curves

Our marginal benefit curves are derived as in Graham (2000). Each point on a benefit function measures the present value tax benefit of a dollar of interest deduction. To illustrate, ignore for this paragraph dynamic features of the tax code such as tax loss carryforwards and carrybacks and other complexities. The first point on the tax benefit function measures the tax savings associated with deducting the first dollar of interest. Additional points on the function measure the tax savings from deducting a second dollar of interest, a third dollar, and so on. Based on the current statutory federal tax schedule, each of these initial interest deductions would be worth \$0.35 for a profitable firm, where 0.35 is the corporate marginal income tax rate. At some point, as incremental interest deductions are added, all taxable income would be shielded by interest deductions, and incremental deductions would be worthless. Therefore, ignoring the complexities of the tax code, a static tax benefit function would be a step function that has an initial value of 0.35 and eventually drops to 0.0.

The dynamic and complex features of the tax code have a tendency to stretch out and smooth the benefit function. First, consider dynamic features such as tax loss carryforwards. At the point at which all current taxable income is shielded by current interest deductions, an extra dollar of interest leads to a loss today, which is carried forward to shield profits in future years. For example, if that extra dollar of interest today effectively shields income next year, it will save the firm \$0.35 one year from today. In this situation, the present value tax savings from an incremental dollar of interest today is worth the present value of \$0.35 today, or about \$0.33. Once carryforwards are considered, therefore, rather than stepping straight down to zero at the point of surplus current-period interest deductions, the benefit function slopes downward, reaching zero gradually. Other features of the tax code that we consider, such as tax loss carrybacks, the alternative minimum tax, and investment tax credits also smooth the tax benefit function (see Graham and Smith, 1999, for details).

Second, consider an uncertain world in which the probability of profitability is between zero and one. Say, for example, that there is a 50-50 chance that a firm will be profitable. In this case, even with a simple, static tax code, the expected tax benefit is \$0.175 for one dollar of interest deduction if profits are taxed at 35 percent. Therefore, we simulate tax benefit functions so that our measure of the tax benefit of interest deductions at any given point is conditional on the probability that the firm will be taxable today and in the future.

More specifically, we calculate one point on a tax benefit function for one firm in one year as follows. (Recall that each point on the function represents the expected corporate marginal tax rate (MTR) for that level of taxable income net of interest deduction.) The first step for a given firm-year involves calculating the historic mean and variance of the change in taxable income for each firm. Using this historical information, the second step forecasts future income many years into the future to allow for full effects of the tax carryforward feature of the tax code (e.g., 2006 tax law specified that tax losses could be carried forward 20 years into the future and back two years, so we forecast 22 years into the future when simulating the 2006 benefit curves). These forecasts are generated with random draws from a normal distribution, with mean and variance equal to that gathered in the first step; therefore, many different forecasts of the future can be generated for each firm.[11] In particular, we produce 50 forecasts of the future for each firm in each year.

The third step calculates the present value tax liability along each of the 50 income paths generated in the second step, accounting for the tax-loss carryback, carryforward, and other dynamic features of the tax code. The fourth step adds $10,000 (the smallest increment observable in Compustat data) to current year income and recalculates the present value tax liability along each path. The incremental tax liability calculated in the fourth step, minus that calculated in the third step, is the present value tax liability from earning extra income today; in other words, the economic MTR. A separate marginal tax rate is calculated along each of the forecasted income paths to capture the different tax situations a firm might experience in different future scenarios. The idea is to mimic the different planning scenarios that a manager might consider. The final step averages across the MTRs from the 50 different scenarios to calculate the expected economic marginal tax rate for a given

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[11] As an alternative to using this random walk with drift model to forecast future taxable income, we construct benefit functions based on the bin forecasting model of Blouin, Core and Guay (2009). Using this alternative approach does not change our qualitative conclusions.

firm-year.

These five steps produce the expected marginal tax rate for a single firm-year, for a given level of interest deduction. To calculate the entire benefit function (for a given firm in a given year), we replicate steps two through five for 17 different levels of interest deductions. Expressed as a proportion of the actual interest that a firm deducted in a given firm-year, these 17 levels are 0%, 20%, 40%, 60%, 80%, 100%, 120%, 160%, 200%, 300%, 400%, ..., 1000%. To clarify, 100% represents the actual level of deductions taken, so this point on the benefit function represents that firm's actual marginal tax rate in a given year, considering the present value effects of the dynamic tax code. The marginal tax benefit function is completed by "connecting the dots" created by the 17 discrete levels of interest deduction. Note that the area under the benefit function up to the 100% point represents the gross tax benefit of debt for a given firm in a given year for its chosen capital structure, ignoring all costs.

These steps are replicated for each firm for each year, to produce a panel of firm-year tax benefit functions for each year from 1980 to 2007. The benefit functions in this panel vary across firms. They can also vary through time for a given firm as the tax code or the firm's circumstances change.

1.2.2 Corporate Financial Statement Data

We obtain corporate financial statement data from Standard & Poor's Compustat database from 1980 to 2007 and calculate tax benefit functions for 126,611 firm-year observations. We normalize interest expense by total book assets, which hereafter we refer to as interest-over-book (IOB). Control variables COL, INTANG, and CF are also normalized by total book assets. For the construction of LTA, we chain total book assets to 2000 dollars to adjust for inflation before taking logarithms. We further remove any firms with negative book asset value, common equity, capital, sales, or dividends. Such firms have either unreliable Compustat data or are likely to be distressed or severely unprofitable and therefore constrained with respect to accessing financial markets. Next, we delete observations that are involved in substantial M&A activity, defined as acquisitions amounting to over 15 percent of total assets. Third, we remove outliers defined as firm-year observations that are in the first and 99th percentile tails for (i) area under the marginal benefits curve (A), (ii) the observed interest-over-book (IOB), (iii) the book to market ratio (BTM), and (iv) the cashflow over assets ratio (CF).[12] Finally we remove all firms in the financial and insurance, utilities, and public administration industries because they tend to be heavily regulated. This results in a sample of 91,687 firm-years, of which 79,942 have non-missing data for IOB and all control variables. Table 1.1 provides an overview of the sample construction.

For each firm, we create empirical measures of the following control variables: collateralizable assets (plant, property, equipment and inventory) over total book assets (COL), log of total book assets (LTA), book equity to market equity (BTM), intangible assets over total book assets (INTANG), cash flow over total book assets (CF), and an indicator for a dividend paying firm (DDIV). We measure financial distress by a modified version of Altman's (1968) Z-score (ZSCORE). Firms are conservatively defined to be non-distressed if they have ZSCOREs in the top tercile. We measure financial constraint as having limited long-term leverage adjustments, as defined by LTDEIR.[13] This approach allows us to address issues related to fixed adjustment costs, as discussed below. Appendix 1.B provides a detailed description of the construction of the control variables.

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[12] Removing the outliers of the other control variables (COL, LTA, INTANG, and DDIV) does not change the distribution of the sample much.

[13] We also look at two other definitions for financial constraint offered in the literature: (i) the Cleary (1999) index (CL), and (ii) the Whited and Wu (2005) index (WW). These are discussed in Section 1.6.

1.2.3 Data Samples, Financial Constraint, and Financial Distress

We perform our empirical analysis on two primary samples:

Sample A : All firm-year observations with non-missing marginal benefit curves, interest over book values, and all control variables

Sample B : Financially non-distressed and unconstrained firms: ZSCORE in top tercile and equity or long term debt issuances/repurchases (LTDEIR) in top tercile

Equity and long-term debt issuances and reductions are obtained from the statement of cash flows and normalized by total book assets. Firms are defined to be financially unconstrained in Sample B if they have any equity issuance, equity reduction, long-term debt issuance, and long-term debt reduction, i.e., any capital structure adjustments (LTDEIR), that are in the top tercile.[14] Summary statistics for the four separate measures are presented in Table 1.2.

There are two reasons that we focus our attention on Sample B. First, our empirical approach assumes that observed debt ratios represent equilibrium choices. Compared to constrained or distressed firms, the observations in Sample B are relatively likely to represent unconstrained, long-term capital structure equilibria. Of course, one could argue that the constrained and distressed firms included in Sample A also make optimal choices, possibly in response to steeper cost functions. In this way of thinking, comparing the results across the samples will highlight the differing costs facing distressed and constrained firms. A conservative cutoff makes it more likely that the firms in our estimation sample are able to make unconstrained (optimal) choices. However, the actual cutoff of the top tercile is arbitrary and is not

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[14] The top tercile is an arbitrary cutoff in an effort to be conservative as we define financially non-distressed and unconstrained and to ensure the validity of the firms in our estimation sample. We explore other cutoffs in section 1.6, and this does not affect our results.

crucial to our estimation results.

The second reason that we focus on Sample B is to attenuate the effect of observations that might be severely affected by fixed adjustment costs. Recent research highlights that firms might not continuously fine-tune their leverage ratios due to non-negligible adjustment costs (Fisher, Heinkel and Zechner, 1989; Leary and Roberts, 2005; Kurshev and Strebulaev, 2006; etc.), which can lead to data that reflect passive, or no change, observations. Sample B avoids this issue by only including firm-year observations for which there is substantial long-term debt and/or equity issuance or repurchase observations for which fixed transactions did not constrain the firm into inaction. Sample B includes firms that are financially unconstrained, defined as having either (i) equity issuances, (ii) equity repurchases, (iii) debt issuances or (iv) debt repurchases above the 66th percentile.[15] Our main results do not change if we loosen or tighten the definition and include firms above the median or 75th percentile. Overall, relative to Sample A, Sample B should be relatively free of the effects of financial constraints, financial distress, and fixed adjustment costs and thus we can interpret observations as representing "equilibrium choices." Table 1.2 presents the summary statistics for the samples.

1.3 Estimation Results

As described in Section 1.1.2, we estimate the marginal cost curve for two main specifications: (i) Panel Approach, (ii) 1986 Tax Reform Act. We repeat specification (i) with firm fixed effects and year fixed effects, which we denote as (iii) and (iv), respectively.

Tables 1.3 and 1.4 report the estimation results of these specifications for Samples B and A, respectively. All control variables, except DDIV, are standardized (i.e., have

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[15] All four categories are scaled by book value.

mean zero and standard deviation of one within Sample A) so that the coefficients have a one standard deviation interpretation. DDIV is a binary variable with values of {0,1}.

We analyze the estimation results in detail below, but first discuss some overarching issues. The signs on the coefficients of the cost control variables are consistent across samples and specifications. It is worth noting that, compared to panel specification (i), the slope is somewhat larger in TRA86 specification (ii), but the intercepts are smaller. So relatively speaking, the MC curve pivots upward in specification (ii). Thus, it is hard to say unambiguously that one estimated MC curve dominates the other (because slope and intercept effects offset). Furthermore, compared to specification (i), the standard errors in specification (ii) are larger. This is expected given that much capital structure variation is cross-sectional (Lemmon, Roberts, Zender, 2008) and not captured in specification (ii). Nonetheless, the qualitative similarity across these two approaches is reassuring.

Within our framework, the capital structure decision follows from a tradeoff between the costs and benefits of debt. It is important to highlight that our marginal benefit curves only measure the tax benefits of debt. As a consequence, the other benefits of debt, such as committing managers to operate efficiently (Jensen, 1986) and engaging lenders to monitor the firm (Jensen and Meckling, 1976), are included as negative costs, and therefore are reflected in our estimated marginal cost curves. Our cost curves also include the traditional costs of debt, such as the cost of financial distress (Scott, 1976), debt overhang (Myers, 1977), agency conflicts between managers and investors, and any other cost or nontax benefits that are reflected in the optimal debt choices. As noted in the introduction, there is ambiguity regarding which agent optimizes debt policy (e.g., managers versus shareholders), and we do not attempt to determine the identity of the optimizing agent.

Below we interpret the cost coefficients embedded in the cost of debt functions, and compare the implications from these coefficients to capital structure regularities documented in the literature. For expositional reasons we henceforth focus on the analysis of Sample B for specification (i), the panel identification approach. Table 1.A summarizes the effect of the control variables on the cost of debt function, and compares these coefficients to standard capital structure results (as presented in Frank and Goyal (2007) and elsewhere). As we highlight below when we discuss the individual control variables, the effects of the control variables on the cost of debt function are consistent with debt usage implications in the existing capital structure literature. This is reassuring, in spite of the fact that we take a different approach and have a different dependent variable ($y^*_{i,t}$) than the existing literature.[16] As for the sign of any given coefficient, there are still open questions in the capital structure literature in terms of interpreting individual coefficients, and by no means does our procedure resolve all the open questions. Rather, our procedure quantifies just how large the influence of individual variables on the cost of debt must be to explain observed capital structure choices.

1.3.1 Marginal Cost Curves

In this section, we discuss the estimated cost curves. Based on panel identification strategy (i), the typical firm has a cost curve of debt with an estimated slope of 4.810 and estimated intercept of 0.112. That is, when control variables are set to their mean values (of zero since they are standardized) and DDIV is set to 0, the estimated slope of the interest-over-book variable equals 4.810 and the estimated intercept is 0.112. Therefore, if IOB changes from 0.02 to 0.03, the marginal cost of taking on this additional debt would be 16.0 cents (= 4.810*0.01 + 0.112) per

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[16] Our approach has a measure of debt on the right hand side, while in the traditional approach debt is on the left hand side as dependent variable. The coefficients we estimate should have the opposite sign to be consistent with the estimates in the traditional approach.

	Dependent Variable	
Control Variable	Cost of Debt	Leverage
COL	−	+
LTA	+	+/-
BTM	−	+
INTANG	−	+
CF	+	−
DDIV	+	−

Table 1.A: The influence of each of the control variables on the cost of debt (as estimated in Tables 1.3 and 1.4) is shown in the left column, in comparison to the influence of the variable on the corporate debt ratios in the right column (as documented in the capital structure literature). COL is asset collateralizability, LTA is firm size in terms of book assets, BTM is the book to market ratio, INTANG is asset intangibility, CF is cashflow, and DDIV is an indicator for dividend paying firms. Generally speaking, our estimated coefficients are consistent with those in the capital structure literature, given that the coefficient signs are opposite between the two approaches.

dollar of interest.[17]

The -0.040 coefficient on COL implies that high collateral firms have a lower cost of debt. All else being equal, a lower cost of debt should lead to higher debt usage, which is consistent with the positive relation between COL and debt ratios found in the standard capital structure literature, as shown in Table 1.A. Further, all else equal, a firm that has COL one standard deviation larger than the average faces a marginal cost intercept of 0.072 as opposed to 0.112 (as shown in Figure 1.3).

The 0.016 coefficient on LTA indicates that large firms face a higher cost of debt. Holding all else constant, a firm that has LTA one standard deviation higher than the average faces an intercept of 0.128 as opposed to 0.112. This might initially seem surprising because it implies that large firms face higher costs of debt or at least make choices as if they do. However, note that our result is consistent with recent

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[17] Recall that the intercept of the marginal cost curve equals the slope of the total cost curve, and the slope of the marginal cost curve equals the convexity of the total cost curve.

research that indicates that large firms use less debt (Faulkender and Petersen, 2006; Kurshev and Strebulaev, 2006).[18] In contrast, other research (as summarized in Frank and Goyal, 2007) documents a positive relation between size and debt usage. The differing firm size implications documented in various capital structure papers implies that the influence of size on the costs versus benefits of debt varies in different settings and samples. In our sample, larger firms use less debt (ceteris paribus) which is consistent with a higher cost of debt.

Firms with growth opportunities (i.e., low book-to-market (BTM)) on average face a higher cost of debt (coefficient of -0.018). This is consistent with the common finding that for growth firms the opportunity cost of debt is high because debt can restrict a firm's ability to exercise future growth opportunities due to debt overhang (Myers, 1977). The inflexibility arising from debt covenants could also restrict a firm's ability to optimally invest and exercise growth options, effectively increasing the cost of debt.

The coefficients on the other variables also have implications that are similar to extant capital structure research (see Table A). The -0.025 coefficient on INTANG suggest that firms with more intangible assets face lower costs of debt, consistent with intangibles supporting debt claims in ways similar to collaterizable assets. The 0.085 coefficient on CF implies that firms with high cash flow behave as though they face higher costs by using less debt, consistent with implications from the pecking order theory. Finally, the 0.064 coefficient on DDIV indicates that dividend paying firms face higher costs of debt, perhaps because dividends are rarely omitted (Brav et al., 2005), and therefore, all else being equal, leave fewer funds to cover interest obligations.

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[18] Kurshev and Strebulaev (2006) argue that fixed costs of external financing lead to infrequent restructuring and create a wedge between small and large firms. Small firms choose proportionally more leverage at the moment of refinancing to compensate for less frequent rebalancing.

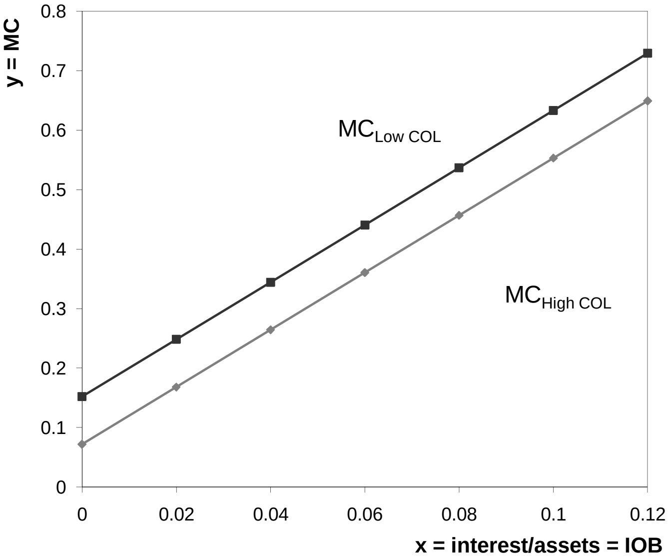

FIGURE 1.3: Comparing marginal cost curves for firms with high and low asset collateral (COL). The figure shows the effect of a one standard deviation increase (decrease) in COL when all other firm characteristics remain at the average. Firms with high collateral face a lower cost of debt.

1.4 Firm-Specific Costs

Using the estimated coefficients from the panel specification (i) in Table 1.3, the marginal cost of debt for any particular firm i at time t can be computed by:

$$MC(IOB) = \alpha + \beta * IOB \tag{1.12}$$

with

$$\begin{aligned} \alpha &= 0.112 - 0.040\ \textsc{col} + 0.016\ \textsc{lta} - 0.018\ \textsc{btm} - 0.025\ \textsc{intang} + 0.085\ \textsc{cf} + 0.064\ \textsc{ddiv} \\ \beta &= 4.810 \end{aligned}$$

Each of the control variables, except DDIV, is standardized (demeaned and divided by the standard deviation) to have a mean of zero and a standard deviation of one. DDIV is a binary variable with values of {0,1}. The mean and standard deviation for each of the non-standardized control variables are reported below:

	COL	LTA	BTM	INTANG	CF
Mean	0.494	5.022	0.757	0.057	0.087
Std. Dev.	0.232	2.171	0.627	0.105	0.163

The equation above provides a linear approximation for firm-specific MC curves of debt. It can be used to estimate the marginal cost of debt for a firm at any given level of debt (IOB). Thus, equation (1.12) allows us to compare marginal costs across firms or subsets of firms, and, when combined with the marginal benefit curves of debt, draw inference about optimal capital structure. Moreover, the estimated marginal cost curve includes not only expected bankruptcy costs, but all costs that are relevant to a firm's capital structure decision. Therefore equation (1.12) can be used in future capital structure research to estimate debt costs.

1.4.1 The Representative Firm

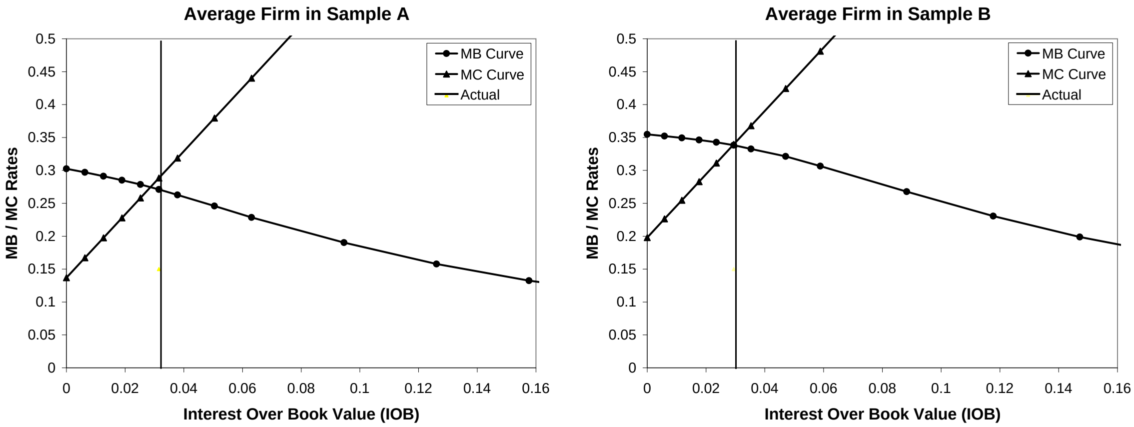

FIGURE 1.4: The average (representative) firms in Samples A and B. The marginal benefit curves are based on the average marginal tax benefit and interest over book values for each sample. The marginal cost curves are obtained using equation (1.12) and sample means of the standardized cost control variables.

In Table 1.5 and Figure 1.4 we show the marginal benefit and cost curves for the average (representative) firm in Samples A and B using data from 1980 to 2007. The marginal cost curves are derived using equation (1.12) above. For Sample A, we set the control variables equal to their average values (0 for all controls except DDIV, which has an average of 0.384) to arrive at the cost curve of debt for the average firm. For Sample B, we calculate the average standardized values for each control variable, using the means and standard deviations from the table above. We then apply these values to equation (1.12). To obtain the average marginal benefit curve, we compute the sample average marginal tax rate and interest over book value at 0%, 20%, 40%, ..., 1000% of the observed IOB.

Figure 1.4 indicates that, on average, firms in Sample B are in equilibrium, as is assumed in the sample estimation. Sample A also includes financially constrained and distressed firms. Relative to Sample B, the average marginal benefit curve in Sample A is shifted downward, and the representative firm is slightly overlevered. The MB and MC data presented in Table 1.5 can be used by researchers to calibrate models of aggregate capital structure behavior.

1.5 Quantifying the Costs of Debt

In the estimation of the marginal cost curves expressed in equation (1.12), we have effectively assumed throughout that firms in Sample B operate in equilibrium, on average. In this section, we analyze all the firms in Sample A which includes constrained and distressed firms that were excluded in the estimation procedure. Since equation (1.12) gives us the marginal cost of debt, we can quantify the total cost of debt by integrating the area under the marginal cost of debt curve up to the observed amount of leverage that the firm has taken. This gives us an average cost of debt of 7.9% of asset value at observed levels. It is worth noting that the observed cost of debt is as high as 17.8% (41.0%) of asset value for firms in the 90th (99th) percentile of cost distribution. All values are reported as percentages of book value in perpetuity, so for example, a total cost of 5% would occur if the annual cost was

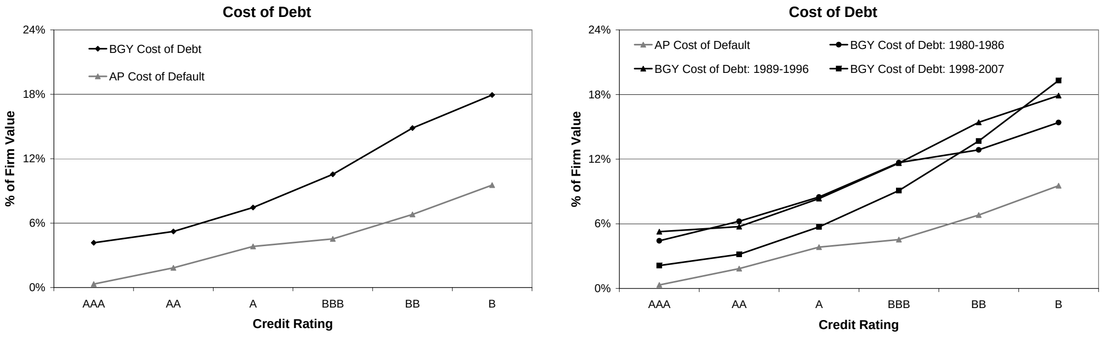

FIGURE 1.5: Comparing Almeida and Phillippon (2007) risk-adjusted net present value distress costs as a percentage of firm value against our ex ante measure of the cost of debt for AAA, AA, A, BBB, BB, and B rated firms. The Almeida and Phillippon (2007) distress costs, based on a default rate of 16.5%, are obtained from Table IV of their paper. Our cost measures are calculated using equation (1.12). A) Cost of debt numbers for the Almeida and Phillippon sample period of 1985 to 2004. The numbers imply that the cost of default is about half of the total cost of debt, suggesting that the other half is due to non-default costs. B) Cost of debt numbers for three periods in our sample period: 1980 to 1986, 1989 to 1996, and 1998 to 2007.

0.5% and the discount rate was 0.10.[19]

1.5.1 Benchmarks and Reality Checks

We now provide a benchmark by comparing our results to the recent literature on default costs of debt. This exercise allows us to quantify the importance of default costs among all costs of debt, and to back out the implied magnitude of costs other than those for default. It also serves as a benchmark to ensure that our numbers are sensible.

Almeida and Phillippon (2007) argue that firms are more likely to face financial distress in bad times when marginal utility is high, and thus the cost of distress should reflect this. They measure the net present value of distress costs using risk adjusted default probabilities calculated for corporate bond spreads (see Table IV of

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[19] We use the Moody's average corporate bond rate as the discount rate for all firms in a given year.

their paper). Figure 1.5A compares their risk-adjusted distress costs as a percentage of firm value to our measure of the ex ante cost of debt as a percentage of firm value for AAA, AA, A, BBB, BB, B rated firms over their sample period from 1985 to 2004. It is comforting that our cost of debt numbers are in the same general ballpark as the Almeida and Phillippon calculations. Our cost of debt measure is larger than the Almeida and Phillippon calculations because our numbers include more than just default costs. Based on this comparison, expected default costs of debt amount to approximately half of the total costs of debt. Agency and other costs constitute the other half of the cost of debt.

As an additional exercise, we also perform this analysis for three time periods. Figure 1.5B compares the Almeida and Phillippon cost of distress against our cost of debt for the following periods: 1980 to 1986, 1989 to 1996, and 1998 to 2007. Periods 1980 to 1986 and 1989 to 1996 are similar to each other. In the period 1998 to 2007, agency and other non-default costs of debt appear to have fallen for investment grade firms (i.e., our estimate is near Almeida and Phillippon's). Thus, either the true costs of debt fell after 1998 and/or corporate debt choices were made less conservatively for credit ratings BBB and higher.

Though we present aggregated numbers in Figure 1.5 to allow comparison to Almeida and Phillippon (2007), we emphasize that one advantage of our approach is that we can also estimate firm-specific costs of debt.

1.6 Robustness Checks

1.6.1 Assessing Other Capital Structure Theories

In this section we address research that explores the effect of specific factors on the cost of debt. Each of the theories involves the inclusion of an additional control variable. As it turns out that these extra variables either have low data quality or are redundant with other control variables in the cross section or time series. For these reasons, we have not included them in the main analysis presented above. However, these examples illustrate that our framework can potentially be used to analyze implications from various capital structure theories.

Macroeconomic Influences

Chen (2008) and Almeida and Philippon (2007) propose that bankruptcies are concentrated in bad times, i.e., periods when marginal utilities are high. This leads investors to demand higher credit risk premia during bad times due to higher default rates and higher default losses. This naturally suggests that credit spreads should play a role in the time variation of the cost of debt.

Table 1.6 presents analysis when Moody's Baa-Aaa credit spread (CS) is included as a control variable. When the spread is high, we expect the cost of debt to be high. Thus, we expect a positive sign on the credit spread variable. We see that this is indeed true and the coefficient is significant (with a coefficient of 0.026). Note that this analysis is infeasible when including year dummies or when using an identification strategy that relies on time series information (such as specification (iv) in Table 1.3).

Personal Tax Penalty

Miller (1977), Green and Hollifield (2003), and others argue that despite the corporate tax deduction from using debt, investors pay higher taxes on interest income, leading to a personal tax penalty for corporate tax usage. If investors face higher interest income tax relative to capital gains tax, they will demand a premium for holding debt, which would be reflected in the cost of debt and deter firms from using debt, all else being equal. Graham (1999) shows that when empirically modeling debt ratios, a specification that adjusts for the personal tax penalty statistically dominates specifications that do not. Following Graham's (1999) method of measuring the personal tax penalty (PTP), we include this measure in our analysis as an additional cost control variable.

Table 1.6 presents the coefficients for the marginal cost curve when including the personal tax penalty (PTP) as a control variable. We see that firms that face a high personal tax penalty do indeed face higher marginal costs of debt (the coefficient indicates a MC function with an intercept 0.037 larger). This is consistent with Graham's (1999) findings. However, the PTP variable is sensitive to outliers, and does not affect other implications, so we exclude it from the main specification.

1.6.2 Time Period Subsamples

In section 1.1.2, we introduce two identification strategies to estimate the marginal cost of debt curve. The panel approach, specification (i), uses the area under the marginal benefits curve, $A_{i,t}$, as the identifying instrument. As previously mentioned, a main advantage of using specification (i) is that it uses both time-series and cross-sectional information. Therefore, this specification can be applied to any time period, even periods without tax regime changes, to identify the marginal cost of debt. Table 1.7 provides the results for the estimation of the marginal cost curve as specified in equation (1.1) for the periods 1980-1986 (pre-TRA 1986), 1989-1997 (post-TRA 1986), 1998-2007 (recent period), and 1980-2007 with year dummies.[20] In all four cases, we are able to identify and obtain reasonable estimates using only cross-sectional information.

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[20] By including year dummies, we remove time series influences and use only cross-sectional information to identify the cost curves.

1.6.3 Alternative Financial Constraint and Distress Measures

As discussed previously, our estimation procedure relies on the assumption that unconstrained and non-distressed firms optimize their capital structures. Previously, we used the lack of a change in long-term debt or equity as an indication of financial constraint. As additional robustness checks, we also identify unconstrained firms based on the Cleary (1999) index, hereafter CL, and the Whited and Wu (2006) index, hereafter WW. Separately, we also tighten our definition of being financially unconstrained to include only firms that have made long-term debt or equity adjustments in the top quartile (as opposed to the top tercile). Finally, we tighten the definition of being financially non-distressed to include firms with ZSCOREs in the top quartile.

Cleary (1999) calculates a general financial constraint measure by grouping firms into categories based on whether they increase or decrease dividend payments. Using this classification procedure, Cleary (1999) performs discriminant analysis to obtain a measure for financial constraint. We reproduce this procedure over our sample period of 1980 to 2007 to obtain the coefficients for a CL index. In a recent paper, Whited and Wu (2006) derive an alternative measure of financial constraint by formulating the dynamic optimization problem of a firm that faces the constraint that the distributions of the firm (e.g., dividends) need to exceed a certain lower bound. They parameterize the Lagrange multiplier on this constraint and estimate its coefficients with GMM. Effectively, the WW index indicates that a firm is financially constrained if its sales growth is considerably lower than its industry's sales growth. In other words, a highly constrained firm is a slow-growing firm in a fast-growing industry. An unconstrained firm is a fast-growing firm in a slow-growing industry. Note that the higher the indices, the more constrained the firm.

In summary, in addition to using Sample A and Sample B throughout the chapter, we also perform our analysis using the following samples:

C : CL in bottom tercile and ZSCORE in top tercile,

D : WW in bottom tercile and ZSCORE in top tercile,

E : LTDEIR above median and ZSCORE above median, and

F : LTDEIR in top quartile and ZSCORE in top quartile.

The estimation results are presented in Table 1.8. The slopes range from 3.491 to 5.578 and the intercepts range from 0.086 to 0.192 for the estimation of equation (1.1). These are similar to the results we obtain in Table 1.3. Furthermore, the qualitative and quantitative results on all control variables except BTM match fairly well. For Sample D where the BTM coefficient is positive, the estimate is insignificant. Overall, the robustness analysis produce results that are largely consistent with those in the main analysis.

1.7 Summary

We use panel data from 1980 to 2007 to estimate the marginal cost function for corporate debt. We simulate debt tax benefit curves and assume that for financially unconstrained and non-distressed firms, the marginal benefit curve intersects the marginal cost curve at the observed level of debt, on average. Using this equilibrium condition, exogenous shifts by the benefit curves enable us to identify the marginal cost function. We employ two identification strategies: (i) a full panel approach using all time-series and cross-sectional information from 1980 to 2007, (ii) a time series approach focused on the 1986 Tax Reform Act.

The estimated marginal cost curves are positively sloped. The intercept depends on firm characteristics such as collateral, size, book-to-market, intangibles, cash flows, and whether the firm pays dividends. As such, our framework provides a new parsimonious environment to evaluate competing capital structure theories. Our findings are robust to firm fixed effects, year fixed effects, across time periods, and when accounting for fixed adjustment costs of debt. We provide an easy-to-use formula that allows for the implementation of firm-specific marginal cost functions.

Our estimates indicate that the average total cost of is about 7.9% of asset value at observed levels, but can be as high as 17.8% of asset value. Finally, our estimates are benchmarked to several papers, including Almeida and Phillippon (2007). We find that default cost of debt amounts to approximately half of total cost of debt, implying that agency costs and other non-default costs contribute about half of the total ex ante costs of debt.

1.A Appendix: Two-staged Least Squares

In this appendix, we present the first and second stage 2SLS equations in the estimation of the marginal cost of debt curve as presented in equation (1.1) in Chapter 1, and discuss the first stage regression results.

In the first stage, equilibrium leverage, x^*, is regressed on the identifying instrument, z, and the set of control variables, C:

$$x^*_{i,t} = \beta_0 + \beta_z z_{i,t} + \sum_{c \in C} \beta_c c_{i,t} + \nu_{i,t}. \tag{1.13}$$

We obtain fitted values from the first stage regression, $\hat{x}$. In the second stage, we regress equilibrium marginal cost, y^*, on the fitted values from the first stage, $\hat{x}$, and control variables, C:

$$y^*_{i,t} = a + b\hat{x}_{i,t} + \sum_{c \in C} \theta_c c_{i,t} + \omega_{i,t}. \tag{1.14}$$

To provide further insight into these identification strategies, we present the first stage regression results in Table 1.B.

In the panel approach, we use the area under the marginal benefit curve, A, as our identifying instrument. Holding the marginal cost curve constant, we expect an outward shift of the marginal benefit curve (which is downward sloping) to result in an increase in leverage. Indeed, the coefficient on A is positive and significant. In the second specification, we use the TRA86 variable, as defined in the main text, over the period 1980-2007 as the identifying instrument. As the new tax regime was implemented, tax rates decreased making leverage less attractive. We therefore expect a negative sign on the TRA86 variable, which is what we find.[21] Note that the estimated coefficients for the control variables have the same signs as those estimated in the extant capital structure literature (see Table A).

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[21] We note that this provides some of the first purely time-series evidence that taxes affect corporate

Table 1.B: First stage regression estimated on unconstrained and non-distressed firms (Sample B). In the first stage regressions, $x^*_{i,t}$ is regressed on z and C, where $x^*_{i,t}$ is the observed interest expenses over book value (IOB), z is the identifying instrument, and C is the set of cost control variables. We consider two main specifications: (i) panel approach, $z \equiv \{A\}$ and (ii) 1986 TRA, $z \equiv \{\text{TRA86}\}$. The set of control variables is $C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}$. All control variables, except DDIV, are standardized to have mean zero and standard deviation one based on Sample A. DDIV is a binary variable with values {0,1}. Robust, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year, as in Thompson (2006) and Petersen (2008). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

$x^*_{i,t} = \beta_0 + \beta_z z_{i,t} + \sum_{c \in C} \beta_c c_{i,t} + \nu_{i,t}$			
	(i)		(ii)
Constant	0.0233 ***	Constant	0.0430 ***
	(0.0010)		(0.0014)
COL	0.0062 ***	COL	0.0083 ***
	(0.0004)		(0.0005)
LTA	-0.0016 ***	LTA	-0.0015 **
	(0.0004)		(0.0005)
BTM	0.0035 ***	BTM	0.0027 ***
	(0.0005)		(0.0006)
INTANG	0.0026 ***	INTANG	0.0039 ***
	(0.0005)		(0.0005)
CF	-0.0110 ***	CF	-0.0048 ***
	(0.0007)		(0.0007)
DDIV	-0.0066 ***	DDIV	-0.0067 ***
	(0.0006)		(0.0008)
A	0.3611 ***	TRA86	-0.0091 ***
	(0.0179)		(0.0016)
No. Obs.	12704	No. Obs.	12883

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capital structure decisions (as called for by Graham, 2003).

1.B Appendix: Variable Definitions

A detailed description follows of the construction of the control variables used in the analysis and variables included in the summary statistics reported in Table 1.2. Numbers in parentheses indicate the corresponding Compustat annual industrial data items.

$$\text{Collateralizable assets, COL} = \frac{\text{Total Inventories (3) + Net Plant, Property, and Equipment (8)}}{\text{Total Book Assets (6)}}$$

$$\text{Log of total assets, LTA} = \log\left(\text{Total Assets (6)} * \text{Adjustment to 2000 Dollars}\right)$$

$$\text{Book equity to market equity, BTM} = \frac{\text{Total Common Equity (60)}}{\text{Fiscal Year Close Price (199) * Common Shares Outstanding (54)}}$$

$$\text{Intangible assets, INTANG} = \frac{\text{Intangibles (33)}}{\text{Total Book Assets (6)}}$$

$$\text{Cash flow, CF} = \frac{\text{Operating Income Before Depreciation (13)}}{\text{Total Book Assets (6)}}$$

$$\text{Dividend paying firms, DDIV} = \begin{cases} 1 & \text{if Common Dividends (21)} > 0 \\ 0 & \text{if Common Dividends (21)} = 0 \end{cases}$$

$$\text{S\&P credit rating, CR} = \begin{array}{l} \text{S\&P Historical Long-Term Debt Ratings (280) organized in 10 credit rating groups:} \\ \text{1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C, 10=D} \end{array}$$

$$\text{Firm Value} = \begin{array}{l} \text{Fiscal Year Close Price (199)} * \text{Common Shares Outstanding (54)} \\ +\text{Debt in Current Liabilities (34)} + \text{Long-term Debt (9)} \\ +\text{Liquidating Value of Preferred Stock (10)} - \text{Deferred Tax and Investment Tax Credit (35)} \end{array}$$

$$\text{Altman's ZSCORE} = \frac{\text{3.3*Pretax Income (170) + 1.0*Net Sales (12) + 1.4*Retained Earnings (36) + 1.2*Working Capital (179)}}{\text{Total Book Assets (6)}}$$

$$\text{Credit spread, CS} = \text{Moody's Baa Rate} - \text{Moody's Aaa Rate} \qquad \text{(Source: Economagic)}$$

Personal tax penalty, PTP = $\tau_p - (1 - \tau_c)\tau_e$
for τ_c = observed marginal tax rate and $\tau_e = [d + (1 - d)g\alpha]\tau_p$

where d is the dividend payout ratio, g is 0.4 before 1987 and 1.0 after (although $g\tau_p$ is never greater than 0.28), α is 0.25, and τ_p is 47.4% for 1980-1981, 40.7% for 1982-1986, 33.1% for 1987, 28.7% for 1988-1992, and 29.6% for 1993 and onwards.

Long-term Debt and/or Equity Issuance and/or Reduction (LTDEIR): firms that are financially unconstrained, defined as having either i) Long-term Debt Issuances (111), ii) Long-term Debt Reductions (114), iii) Equity Issuances (108), iv) Equity Repurchases (115) above the 66th percentile. All four categories are scaled by total book assets (6).

Table 1.1: Sample construction. y^* is the "equilibrium" marginal benefit/cost level, x^* is the observed or "equilibrium" interest payments over book value (IOB), and $C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}$, is the set of (cost) control variables. ZSCORE is a measure of financial distress. LTDEIR stands for long-term debt or equity issuances or repurchases as described in the text. CL and WW are financial constraint measures as defined by Cleary (1999) and Whited and Wu (2005) indices, respectively.

Sample		No. Obs
All firm-year obs. w/ marginal benefit curves and Compustat data in 1980-2007		126,611
Non-M&A firm-years w/ positive book value, common equity, capital, and sales		112,239
Sample excl. finance and insurance, utilities, and public administration industries		91,687
Sample with non-missing $(y^*_{i,t}, x^*_{i,t}, C_{i,t})$ variables:	Sample A	81,067
Sample of financially unconstrained and non-distressed firm-years: LTDEIR above second tercile and ZSCORE above second tercile	Sample B	12,833
For robustness checks:		
Sample of financially unconstrained and non-distressed firm-years: CL in bottom tercile and ZSCORE in top tercile	Sample C	10,199
Sample of financially unconstrained and non-distressed firm-years: WW in bottom tercile and ZSCORE in top tercile	Sample D	10,316
Sample of financially unconstrained and non-distressed firm-years: LTDEIR above median and ZSCORE above median	Sample E	20,479
Sample of financially unconstrained and non-distressed firm-years: LTDEIR in top quartile and ZSCORE in top quartile	Sample F	6,623

Table 1.2: Summary statistics for Samples A and B. IOB is the observed interest over book value (x^*), COL is collateralizable assets over total book values, LTA is log of total assets expressed in 2000 dollars, BTM is book equity to market equity, INTANG is intangible assets over total book values, CF is net cashflow over total book values, and DDIV is an indicator for dividend paying firms. AREA is the area under the marginal benefit curve, used as the identifying instrument in specification (i). CR is the credit rankings based on the S&P long-term domestic issuer credit ratings, where 1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C, 10=D. ZSCORE is a measure of financial distress. DISS, DRED, EISS, and ERED are long-term debt issuance, long-term debt reduction, equity issuance, and equity reduction, respectively, that are used to calculate LTDEIR. CL and WW are financial constraint measures as defined by the Cleary (1999) and Whited and Wu (2005) indices, respectively.

Sample A: All Firms

	No. Obs.	Mean	Std. Dev.	Min	Med	Max
IOB	81067	0.031	0.024	0.000	0.026	0.136
COL	81067	0.494	0.232	0.000	0.514	1.000
LTA	81067	5.022	2.171	-3.518	4.870	12.989
BTM	81067	0.757	0.627	0.030	0.584	4.539
INTANG	81067	0.057	0.105	0.000	0.000	0.593
CF	81067	0.087	0.163	-0.985	0.118	0.395
DDIV	81067	0.384	0.486	0.000	0.000	1.000
AREA	79125	0.033	0.027	0.000	0.028	0.139
CR	14155	4.189	1.307	1.000	4.000	10.000
ZSCORE	77408	1.588	2.156	-15.693	1.977	5.591
DISS	79353	0.082	0.220	0.000	0.007	8.568
DRED	79448	0.079	0.221	0.000	0.020	8.396
EISS	79652	0.039	0.123	0.000	0.002	2.804
ERED	79698	0.011	0.045	0.000	0.000	5.690
CL	60104	0.562	2.606	-6.006	0.184	34.272
WW	73600	-0.242	0.120	-0.541	-0.237	0.078

Sample B: Financially Unconstrained and Non-distressed Firms
(LTDEIR in top tercile and ZSCORE in top tercile)

	No. Obs.	Mean	Std. Dev.	Min	Med	Max
IOB	12883	0.029	0.023	0.000	0.024	0.135
COL	12883	0.493	0.203	0.000	0.512	0.976
LTA	12883	5.283	1.819	0.211	5.156	12.211
BTM	12883	0.633	0.509	0.030	0.493	4.443
INTANG	12883	0.053	0.088	0.000	0.007	0.591
CF	12883	0.179	0.082	-0.441	0.177	0.395
DDIV	12883	0.494	0.500	0.000	0.000	1.000
AREA	12704	0.045	0.028	0.000	0.041	0.139
CR	2124	3.718	1.252	1.000	4.000	10.000
ZSCORE	12883	3.169	0.659	2.372	2.997	5.586
DISS	12833	0.131	0.358	0.000	0.017	8.568
DRED	12833	0.134	0.363	0.000	0.040	8.396
EISS	12833	0.035	0.079	0.000	0.006	0.994
ERED	12833	0.034	0.069	0.000	0.001	1.730
CL	10257	-0.201	0.911	-6.006	-0.108	15.387
WW	12061	-0.266	0.101	-0.541	-0.264	0.075

Table 1.3: Marginal cost of debt using unconstrained, nondistressed firms (Sample B). We estimate the coefficients in equation (1.1), where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB), z is the identifying instrument, and C is the set of cost control variables. We consider two main specifications: (i) panel approach, $z \equiv \{A\}$, (ii) 1986 TRA, $z \equiv \{\text{TRA86}\}$. Specifications (iii) repeats (i) with firm fixed effects. Specification (iv) repeats specification (i) with year dummies. The set of control variables is $C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}$. All control variables, except DDIV, are standardized to have mean zero and standard deviation one based on Sample A. DDIV is a binary variable with values {0,1}. Robust, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2008). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(1.1) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} + \xi_{i,t}$			
	$Z \equiv \{A\}$ (i)	$Z \equiv \{TRA86\}$ (ii)	$Z \equiv \{A\}$ (iii)	$Z \equiv \{A\}$ (iv)
Constant	0.112 ***	-0.188 **	-0.128 ***	0.227 ***
	(0.018)	(0.089)	(0.042)	(0.014)
IOB	4.810 ***	13.188 ***	12.002 ***	3.139 ***
	(0.534)	(2.407)	(1.199)	(0.193)
COL	-0.040 ***	-0.112 ***	-0.076 ***	-0.028 ***
	(0.005)	(0.022)	(0.015)	(0.003)
LTA	0.016 ***	0.036 ***	0.110 ***	0.019 **
	(0.003)	(0.008)	(0.016)	(0.002)
BTM	-0.018 ***	-0.046 ***	-0.040 ***	-0.018 ***
	(0.004)	(0.010)	(0.007)	(0.002)
INTANG	-0.025 ***	-0.052 ***	-0.032 ***	-0.013 ***
	(0.005)	(0.012)	(0.007)	(0.002)
CF	0.085 ***	0.120 ***	0.088 ***	0.075 ***
	(0.007)	(0.017)	(0.010)	(0.004)
DDIV	0.064 ***	0.106 ***	0.090 ***	0.042 ***
	(0.008)	(0.020)	(0.013)	(0.004)
No. Obs.	12704	12833	12704	12704
Firm Fixed Effects?	N	N	Y	N
Year Fixed Effects?	N	N	N	Y

Table 1.4: Marginal cost of debt using all firms (Sample A). We estimate the coefficients in equation (1.1), where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB), z is the identifying instrument, and C is the set of cost control variables. We consider two main specifications: (i) panel approach, $z \equiv \{A\}$, (ii) 1986 TRA, $z \equiv \{\text{TRA86}\}$. Specifications (iii) repeats (i) with firm fixed effects. Specification (iv) repeats specification (i) with year dummies. The set of control variables is $C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}$. All control variables, except DDIV, are standardized to have mean zero and standard deviation one based on Sample A. DDIV is a binary variable with values {0,1}. Robust, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2008). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(1.1) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \theta_c c_{i,t} + \xi_{i,t}$			
	$Z \equiv \{A\}$ (i)	$Z \equiv \{TRA86\}$ (ii)	$Z \equiv \{A\}$ (iii)	$Z \equiv \{A\}$ (iv)
Constant	-0.029 *	-0.133 **	-0.355 ***	-0.025 ***
	(0.016)	(0.056)	(0.054)	(0.008)
IOB	7.915 ***	10.856 ***	17.984 ***	7.829 ***
	(0.423)	(1.492)	(1.614)	(0.229)
COL	-0.070 ***	-0.092 ***	-0.126 ***	-0.068 ***
	(0.005)	(0.011)	(0.014)	(0.003)
LTA	0.015 ***	0.017 ***	0.069 ***	0.013 ***
	(0.003)	(0.004)	(0.013)	(0.002)
BTM	-0.018 ***	-0.022 ***	-0.025 ***	-0.015 ***
	(0.002)	(0.003)	(0.004)	(0.002)
INTANG	-0.037 ***	-0.046 ***	-0.040 ***	-0.039 ***
	(0.004)	(0.007)	(0.006)	(0.002)
CF	0.080 ***	0.083 ***	0.103 ***	0.081 ***
	(0.005)	(0.005)	(0.009)	(0.002)
DDIV	0.133 ***	0.156 ***	0.160 ***	0.134 ***
	(0.009)	(0.015)	(0.014)	(0.005)
No. Obs.	79125	79942	79125	79125
Fixed Effects?	N	N	Y	N
Year Fixed Effects?	N	N	N	Y

Table 1.5: Marginal benefit and marginal cost functions of debt for the average (representative) firm in Sample A and Sample B. The marginal benefit curve is calculated by taking the average of the marginal tax rates and interest expenses over book assets at 0%, 20%, 40%, ..., 1000% of observed IOB. That is, 100% of observed is the actual level of IOB in a given firm-year. The marginal cost curve is calculated using equation (1.12) and the sample means of the standardized values of the cost control variables.

	Sample A			Sample B		
	Interest Over Book Value (IOB)	Marginal Benefit (MB)	Marginal Cost (MC)	Interest Over Book Value (IOB)	Marginal Benefit (MB)	Marginal Cost (MC)
0% of Observed	0.0000	0.3033	0.1123	0.0000	0.3547	0.1738
20% of Obs.	0.0063	0.2978	0.1427	0.0060	0.3519	0.2025
40% of Obs.	0.0127	0.2920	0.1732	0.0119	0.3491	0.2312
60% of Obs.	0.0190	0.2858	0.2036	0.0179	0.3459	0.2599
80% of Obs.	0.0253	0.2791	0.2341	0.0239	0.3421	0.2886
100% of Obs.	0.0317	0.2715	0.2646	0.0299	0.3377	0.3174
120% of Obs.	0.0380	0.2629	0.2950	0.0358	0.3318	0.3461
160% of Obs.	0.0507	0.2459	0.3559	0.0478	0.3200	0.4035
200% of Obs.	0.0633	0.2282	0.4168	0.0597	0.3049	0.4609
300% of Obs.	0.0950	0.1893	0.5691	0.0896	0.2649	0.6045
400% of Obs.	0.1266	0.1564	0.7213	0.1194	0.2269	0.7481
500% of Obs.	0.1583	0.1308	0.8736	0.1493	0.1945	0.8916
600% of Obs.	0.1900	0.1117	1.0259	0.1791	0.1687	1.0352
700% of Obs.	0.2216	0.0970	1.1781	0.2090	0.1480	1.1788
800% of Obs.	0.2533	0.0858	1.3304	0.2388	0.1307	1.3224
900% of Obs.	0.2849	0.0768	1.4827	0.2687	0.1167	1.4659
1000% of Obs.	0.3166	0.0697	1.6349	0.2985	0.1056	1.6095

Table 1.6: Alternative control variables. We estimate the coefficients in equation (1.1), where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB), z is the identifying instrument, and C is the set of cost control variables. We consider the panel approach for which $z \equiv \{A\}$. The set of control variables is $C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}$, and one of each alternative control specification: $\{CS, PTP\}$. CS is the spread between Moody's Baa rate and Aaa rate, and PTP is the personal tax penalty as measured in Graham (1999). All control variables, except DDIV, are standardized to have mean zero and standard deviation one based on Sample A. DDIV is a binary variable with values {0,1}. Robust, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2008). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(1.1) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} + \xi_{i,t}$	
	(CS)	(PTP)
Constant	0.153 ***	0.167 ***
	(0.017)	(0.012)
IOB	3.770 ***	3.197 ***
	(0.405)	(0.295)
COL	-0.033 ***	-0.028 ***
	(0.004)	(0.003)
LTA	0.018 ***	0.022 ***
	(0.002)	(0.002)
BTM	-0.020 ***	-0.019 ***
	(0.004)	(0.003)
INTANG	-0.019 ***	-0.012 ***
	(0.003)	(0.003)
CF	0.078 ***	0.066 ***
	(0.006)	(0.005)
DDIV	0.050 ***	0.066 ***
	(0.006)	(0.005)
CS	0.026 ***	
	(0.004)	
PTP		0.037 ***
		(0.005)
No. Obs.	12704	11907

Table 1.7: Marginal cost of debt estimated on unconstrained and non-distressed firms (Sample B) using panel specification (i) for 1980-1986, 1989-1997, 1998-2007, and 1980-2007 with year dummies. We estimate the coefficients in equation (1.1), where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB), z is the identifying instrument, and C is the set of cost control variables. We consider specification (i) where $z \equiv \{A\}$. All control variables, except DDIV, are standardized to have mean zero and standard deviation one based on Sample A. DDIV is a binary variable with values {0,1}. Robust, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2008). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(1.1) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} + \xi_{i,t}$			
	1980-1986	1989-1997	1998-2007	1980-2007
Constant	0.177 ***	0.187 ***	0.197 ***	0.227 ***
	(0.029)	(0.011)	(0.013)	(0.014)
IOB	4.275 ***	2.336 ***	2.032 ***	3.139 ***
	(0.509)	(0.210)	(0.233)	(0.193)
COL	-0.042 ***	-0.022 ***	-0.020 ***	-0.028 ***
	(0.006)	(0.003)	(0.003)	(0.003)
LTA	0.025 ***	0.020 ***	0.021 ***	0.019 ***
	(0.005)	(0.002)	(0.002)	(0.002)
BTM	-0.026 ***	-0.017 ***	-0.023 ***	-0.018 ***
	(0.005)	(0.005)	(0.004)	(0.002)
INTANG	-0.029 ***	-0.009 ***	-0.011 ***	-0.013 ***
	(0.006)	(0.002)	(0.002)	(0.002)
CF	0.117 ***	0.062 ***	0.061 ***	0.075 ***
	(0.013)	(0.004)	(0.006)	(0.004)
DDIV	0.050 ***	0.034 ***	0.026 ***	0.042 ***
	(0.006)	(0.005)	(0.004)	(0.004)
Year fixed effects?	N	N	N	Y

Table 1.8: Analysis of alternative definitions of being financially unconstrained (C) CL index in bottom tercile, (D) WW index in bottom tercile, (E) LTDEIR above median and ZSCORE above median, (F) LTDEIR in top quartile and ZSCORE in top quartile. We estimate the coefficients in equation (1.1), where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB), z is the identifying instrument, and C is the set of cost control variables. We consider the panel approach for which $z \equiv \{A\}$. The set of control variables is $C \equiv \{COL, LTA, BTM, INTANG, CF, DDIV\}$. All control variables, except DDIV, are standardized to have mean zero and standard deviation one based on Sample A. DDIV is a binary variable with values {0,1}. Robust, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2008). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(1.1) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} + \xi_{i,t}$			
	Sample C	Sample D	Sample E	Sample F
Constant	0.192 ***	0.175 ***	0.086 ***	0.117 ***
	(0.012)	(0.019)	(0.017)	(0.021)
IOB	3.491 ***	4.175 ***	5.578 ***	4.493 ***
	(0.488)	(0.466)	(0.504)	(0.586)
COL	-0.021 ***	-0.032 ***	-0.048 ***	-0.037 ***
	(0.004)	(0.005)	(0.005)	(0.005)
LTA	0.014 ***	0.007 *	0.018 ***	0.015 ***
	(0.003)	(0.004)	(0.002)	(0.004)
BTM	-0.002	0.004	-0.021 ***	-0.014 ***
	(0.005)	(0.005)	(0.003)	(0.005)
INTANG	-0.016 ***	-0.021 ***	-0.026 ***	-0.022 ***
	(0.004)	(0.004)	(0.004)	(0.005)
CF	0.068 ***	0.066 ***	0.092 ***	0.085 ***
	(0.007)	(0.009)	(0.007)	(0.009)
DDIV	0.050 ***	0.054 ***	0.070 ***	0.061 ***
	(0.008)	(0.010)	(0.007)	(0.008)
No. Obs.	8495	10241	28169	6518

2

Optimal Capital Structure

How much debt should a company use, and how does the use of debt affect firm value? Theoretical papers agree that there are many benefits to using debt, including the tax benefits of interest deductibility, corporate monitoring by intermediaries or financial markets, and the commitment by managers to run a tight ship due to the obligation to pay out free cash flows. The costs of debt are considered to be financial distress and bankruptcy costs, the possibility that a firm will pass up positive net present value projects if it has too much debt overhang, and the agency costs that can result if debt ends up creating conflicts between managerial objectives versus those of bondholders and stockholders.

Despite all this research, a consensus view on optimal capital structure has yet to emerge. Consequently, in many cases it is difficult to make a specific, defendable recommendation about how much debt a given company should use. The uncertainty regarding the ideal amount of debt for a particular company is evident in a survey of 400 large companies by Graham and Harvey (2001), who report that only a few of the most common reasons that financial executives cite to describe their debt choices are closely linked to academic theories.

In the previous chapter, we study the cost of debt and develop an identification strategy using the marginal tax benefits of debt and observed debt choices made by thousands of companies to estimate marginal cost of debt curves. The costs vary by company and are a function of whether assets can be easily used as collateral, firm size, investment opportunities, the amount of intangible assets, free cash flow, and dividend policy.

In this chapter, we make specific recommendations about the optimal amount of debt any given firm should use by using the implicit benefits of debt along with the costs of debt inferred from observed leverage choices. The benefits of debt are modeled directly as the expected value of tax savings associated with incremental dollars of interest deductions, accounting for the probability that the deduction will be used in some future scenarios.

Financial theory tells us that the optimal choice of debt occurs at the point where the marginal benefit of debt just equals the marginal cost. For example, consider the marginal benefit and marginal cost functions to Barnes & Noble in 2006 (shown in Figure 2.1). The optimal amount of debt for Barnes & Noble in 2006 occurs at the intersection of the marginal benefit and marginal cost curves (at point A in Figure 2.1). If Barnes & Noble were to use too little debt (e.g., at point B), the benefit of using more debt would be greater than the cost of using more, so the company could increase firm value by using more debt. If a firm uses too much debt (e.g., at point C), the benefit of the last dollars of debt are less than the costs, so the company could increase firm value by reducing its debt usage to point A. We are able to explicitly quantify the dollar cost of being underlevered (the shaded area in Figure 2.1 if Barnes & Noble were to use B amount of debt), as well as the cost of being overlevered (the dotted area if Barnes & Noble were to use C amount of debt),

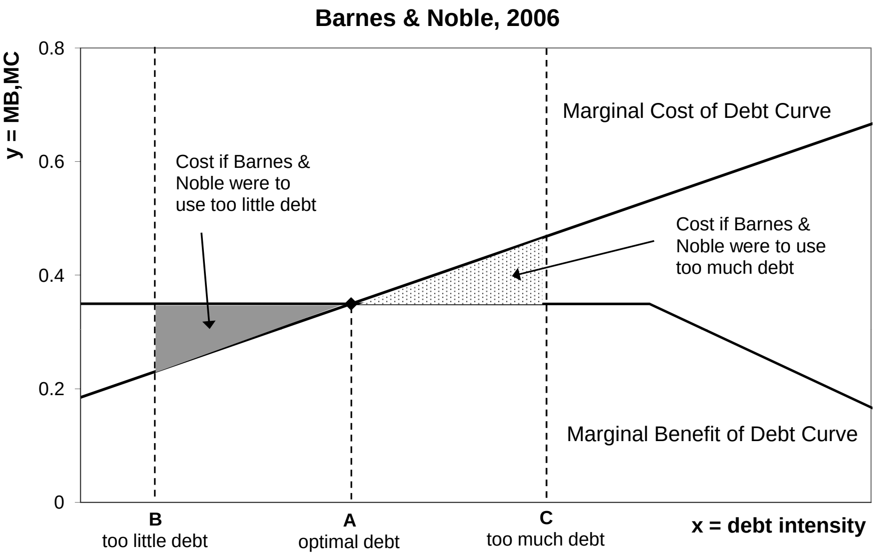

FIGURE 2.1: Marginal benefit and marginal cost curves of debt for Barnes & Noble in 2006. The intersection of the two curves reflect the optimal amount of debt (point A). Having debt below the optimal amount results in too little debt (point B) and having debt above the optimal results in too much debt (point C). The shaded and dotted areas reflect the cost to underlevering and overlevering, respectively.

to explicitly quantify how much value a company would lose due to suboptimal debt policy.

By integrating the area between the curves, we can estimate the net benefits of debt financing, and similarly estimate the cost of deviating from the optimum. For the full sample of firms, Sample A as defined in Chapter 1, the equilibrium gross benefits of debt are 10.4% of book value, the costs are 6.9% of book value, and the net benefits are 3.5% of book value.[1] For some companies, the benefits are much greater, as high as 10.8% of book value. In this full sample, among firms that we label as financially constrained or distressed, our numbers imply that deadweight losses from using less debt than the implied optimum (i.e., actual debt usage is less than the debt ratio at the intersection of marginal cost and benefit) average 1.4% of

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[1] Note that these are the net total benefits of debt, not just the net tax benefits of debt. Also note that the 6.9% cost estimate is a lower bound because it includes as negative costs any nontax benefits of debt; however, the 3.5% net benefit estimate is not affected by this negative cost issue. See footnote 7.

book value. In contrast, deadweight losses from superoptimal debt choices are 3.8% of book value. Thus, in our sample, the cost of being overlevered appears to be more severe than being underlevered.

Being able to make specific, firm-by-firm debt policy recommendations is an important addition to the current state of affairs. Most empirical academic research uses reduced form regressions to identify the factors that are correlated with debt ratios. While this approach can make directional predictions related to corporate characteristics (e.g., firms with collateral use more debt on average), it does not directly lead to predictions about optimal debt ratios, nor can the reduced form regression approach precisely quantify the cost of suboptimal leverage. At the other end of the spectrum, theoretical capital structure research can be used to derive an optimal debt ratio. However, the recommended debt ratio is sometimes far out of whack with reality, and/or the model has to be "calibrated" to produce reasonable implications about real world debt ratios. Further, most theoretical research focuses on one or two costs or benefits of debt, ignoring other debt features in order to keep the model tractable.

Our approach, in contrast, uses actual capital structure choices to back out the implicit cost of debt, and this estimated cost of debt encompasses all the ex ante costs that affect corporate financing choices. All else equal, companies that do not use much debt often face large costs of debt, which translates into a steeply sloped cost of debt curve in our approach. Reassuringly, the costs implied in our analysis are consistent in sign with the costs estimated in other empirical research. However, we can do much more with the estimated cost and benefit functions than determine whether, for example, firms with collateral face lower costs of debt (and therefore use more debt). We can make explicit recommendations about optimal capital structure, estimate the value added to using the correct amount of debt, as well as other implications that are described below.

The rest of the chapter proceeds as follows. In Section 2.1, we explain the estimation of the marginal benefit and cost functions for debt. Section 2.2 describes the concept of the optimal capital structure within the framework of our model and calculates gross benefits of debt, cost of debt, and measures net benefits of debt. Section 2.3 quantifies the amount that debt usage adds to firm value and the costs to deviating from the optimal capital structure. Section 2.4 showcases several case studies of firms within our optimal capital structure framework. Finally, section 2.5 summarizes the main points of the chapter.

2.1 Estimating Benefit and Cost Functions for Debt

To determine optimal capital structure for a given firm, our approach requires that we first estimate marginal benefit functions of debt and marginal cost functions of debt. The optimal capital structure occurs at the intersection of these benefit and cost curves. In the next section, we explain how we simulate tax benefit curves for debt. Section 2.1.2, describes how we use variation in those benefit curves to identify debt cost curves. Section 2.1.3 provides an easy to use formula to calculate firm-specific costs of debt.

2.1.1 The Tax Benefit of Debt

We simulate tax benefit functions using the methodology of Graham (2001). Consider the value of an additional dollar of interest deduction for the hypothetical firm depicted in Figure 2.2. The company currently uses \$4 of interest, as reflected as the point where $x^* = 4$ on the horizontal axis. At this level of interest, the company's marginal tax rate is currently 0.25, and therefore, an extra dollar of interest deduction is expected to save the company \$0.25 in taxes this year. That is, the marginal tax benefit of a dollar of interest is \$0.25.

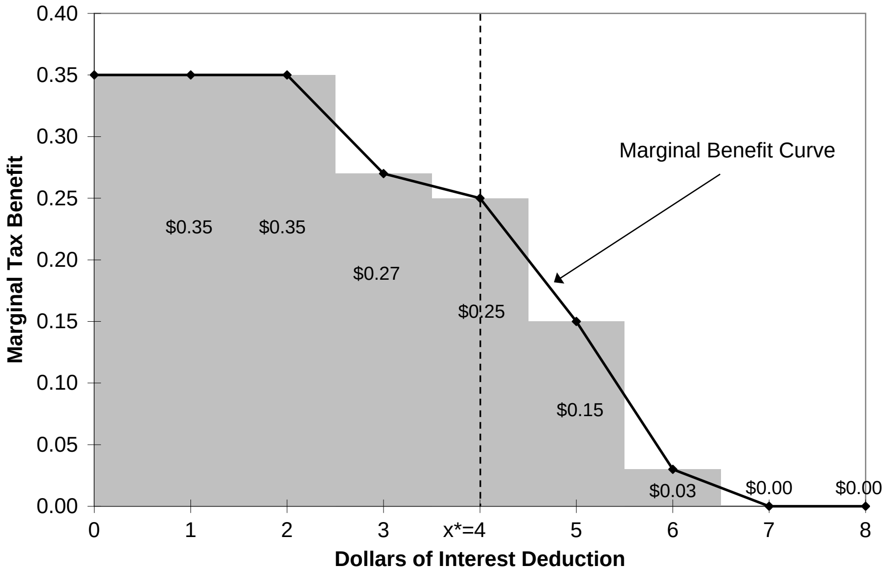

FIGURE 2.2: The figure depicts the marginal tax benefit of debt curve for a hypothetical firm. Each rectangular box represents the present value tax benefit of adding another dollar of interest deduction. By adding up the area inside all of the rectangular boxes, we integrate under the benefit function to determine the area under the curve, $A_{i,t}$, mentioned below. Notice how the marginal benefit of debt is a downward sloping, declining function of the level of interest deductions, reflecting the declining value of each incremental dollar of interest deduction. x^* depicts the observed interest deduction level for our hypothetical firm.

It's worth taking a minute to explain how a company's marginal tax rate could be 0.25. Assume that the top corporate marginal tax rate is 0.35. In the simplest setting, a company could have a 5/7 probability of being profitable (and taxed), and a 2/7 chance of being unprofitable (and not taxed), and therefore have an expected marginal tax rate of 0.25 (= 0.35*(5/7) + 0*(2/7)). Our approach captures the probability that a firm will be profitable, like in this example, but is much more sophisticated. As outlined in the footnote, we also model the tax-loss carryback and carryforward features of the tax code,[2] as well as investment tax credits and

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[2] Consider how the tax-loss carryforward feature can affect expected marginal tax rates. Assume that a firm is losing \$10 today but expects to earn \$20 next year. This company would carry forward the \$10 loss and only pay taxes on \$10 next year. This would lead to \$3.50 in taxes next year if the corporate marginal income tax rate is 35%. If this firm were to earn an extra dollar of income today, it would lose \$9 rather than \$10, and only carry forward a \$9 loss. Given \$1

the alternative minimum tax. Considering these dynamic features of the tax code requires forecasting future taxable income, in order to determine the present value of taxes owed if the firm were to earn an extra dollar of income this year. The bottom line is that we can estimate expected marginal tax rates for any given firm at any given level of income in any year. Knowing the marginal tax rate allows us to determine the tax benefit of debt because one additional dollar of interest deduction would save the company an amount of taxes equal to its marginal tax rate in the year the deduction is relevant. Therefore, the marginal tax benefit of a dollar of interest equals the present value of the marginal tax rate at the appropriate level of taxable income.

Let's return to the example shown in Figure 2.2 and evaluate the marginal tax benefit that the company would realize if it deducted \$5 in interest. The figure shows that the marginal benefit of the 5th dollar of interest is \$0.15. This implies that the marginal tax rate of the company is only 15% when the company has \$5 of interest deductions. To see how this could be the case, note that interest deductions reduce taxable income, and therefore, using more debt reduces a company's marginal tax rate. In this example, extra deductions would reduce the marginal tax rate because the incremental interest deductions push down taxable income so much that there is now a 4/7 chance that the firm will be unprofitable, so its marginal tax rate is 0.15 (= 0.35*(3/7) + 0*(4/7)).

At the other end of the spectrum, what would the company's marginal tax rate be if it did not have any interest deductions? In this case, the company's marginal tax

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smaller loss to carry forward, next year the company would pay tax of \$3.85 on \$11 of taxable income. Therefore, the present value of taxes owed on an extra dollar of income earned today (that is, the expected marginal tax rate) is $0.32 \approx 0.35/1.10$ if the discount rate is 10%. More generally, in our algorithm to determine corporate marginal tax rates we consider the full carryforward and carryback features of the tax code. For example, in 2008 the tax loss carryback period is two years and the carryforward period 20 years. We forecast taxable income using a random walk with drift model (see Graham 2000) in order to determine the present value effects of income earned today in companies that might experience losses today or in the future.

rate is 35%. This implies that the company is fully taxable in all possible scenarios, or has a loss small enough that it is fully utilized on a tax loss carrybacks, so there is a 7/7 chance that the firm will pay taxes of \$0.35 on an extra dollar of income earned today. This also means that if the company used debt, the first dollar of interest would save the firm \$0.35 in taxes, and increase its cash flow by the same amount.

The marginal tax benefit function in Figure 2.2 maps out the tax benefit of each dollar of interest deduction. Note that the benefit function is initially flat at 0.35 (representing the "fully taxable outcomes" that occur when the company has few interest deductions), then becomes downward sloping at \$2 of interest at the "kink" in the benefit function. At \$7 of interest, the marginal benefit of an extra dollar of interest is zero. This occurs because if the company had \$7 of interest deductions this year, it would produce a taxable loss so large that the company would not pay taxes in any year during the entire tax-loss carryback or carryforward forecast horizon. (Under current law, losses can be carried back two years to shield income in t-2 and t-1, or can be carried forward 20 years to shield profits in any year up to t+20).

The total tax benefit of the firm's chosen amount of interest deductions is represented by the area under the benefit function up to x^*. In the Figure 2 example, \$4 of interest saves the firm \$1.22 in taxes (\$0.35 + \$0.35+ \$0.27 + \$0.25), and increases cash flow by a like amount, in the current year. Note that this gross tax benefit calculation ignores all costs of debt. We now turn our attention to estimating the costs of debt.

2.1.2 The Cost of Debt

Consider the three points depicted in Figure 2.3A. Assume that these points represent the actual amount of interest used by three different companies making optimal debt choices in 2006 (shown as x^*_A, x^*_B, and x^*_C). In order to map out the marginal cost function (or in the language of statistics, to identify the cost curve), we need all of

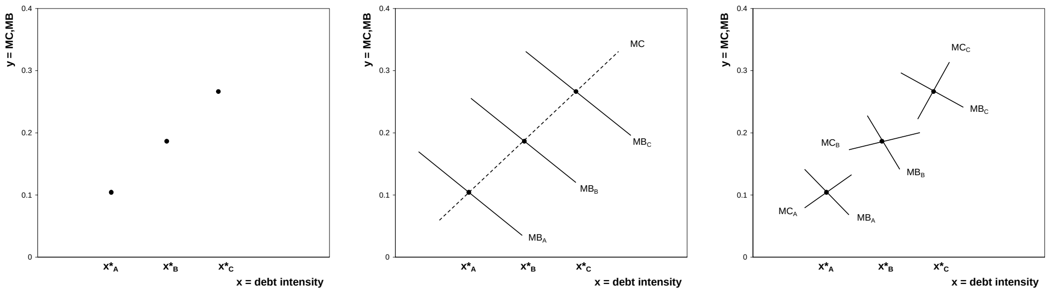

FIGURE 2.3: A) Optimal capital structure choices of three different companies: A, B, and C. B) The ideal setting when all movements between points are due to benefit curve shifts and the cost curve stays the same. This allows us to "connect the dots" to identify the marginal cost curve. C) The general setting when movements between points are due to a combination of shifts in both the marginal benefit function and the marginal cost function. It is not possible to identify the cost curve in this setting.

the variation in these points to occur because of benefit function shifts while the cost function remains fixed in one place. In this ideal setting, we can then "connect the dots" and trace out the marginal cost curve of debt, as depicted in Figure 2.3B. In general, however, when you observe real world debt choices by three different firms, you can not tell whether these choices are due to shifts in the benefit function while the cost function remains fixed (the ideal setting), shifts in the cost function while the benefit function remains fixed, or a combination of shifts in both curves where neither curve remains fixed (as shown in Figure 2.3C).

In the usual scenario, where we cannot be sure that shifts come solely from benefit functions, in an effort to identify the cost function as in Figure 2.3B, an economist is left trying to find an "instrument" (i.e., a variable) that is highly correlated with shifts in the benefit function but not at all correlated with shifts in the cost function. Because all the variation in such a hypothetical perfect instrument would come from shifts of the benefit function, and none from the cost function, it would be possible to statistically map out the cost function. (This is completely analogous to identifying supply or demand functions as discussed in most econometrics textbooks; see for example, Greene 2008). While using an instrument sounds straight-forward, in fact, finding an appropriate instrument is very difficult, and using the wrong instrument introduces a host of statistical problems.

In our case, we have a big advantage. We can explicitly estimate marginal benefit curves, as described in Section 2.1.1. Therefore, we know exactly when the benefit function is shifting and by how much. This allows us to map out the cost curve with relative confidence that we are observing situation like that depicted in Figure 2.3B (rather than possibly being in a situation like Figure 2.3C).

Even better, because we explicitly know the benefit function, we can map out the cost function in several different settings. First, we can identify the cost curve by observing debt choices made by different firms in the same year. Second, we can identify the cost function based on debt choices (and shifts in the benefit function) for a single firm in several different years (e.g., a firm's benefit function will shift when the federal government changes the tax code and corporate tax rates, therefore also changing the benefit of interest deductions). Or, third, we can estimate the cost functions based on variation in benefit functions both through time and across firms.

In van Binsbergen, Graham, and Yang (2010) and Chapter 1, we describe in full detail how we use all three sources of variation to identify the cost curves of debt presented in this chapter. As an example of the second approach (i.e., in which we rely on changes in tax rates that occur due to changes in tax law), consider Burlington Coat Factory Warehouse, presented in Figure 2.4. The Tax Reform Act of 1986 reduced the top corporate marginal tax rate, and hence the benefit of interest deductions, from 46% to 34% over a three year period. For Burlington, this phase-in resulted in a maximum possible marginal tax rate of 46% in fiscal year 1986, 41% in 1987, and 34% in 1988. Notice how the benefit function shifts downward in Figure 2.4 as the tax rate falls, reflecting that the benefit of a dollar of deduction falls as the

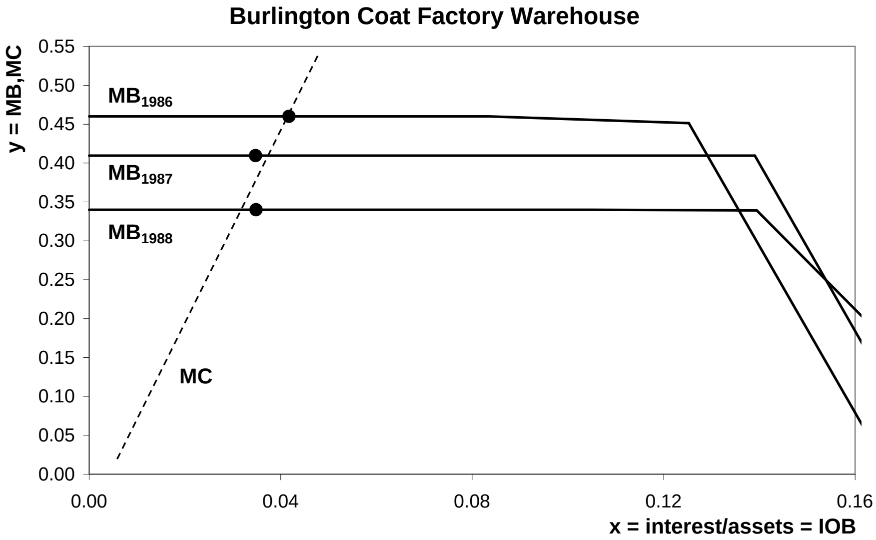

FIGURE 2.4: The figure depicts the marginal tax benefit of debt curve for Burlington Coat Factory Warehouse in 1986, 1987, and 1988. The points on the marginal benefit curves represent the actual leverage used in those years. Following the Tax Reform Act of 1986 maximum corporate tax rates were reduced from 46% to 34% over a three year period, allowing us to trace out the marginal cost curve of debt.

tax burden declines. Because we know the benefit function for Burlington in each year, and we know the chosen amount of debt (depicted as a point on each marginal benefit curve), we can trace out the marginal cost curve as shown with a dotted line in the figure.

There is an important statistical issue that we must deal with in order to map out cost of debt functions. Technically, the cost curve must remain in one place as the benefit curve shifts, in order for us to be able to use variation in the benefit function to identify the cost function.[3] That is, the cost curve can not be shifting around

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[3] A somewhat more subtle issue is that for our approach to provide recommendations for optimal capital structure, it needs to be estimated on a sample of firms that are believed a priori to make optimal choices, or at least that deviations from optimal capital structure are not too large in the estimation sample and are averaged away when we consider the full sample. Then, using the formula we estimate on firms that make optimal choices, we can extrapolate to make optimal capital structure recommendations for any firm in any year. To create a sample of firms that are believed to operate near optimal, we delete firms that are financially distressed and/or constrained in their access to debt markets. In the end, our recommendation of "optimal capital structure" can be thought of as describing how much debt similar firms, with similar characteristics, would use if

at the same time as the benefit function, else we could end up in the ambiguous situation depicted in Figure 2.3C. We deal with this issue by using a multivariate regression in which we "purge" shifts that are attributable to costs. We accomplish this by including "control variables" that are hypothesized in the academic literature to be correlated with the cost of debt: firm size, whether a company's assets are easily usable as collateral, etc. By including these variables in the regression, we statistically hold the cost curve constant in terms of not allowing it to vary for costs captured by these control variables; therefore, the remaining variation must be attributable just to shifts in the benefit function. In addition, using control variables results in cost of debt curves that are themselves functions of particular firm characteristics.

It is important to highlight just what we capture in our cost functions. The cost functions of course capture the various possible costs of debt (e.g., expected bankruptcy costs, "debt overhang" cost that might discourage a firm from initiating a profitable project because it currently has too much debt, etc.) These costs are reflected in firm's choices, so we do not have to specify which cost is largest or smallest, we let the data and our estimation procedure tell which costs matter the most. Also, recall that the benefit functions capture tax benefits only. Therefore, any nontax benefits show up as "negative costs" in the marginal cost functions that we estimate. This is fine and does not affect our ability to use the cost functions to make recommendations about optimal capital structure.

2.1.3 Formula to Estimate The Cost of Debt

Once we have completed the estimation procedure described in the previous section (see Chapter 1), it is possible for anyone to approximate our estimated cost curves simply by multiplying the estimated coefficients by values for various firm character-

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these firms were not financially constrained or distressed, or faced with some other extraordinary circumstances.

istics. The marginal cost of debt for any particular firm i at time t can be determined by:

$$MC(IOB) = \alpha + \beta * IOB \tag{2.1}$$

with

$$\begin{aligned}
\alpha &= 0.112 - 0.040\ \text{COL} + 0.016\ \text{LTA} - 0.018\ \text{BTM} - 0.025\ \text{INTANG} + 0.085\ \text{CF} + 0.064\ \text{DDIV} \\
\beta &= 4.810
\end{aligned}$$

Each of the control variables, except DDIV, is standardized (demeaned and divided by the standard deviation) to have a mean of zero and a standard deviation of one. DDIV is a binary variable with values of {0,1}. The mean and standard deviation for each of the non-standardized control variables are reported below:

	COL	LTA	BTM	INTANG	CF
Mean	0.494	5.022	0.757	0.057	0.087
Std. Dev.	0.232	2.171	0.627	0.105	0.163

COL is collateral and is the sum of physical assets and inventories divided by total book assets for a firm. LTA is the log of total book assets. BTM is the ratio of book equity to market equity. INTANG is the ratio of intangible assets to total book assets. CF is the net cashflows over total book assets. DDIV has a value of “1” if the firm pays dividends and otherwise is “0.” Finally, IOB is interest expenses over total book assets for a firm and is our measure of debt intensity.

The coefficients in our estimated cost of debt function are consistent with implications from previous capital structure research. For example, Frank and Goyal (2005) show that firms use less debt when they have less collateral. Our estimated coefficients indicate that the cost of debt is high when firms have fewer collateralizable assets. Given that a high cost of debt implies that, all else equal, a firm should use less debt, the directional effect of collateral on our estimated cost curves is consistent with existing literature, which is reassuring.

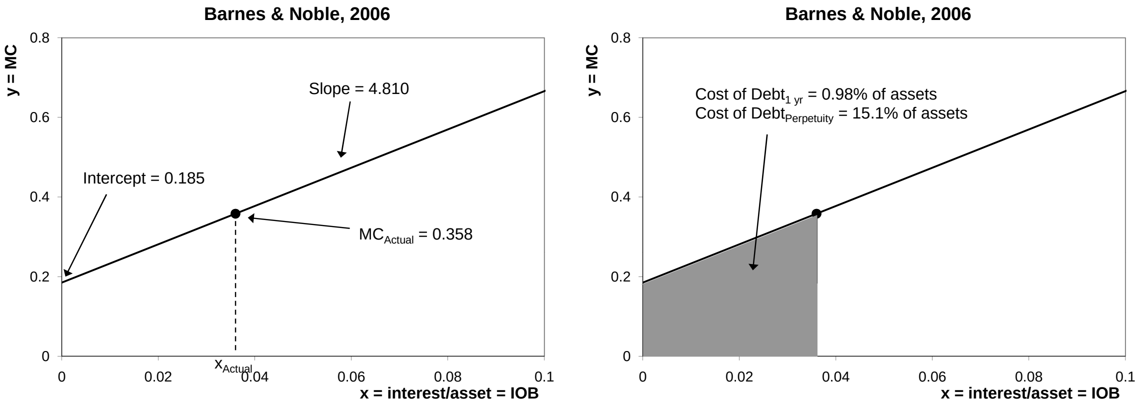

FIGURE 2.5: A) Marginal cost curve for Barnes & Noble in 2006. The point represents actual debt usage in 2006. B) The one year cost of debt is the area under the MC curve. The cost of debt in perpetuity is the one year cost of debt discounted at the Moody Baa rate.

To see how to implement equation (2.1) above, let's take the example of Barnes & Noble in 2006. The table below reports both the raw and standardized firm characteristics for Barnes & Noble in 2006:

	COL	LTA	BTM	INTANG	CF	DDIV
Raw	0.676	7.910	0.459	0.110	0.133	1
Standardized	0.784	1.331	-0.454	0.502	0.279	1

The standardized value for COL is 0.784, which equals collateralizable assets as a proportion of total assets for Barnes & Noble in 2006 (0.676), minus the mean COL for the sample (0.494) from the previous table, and the difference is divided by the sample standard deviation of COL (0.232) also from the previous table. The standardized variables for the other firm characteristics are similarly calculated. We plug the standardized firm characteristics into equation (2.1) to get a marginal cost curve for Home Depot in 2007: $MC = 0.185 + 4.810 * IOB$. Figure 2.5A depicts this marginal cost curve for Barnes & Noble in 2006.

Knowing the entire marginal cost curve of debt (as in Figure 2.5A) allows us to determine the marginal cost of debt for any level of debt Barnes & Noble might choose. To determine Barnes & Noble's marginal cost of debt for its actual amount of debt in 2006, we plug in the firm's actual interest/assets ratio (IOB) into the MC function we just estimated. In 2006, Barnes & Noble's interest to book assets ratio is 0.036 (i.e., interest expense accounts for 3.6% of book assets). This implies that if Barnes & Noble were to use debt that produced another dollar of interest expense, the cost of that additional extra interest would be about \$0.358 ($\approx 0.185 + 4.810 * 0.036$). These costs represent the sum of expected costs of bankruptcy should it occur, the quantification of agency costs that occur when there are conflicts between difference classes of security-holders, and any other effect that debt can have that reduces firm value. Note that we can use the cost curve to estimate the cost of debt for any possible amount of debt, not just the actual amount.

Armed with marginal cost functions calculated using equation (2.1), we can also estimate the total cost of using debt, or simply, the cost of debt. Note that previously we calculated the marginal cost of debt, i.e., the cost of debt for moving from X amount of debt to X+1 amount of debt. Now we calculate the (total) cost of debt, i.e., the cost of debt for having X amount of debt, which is the cost of moving from 0 to 1 dollar of debt plus the cost of moving from 1 to 2 dollars of debt, etc., up to X amount of debt. For a particular debt level, for a particular firm in a particular year, the one year cost of debt equals the area under the cost curve up to that amount of debt. Continuing with Barnes & Noble, the one year cost of debt in 2006 is the shaded region in Figure 2.5B which is equal to about 0.98% of asset value or, equivalently, 1.31% of firm value. To determine the (overall, capitalized) cost of debt, we need to determine the present value of the cost of debt in all future years. We calculate this using the perpetuity formula and discounting at Moody's Baa rate (or a comparable discount rate). For Barnes & Noble, this approach implies a cost of debt equal to 15.1% of asset value (discounting at rate of 6.5%), equivalent to 20.2%

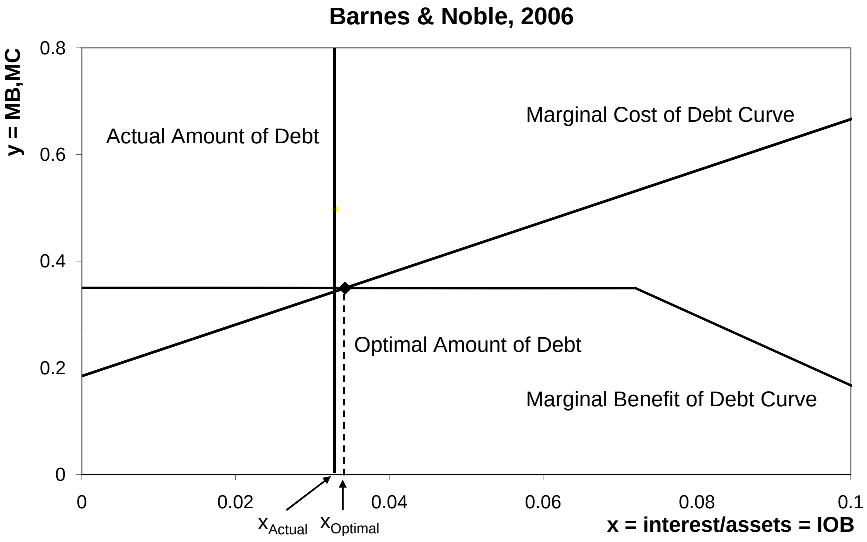

FIGURE 2.6: Marginal benefit and marginal cost curves of debt for Barnes & Noble in 2006. The solid vertical line reflects actual debt usage and the dotted line from the intersection of the two curves reflect the optimal debt level for the firm. In 2006, Barnes & Noble operated very near its model implied optimal capital structure.

of firm value.

2.2 The Optimal Amount of Debt Financing

Now that we have both the firm-specific marginal benefit and marginal cost curves, we can determine firm-specific optimal capital structure. Furthermore, we can use our curves to quantify the gross benefit of debt, the cost of debt, and the net benefit of debt at actual (observed) and optimal (model-implied) debt levels.

2.2.1 Determining Optimal Capital Structure

Using both the benefit and cost functions, we can determine the optimal amount of debt for any given firm. This optimal debt choice occurs where the marginal benefit and cost curves intersect. For example, we again consider Barnes & Noble in Figure 2.6. In 2006, Barnes & Noble's chosen amount of debt is near its optimal capital structure (as recommended by our model) because its actual interest/assets ratio

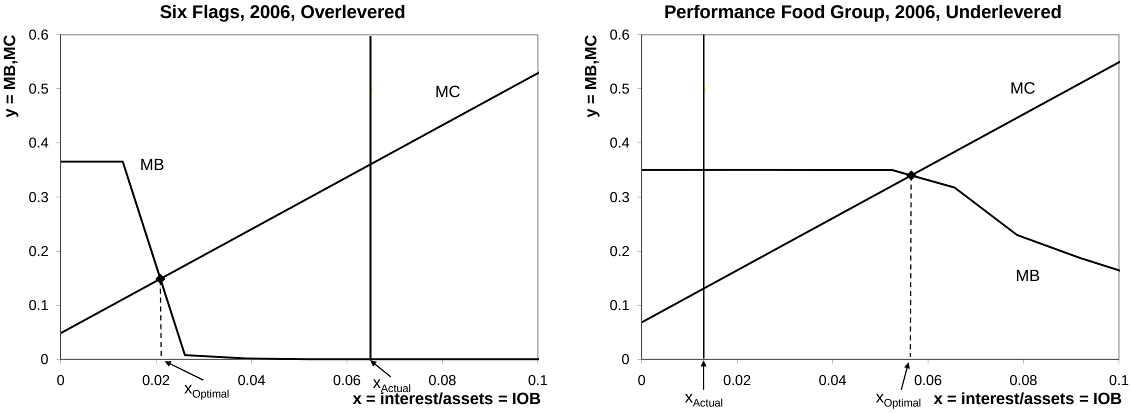

Figure 2.7: A) Marginal benefit and marginal cost curves of debt for Six Flags in 2006. In 2006, Six Flags was overlevered relative to its model implied capital structure. B) Marginal benefit and marginal cost curves of debt for Performance Food Group in 2006. In 2006, Performance Food Group was underlevered relative to its model implied capital structure. Interestingly, in 2008 Performance completed a highly levered transaction that increased its IOB to very near x_{Optimal}.

occurs nearly exactly where its cost and benefit functions intersect.

Not all companies operate near their optimal capital structures. Consider Six Flags, Inc in Figure 2.7A. Six Flags is overlevered in 2006 because its actual debt usage is over three times the recommended amount of debt.[4]

It is worth spending an extra minute interpreting just what we mean when we say a firm is overlevered. We make an optimal capital structure recommendation based on the marginal cost and marginal benefit of debt for a given firm. That firm's cost function is determined based on coefficients that we estimate on a sample of firms that are likely to have made optimal capital structure choices. Therefore, when we say that Six Flags is overlevered, we mean that it has more debt than do similar companies (i.e., companies with similar asset collateral, size, cash flow, etc.) that are thought to be making optimal choices. The debt choices of these similar firms

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[4] Due to aggressive expansion in the 1990s, Six Flags accumulated over $2 billion in debt by 2006. To pay down some of its debt, Six Flags sold several of its theme parks to Parc Management in early 2007 for $312 million.
Source: http://www.washingtonpost.com/wp-dyn/content/article/2007/01/11/AR2007011100602.html

are captured in the coefficients of the estimated marginal cost curve, as presented in equation (2.1) in the previous section. Therefore given that Six Flags has more debt than is recommended by our cost and benefit estimates, Six Flags is "overlevered" relative to these other companies.

Companies can also be underlevered. For example, consider Performance Food Group, Co. in Figure 2.7B. Performance Food Group is underlevered because its actual amount of debt is about a quarter of the recommended debt usage in 2006. As before, when we say a firm is underlevered, we mean that is has less debt than do companies with similar characteristics (size, asset collateral, etc.) that are thought to be making optimal choices.

In January 2008, Blackstone Group LP and Wellspring Capital Management LLC agreed to acquire Performance Food Group for \$1.3 billion.[5] To support this buyout, on April 30, 2008, Performance Food Group set up \$1.1 billion of debt in a revolving line of credit at a rate of LIBOR+225. This translates to about \$58.6 million in interest or a IOB of 4.31% of book assets. Combined with an existing IOB of 1.31% for Performance Food Group in 2006, the leveraged buyout would increase Performance Food Group's 2006 IOB to 5.62%. Compared to our model implied optimal capital structure of 5.65% IOB in Figure 2.7B, this would suggest that the leveraged buyout moved Performance Food Group almost exactly to its optimal debt ratio.

2.2.2 Quantifying the Benefits and Costs of Debt

More broadly, we estimate the optimal (and observe the chosen) amount of debt for all firms on Standard and Poor's Compustat database between 1980 and 2007 with available firm characteristics and interest expense data, using the same methods

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[5] Source: http://www.bloggingbuyouts.com/2008/01/18/blackstone-pays-1-3-billion-for-performance-food-group/

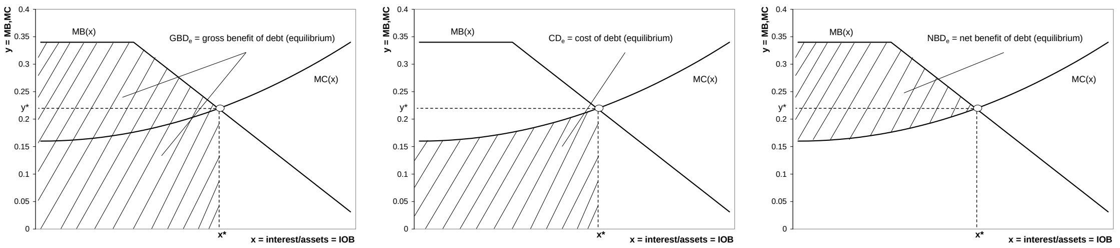

FIGURE 2.8: The figures show the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, and the equilibrium level of debt, x^*, that occurs where marginal cost and marginal benefit are equated. The marginal benefit level at x^* (which equals the marginal cost level at x^*) is denoted by y^*. Panel A depicts the equilibrium gross benefit of debt, the shaded area under the MB curve up to x^*. Panel B depicts the equilibrium cost of debt, the shaded area under the MC curve up to x^*. Panel C depicts the equilibrium net benefit of debt, the shaded area between the MB and MC curves up to x^*.

that we used for Barnes & Noble, Six Flags, and Performance Food Group. In this analysis, we include the financially constrained and financially distressed firms that we removed from the initial estimation of the marginal cost curve. This allows us to determine the gross benefits of debt, costs of debt, and net benefit of debt for any given firm in any given year. Figure 2.8 illustrates how we measure these quantities.

The observed (equilibrium) gross tax benefits of debt, GBD$_o$ (GBD$_e$), is the area under the marginal benefit curve up to the observed (equilibrium) level of interest over book value (IOB). The observed (equilibrium) cost of debt, CD$_o$ (CD$_e$), is the area under the marginal cost curve up to the observed (equilibrium) level of IOB. The observed (equilibrium) net benefit of debt, NBD$_o$ (NBD$_e$), is the difference between the gross benefit of debt and the cost of debt (i.e., the area between the curves, up to the observed (equilibrium) level of IOB). Cost measures are based on equation (2.1).

Panel A of Table 2.1 reports the unconditional summary statistics for the gross benefit, cost, and net benefit of debt for all firm-year observations in Sample A as defined in Chapter 1. Recall that this analysis includes constrained and distressed firms that were excluded in the estimation of equation (2.1). All values are reported as percentages of book value in perpetuity, so for example, a gross benefit of 5% would occur if the annual benefit was 0.5% and the discount rate was 0.10.[6] We see that the average gross benefit of debt is higher at the equilibrium levels of debt (10.4%) than at the observed levels (9.0%). In contrast, the average cost of debt is lower at the equilibrium levels (6.9%) than at the observed levels (7.9%). It is worth noting that the ex ante equilibrium cost of debt is 13.7% (17.7%) of asset value for firms in the 90th (99th) percentile of the cost distribution, much lower than the observed cost of debt of 17.8% (41.0%) of asset value for firms in the 90th (99th) percentile. These numbers imply that the net benefit of debt would be larger if firms were to operate at the equilibria implied by our analysis, relative to their observed levels: on average, the net benefit of debt at the implied equilibrium is 3.5% of book value in perpetuity versus 1.1% at observed debt levels.[7] Although 3.5% of book value seems modest, for a portion of the sample, the net benefits of debt are large. Figure 2.9A presents a histogram of firms sorted according to their equilibrium gross benefit of debt and paired with their corresponding equilibrium cost of debt. Firms above the 95th percentile have net benefits of debt that average 10.8% of book value at equilibrium levels. Figure 2.9B shows the time series of the equilibrium gross and net benefits of debt for all firms and for firms with high (above median) equilibrium net benefits of debt. The decrease in benefits around 1987 is the result of the reduction in corporate marginal tax rates following the Tax Reform Act of 1986.

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[6] We use the Moody's average corporate bond rate as the discount rate for all firms in a given year.

[7] Footnote 1 in Chapter 1 conveys that the cost of debt functions include non-tax benefits of debt and therefore can be thought of as lower bound cost estimates. That is, if all benefits of debt were captured in the benefit function and no benefits were captured as negative costs, both the cost and benefit functions would shift upwards relative to our curves. Intuitively, however, the area between the curves would not be affected. Thus, while the effect of non-tax benefits affects the interpretation of the cost function, this does not affect the interpretation of the area between the benefit and cost functions as representing the net benefit of debt. In our estimates, therefore, this area measures the total net benefit of debt, not just the net non-tax benefit of debt.

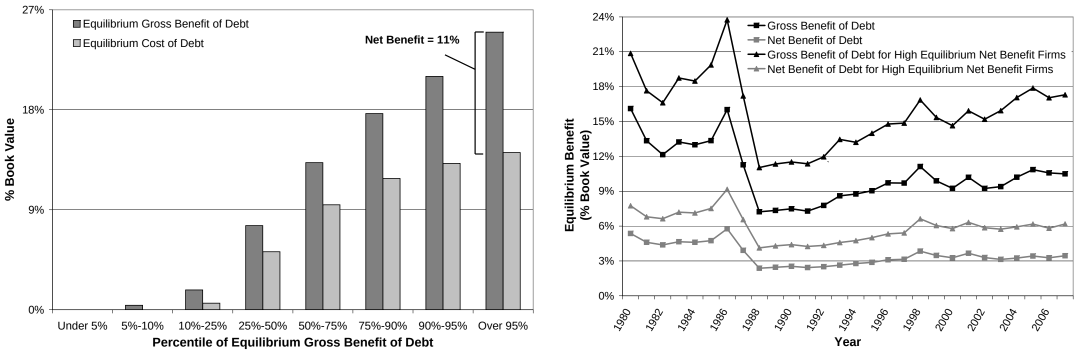

FIGURE 2.9: A) Histogram based on equilibrium gross benefit of debt percentiles with paired equilibrium cost of debt observations, B) equilibrium gross and net benefit of debt from 1980 to 2007 for all firms and high equilibrium net benefit firms (firms with equilibrium net benefit of debt above the 50th percentile).

2.3 Firm Value Gain or Loss Due to Debt Financing

As we have just discussed, the difference between the gross benefit of debt and the cost of debt equals the net benefit of debt for any given firm. For example, in Figure 2.10, the net benefit of debt for Barnes & Noble is 0.3% of asset value for 2006 and 4.4% of asset value when capitalized. (Note that for Barnes & Noble in 2006, 4.4% of asset value is equivalent to 5.9% of total firm value). This means that 5.9% of Barnes & Noble's firm value (common stock plus debt) comes from the benefits of debt financing (such as interest tax deductions), net of all costs. In other words, Barnes & Nobles's firm value would be 5.9% less if it did not use debt.

Let's turn back to the overlevered case of Six Flags in 2006 (see Figure 2.11A). Rather than adding 7.7% of firm value at the optimal amount of debt (area A in Figure 2.11A), Six Flags' overleverage is reducing firm value by 9.9% (area A-area B in Figure 2.11A). At the actual level of debt usage, Six Flag's capitalized gross benefit of debt is about 11.2% of asset value. However, the cost of debt is larger, about 20.6% of asset value. This results in a capitalized net benefit of -9.4% of asset value, the difference between areas A and B in Figure 2.11A, or equivalently -9.9%

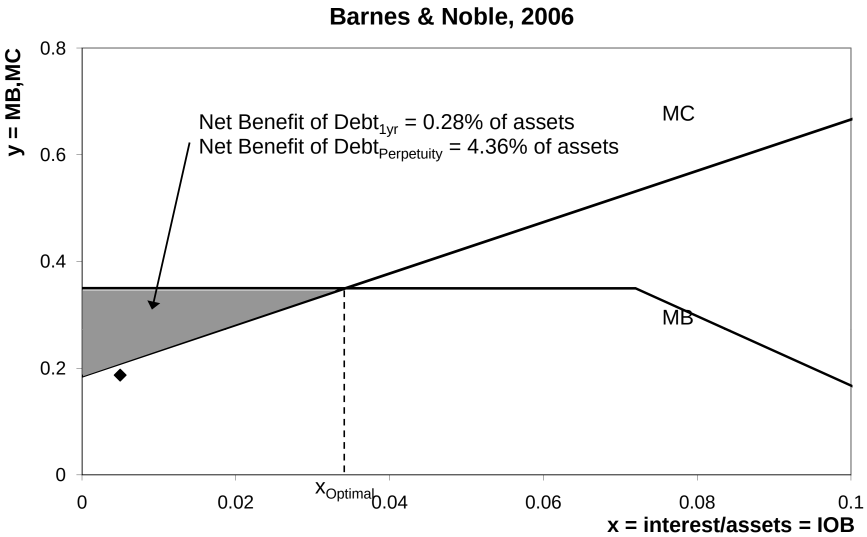

FIGURE 2.10: Net benefit of debt for Barnes & Noble in 2006. The net benefit of debt is the difference between the area under the marginal benefit of debt and the area under the marginal cost of debt.

of firm value. That is by operating above the recommended debt level, Six Flag's market value is reduced by 9.9%.

Let's turn now to our underlevered company, Performance Food Group, in 2006 (presented in Figure 2.11B.) At the actual level of debt usage, Performance Food's gross benefit is 7.1% of asset value in perpetuity and the cost of debt is 2.0%, resulting in a net benefit of debt equal to 5.1% of asset value, or 6.9% of firm value. Although Performance Food Group's debt policy adds to market value, the company is leaving money on the table in terms of unexploited net benefits of debt (area B in Figure 2.11B). That is, by increasing leverage to the recommended level, Performance Food Group can further increase its net benefit of debt. At the optimal capital structure, Performance Food Group would face a capitalized gross benefit equal to 30.5% of asset value and a cost of 17.8%. This results in a capitalized net benefit of 12.7% of asset value, the sum of areas A and B in Figure 2.11B, or a net benefit equal to 17.1% of firm value.

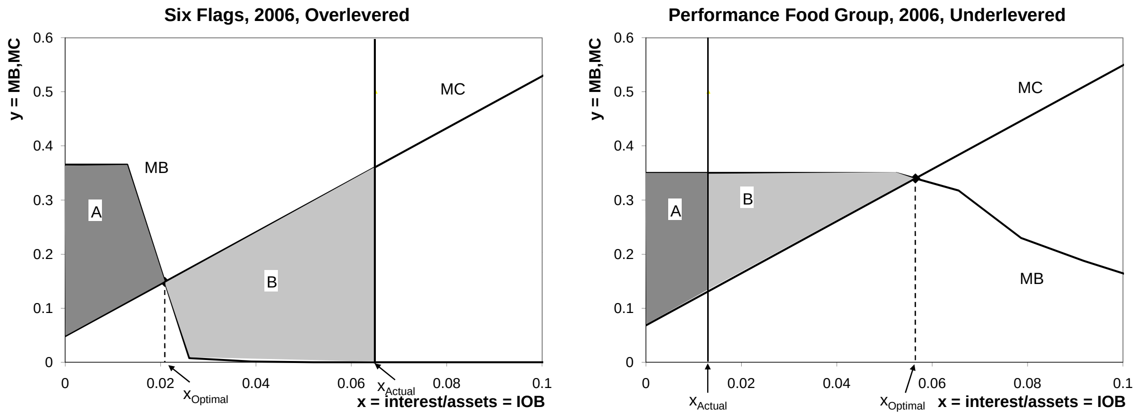

FIGURE 2.11: A) Net benefit of debt for Six Flags in 2006 is the difference between areas A and B. Six Flag faces a negative net benefit of debt due to overlevering. B) Net benefit of debt for Performance Food Group in 2006 is the sum of areas A and B. Performance Food Group leaves money on the table by not taking advantage of area B when underlevering.

Recall that Six Flags faces a net loss of 9.9% of firm value in perpetuity in 2006 when it could have had a net benefit of 7.7% by operating at the optimal capital structure recommended by our model. This implies that the cost of "being out of equilibrium" or the cost of not optimizing is 17.6% (= 7.7%-(-9.9%)) of firm value (as depicted by area B in Figure 2.11A). In Six Flag's case, this is also the cost of being overlevered. Levering correctly would increase Six Flag's market value by 17.6%.

In contrast, Performance Food Group faces a net benefit of 6.9% of firm value in 2006, when it could have had a net benefit of 17.1% by operating at the optimal capital structure. This yields a cost of being out of equilibrium, or in this example the cost of underlevering, equal to 10.2% (= 17.1%-6.9%) of firm value (as depicted by area B in Figure 2.11B). This means that Performance could increase firm value by 10.2% if it used debt optimally.[8] Note that the cost of Performance being

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[8] Recall from the previous section that Performance's LBO raised leverage to almost exactly the amount recommended by our model. This means that the LBO raised Performance's firm value by 10.2% (see Figure 2.15).

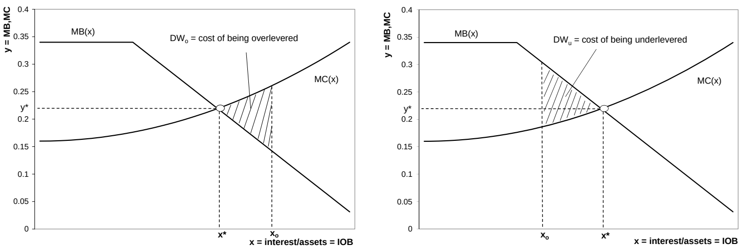

FIGURE 2.12: The figures show the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, the observed level of debt, x_o, and the equilibrium level of debt, x^*, that occurs where marginal cost and marginal benefit are equated. The marginal benefit level at x^* (which equals the marginal cost level at x^*) is denoted by y^*. Panel A depicts the cost of being overlevered, the shaded area between the MC and MB curves from the equilibrium, x^*, to the observed debt, x_o, in the case where the actual level of debt, x_o, exceeds the equilibrium level of debt x^*. Panel B depicts the cost of being underlevered, in the case where the equilibrium level of debt, x^*, exceeds the actual level of debt, x_o.

underlevered is smaller than the 17.6% cost of overleverage that Six Flag faces.

2.3.1 Cost of Being Underlevered or Overlevered

As shown in the examples above, our analysis allows us to address the question: how costly is it for firms to operate out of capital structure equilibrium? The cost of being "overlevered" can provide insights into the potential cost of financial distress, while the cost of being "underlevered" can shed light on the cost of financial constraints or managerial conservatism. The cost of being overlevered, DW_o, is the deadweight loss measured as the area between the cost and benefit curves when a firm has more debt than recommended by our model (see Figure 2.12A). The cost of being underlevered, DW_u, is the deadweight loss from leaving money on the table due to using less debt than implied by the model (see Figure 2.12B). One interpretation of DW_u is that it represents the value lost from suboptimal debt usage (relative to unconstrained debt usage) imposed by financial constraints limiting the amount of debt a firm can use.

Panel B of Table 2.1 reports DW_o and DW_u for firms that are financially distressed and/or constrained. The table shows that on average the cost of overlevering is 3.8%

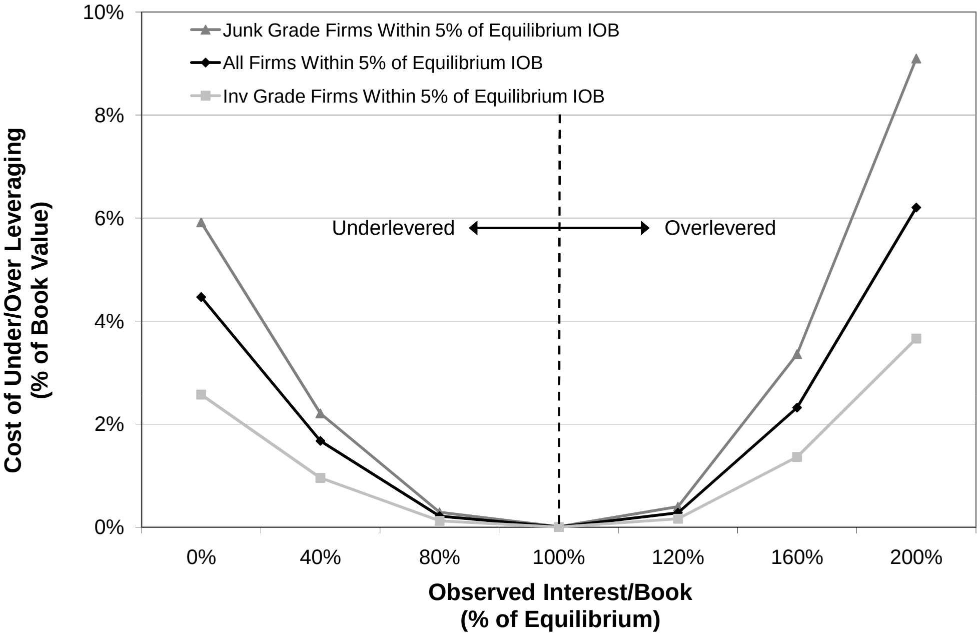

FIGURE 2.13: Hypothetical deadweight costs of being underlevered or overlevered for companies within 5% of their equilibrium IOB among Sample A firms, investment grade firms, and junk rated firms.

of book value in perpetuity, while the average cost of underlevering is 1.4%. This asymmetry of higher costs to being overlevered than underlevered is consistent with the rebalancing behavior documented in Leary and Roberts (2005).

In extreme cases (99th percentile), the capitalized cost of overlevering can be as high as 30.1% of book value, while the cost of being underlevered reaches only 8.1%. Note that the cost of overleverage is 10.6% at the 90th percentile. These numbers are in the same ballpark as the 10% to 23% of firm value estimates of the ex post cost of distress for the 31 highly leveraged transactions studied by Andrade and Kaplan (1998).

One way to conceptualize the cost of being under- or overlevered is to study companies that operate at or near their model-implied equilibrium and examine what the implied cost of debt would be if they were to hypothetically lever up or down.[9]

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[9] Another way to conceptualize the cost of being out of equilibrium is to study firms that actually

Table 2.2 summarizes the cost of being underlevered or overlevered if firms that are currently within 5 percent of their equilibrium were to hypothetically change their IOB to X% of their equilibrium IOB. Panel A analyzes Sample A firms that operate near model implied equilibrium. As expected, the gross benefit of debt and cost of debt increase with IOB. As seen before, the numbers reveal that the cost of debt is disproportionately higher if a firm were to overlever versus underlever. If firms were to hypothetically move away from their equilibria by doubling their leverage, they would on average face a deadweight cost of 6.2% of book value. On the other hand, if firms were to hypothetically move away from their equilibria by eliminating their debt, they would face a deadweight cost of 4.5%. These results are shown in Figure 2.13. The asymmetrically larger costs of overleverage helps explain at least partially why some firms might use debt conservatively.

Panels B and C of Table 2.2 present the hypothetical results for investment grade and speculative grade firms that are in equilibrium, respectively. For both sets of firms, the cost of being overlevered is again larger than being underlevered (see Figure 2.13). The asymmetry between the cost of being overlevered versus being underlevered is minimal for investment grade firms and is more severe for junk rated firms. These results are reassuring in that this analysis implies that speculative rated firms face higher marginal costs than do investment grade firms.

2.3.2 Value Added Graph

Finally, Figure 2.14A presents the "value gained from capital structure" graph that appears in Myers (1984) and in most corporate finance textbooks (e.g., Graham, Smart, and Megginson, 2010).[10] The value function is humped-shaped because capi-

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operate out of equilibrium in that they deviate from the model implied equilibrium. Our analysis indicates that the implications are the same in this experiment: there is a larger cost to being overlevered relative to being underlevered.

[10] Most finance textbooks present a stylistic graph that shows how much a hypothetical firm could add to its market value by using various amounts of debt in its capital structure.

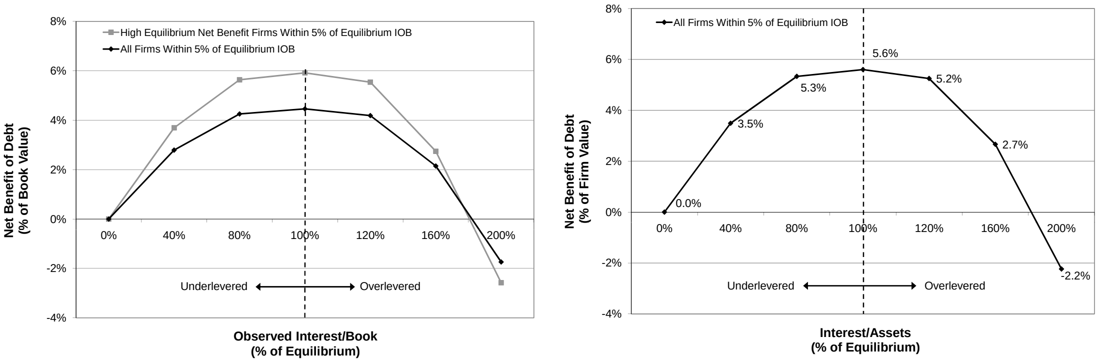

FIGURE 2.14: A) Hypothetical net benefit of debt (gross benefit of debt minus cost of debt) for firms within 5% of their equilibrium IOB and for firms with high equilibrium net benefit of debt (firms with equilibrium net benefit above the 50th percentile). The curve shows that for the typical near-equilibrium firm, optimal capital structure increases book value by an amount equal to 4.5% of book assets. For a firm with high benefits of debt, optimal capital structure increases firm value by about 5.9% of book assets. The capital structure value function is fairly flat for movements within ±20% of optimal, but falls off steeply for larger deviations. B) Hypothetical net benefit of debt for firms within 5% of their equilibrium IOB. The curves shows that for the typical near-equilibrium firm, optimal capital structure increases firm value by an amount equal to 5.6% of firm assets.

tal structure adds value up to the optimal point (the intersection of the marginal cost and marginal benefit curves), then declines after that point. We use our empirical estimates to calibrate this well-known graph, based on firms that operate within ±5% of model-implied optimal debt usage and again for firms that have high net benefits of debt. One previously unanswered question about the value graph is whether it is flat, and over what region; that is, how much value is lost if a firm does not make an capital structure? Our results indicate that for the typical near-equilibrium firm, optimal capital structure increases firm value by 4.5% of book assets (and 5.6% of firm value in 2.14B) on average, and by 5.9% of book assets for high net benefit firms. As mentioned earlier, the value reaches more than 11% for one in twenty firms (see Figure 2.9A). The value function is fairly flat if a typical firm operates within ±20% of the optimum.

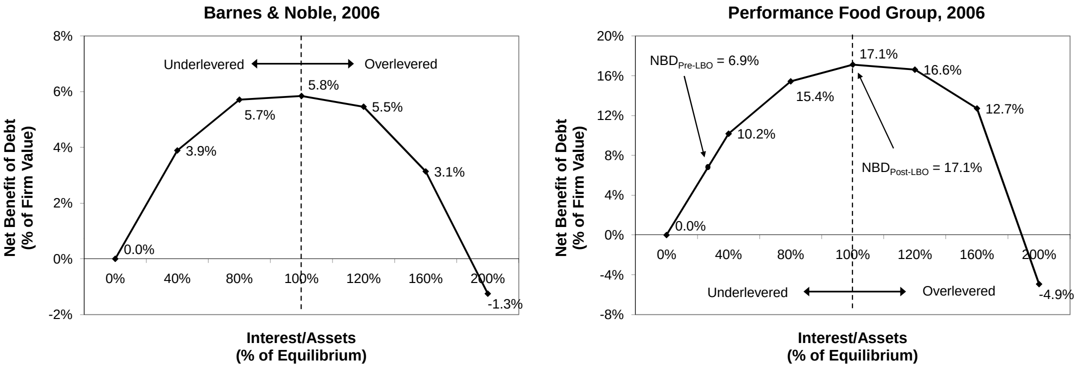

FIGURE 2.15: A) Hypothetical net benefit of debt for Barnes & Noble in 2006 depicting the value gained from capital structure. The value graph is hump-shaped because capital structure adds value up to the optimal point, then declines after that point. B) Hypothetical net benefit of debt for Performance Food Group in 2006 depicting the value gained from capital structure.

Returning to our examples, Figure 2.15A plots the net benefit of debt for Barnes & Noble if the company were to hypothetically use different amounts of debt in 2006. That is, this is the "value gained from capital structure" graph for Barnes & Noble. In 2006, optimal capital structure increases Barnes & Noble's firm value by 5.9% at the optimum financing choice – said differently, if Barnes & Noble were to stop using debt, its firm value would fall by 5.9% (ignoring possible "signaling" and other effects associated with financing announcements).

Figure 2.15B plots the net benefit of debt for Performance Food Group. In this case, using the correct amount of debt adds 17.1% to the market value of Performance. In 2006, Performance was underlevered and used only a quarter of its optimal amount of debt (denoted by a solid circle in the figure). Figure 2.11B indicates that using too little debt cost Performance 10.2% of firm value. Recall from our earlier discussion that Performance completed an LBO in 2008 that placed the firm more or less in equilibrium. Figure 2.15B makes it clear that the LBO added to market value by making a financing choice near the optimum.

By comparing Figure 2.15A and Figure 2.15B, we see that the value function is sometimes steep (suboptimal capital structure is more costly for Performance, in Figure 2.15B) and sometimes it is relatively flat (Barnes & Noble would not lose much value if it were to deviate within a reasonable range from its optimum).

2.4 Additional Case Studies

In previous sections, we showed how we used our marginal benefit and marginal cost curves of debt to examine optimal capital structure using Barnes & Noble, Six Flags, and Performance Food Group as examples. Our analysis showed that Barnes & Noble more or less used its model recommended debt level. Six Flags used too much debt, and Performance Food Group used too little in 2006. In this section, we examine four additional case studies, in particular, companies that altered their financing mix relative to their optimal capital structure.

2.4.1 Hasbro

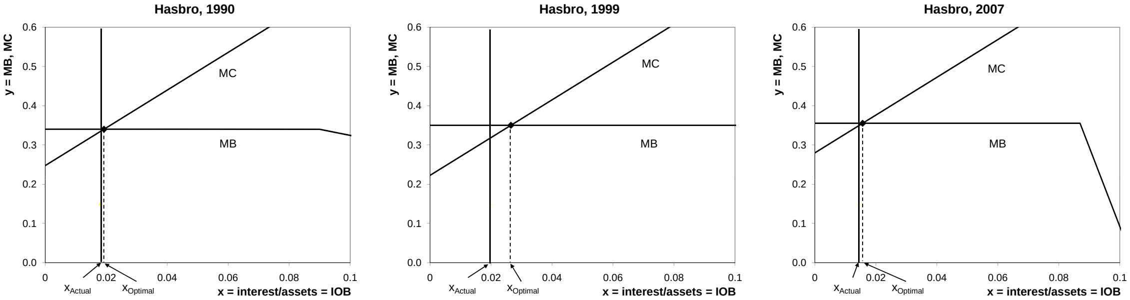

FIGURE 2.16: Marginal benefit and marginal cost curves for Hasbro in 1990, 1999, and 2007. The solid vertical line reflects the actual debt usage. The dotted vertical line reflects the optimal capital structure.

The first panel of Table 2.3 displays the decile rankings of financial ratios for Hasbro, Inc. in 1990, 1999, and 2007. Hasbro is a large family leisure product manufacturing company that consistently pays dividends and has relatively high intangible assets. From 1990 to 1999, Hasbro's intangibles doubled and book-to-market ratio almost halved. The increase in intangibles decreased the marginal cost of debt, while the increase in growth opportunities raised the marginal cost, with the net effect of a lower marginal cost curve. From 1999 to 2007, Hasbro's intangibles decreased, cash flows increased, and the company's book-to-market ratio decreased. All three effectively increased the marginal cost of debt, resulting in a higher marginal cost of debt curve (the firm-specific intercept of the marginal cost curve decreased from 0.247 in 1990 to 0.222 in 1999 and increased to 0.280 in 2007).

Consistent with these changes in marginal cost, Hasbro's model-implied optimal interest-over-book increased from 0.019 in 1990 to 0.027 in 1999 and decreased to 0.016 by 2007 (see Figure 2.16). In 1990 Hasbro chose an actual IOB that is approximately at the model-implied "equilibrium", i.e., the point where the estimated marginal cost and marginal benefit curves intersect. In 1999, Hasbro increased actual debt usage, consistent with a reduction in costs, though the firm did not use the full amount of debt that the model implies it should. By 2007, the firm changed debt in the direction recommended by the model and operated at the model-implied equilibrium level of debt.

2.4.2 Black & Decker

The second panel of Table 2.3 displays fundamentals for Black & Decker in 1990, 1999, and 2007. Black & Decker is a large firm that pays dividends and has stable sales. The firm's low collateral and intangible assets suggest high marginal costs based on our estimation results, and the model recommends less debt than Black and Decker uses in 1990. That is, relative to the model implied debt ratio, Black and Decker was overlevered in 1990. This excessive debt stems from Black and Decker's highly levered acquisition of Emhart Corporation in 1989. In the mid 1990s, Black

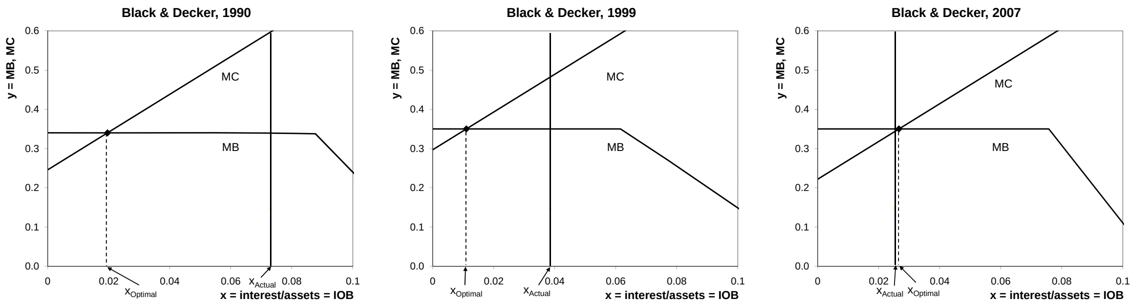

FIGURE 2.17: Marginal benefit and marginal cost curves for Black & Decker in 1990, 1999, and 2007. The solid vertical line reflects the actual debt usage. The dotted vertical line reflects the optimal capital structure.

and Decker issued equity in order to pay down its debt.[11] Thus by 1999, Black and Decker's actual leverage had decreased and the firm had moved closer to its model-implied optimal debt ratio. In 2007, the firm was in equilibrium given that its actual IOB coincides with the model-implied interest-over-book-assets ratio.

2.4.3 Home Depot

Figure 2.18 depicts the optimal capital structure for Home Depot in 1990, 1999, and 2007. Home Depot is a large retailer store focused on home construction supplies with large capital, large cash flows, and consistent dividend payments. The company is slightly overlevered in 1990. By 1999, Home Depot has actually reduced their debt (as we see in Panel C of Tabl 2.3 from a debt to equity ratio of 0.324 to 0.044 and becomes underlevered with about half of the amount of debt than recommended. The capitalized cost of being underlevered amounts to only 0.1% of firm value. However, given Home Depot's large market value, this amounts to $130 million. By 2007, Home Depot has increased their leverage to levels near its model implied optimum.

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[11] Source: http://query.nytimes.com/gst/fullpage.html?res=9E0CE3DB1E3CF930A25750C0A964958260

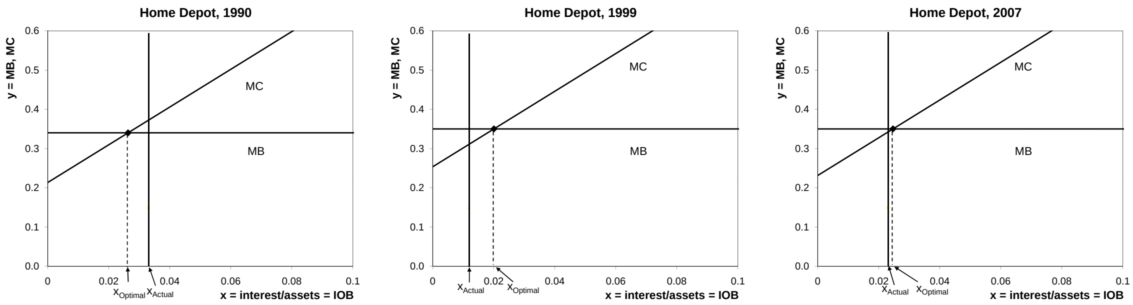

FIGURE 2.18: Marginal benefit and marginal cost curves for Home Depot in 1990, 1999, and 2007. The solid vertical line reflects the actual debt usage. The dotted vertical line reflects the optimal capital structure.

2.4.4 U.S. Playing Cards

The last panel of Table 2.3 shows financial ratios for U.S. Playing Card Company for 1980, 1983, and 1986. We present this firm because it underwent a leveraged buyout (LBO) in 1981 but still had Compustat data until 1986. An ideal LBO target would have the potential for large gains from increasing debt, perhaps even being underlevered prior to the LBO. We see from Figure 2.19 that in 1980, this is indeed the case for U.S. Playing Card Company.

In 1980, the potential value gain from perpetually levering up to the implied optimum would amount to approximately 10.9% of firm value. The leveraged buyout for U.S. Playing Card was announced and effective in 1981. By 1983, we see a huge increase in the firm's debt to equity ratio (from 0.028 to 0.453), and the company became highly overlevered. However, by 1986 the marginal benefits curve has shifted upward, indicating improved financial health of the firm (in that the firm is more likely to earn positive profits). Furthermore, we start to see the company slowly decreasing its debt obligations towards its model-implied optimum. Unfortunately, U.S. Playing Card disappears from Compustat in 1986 and we cannot observe whether it eventually reaches its optimum. From what we do observe, this case is consistent with the implication that although an LBO initially puts a firm in an overlevered

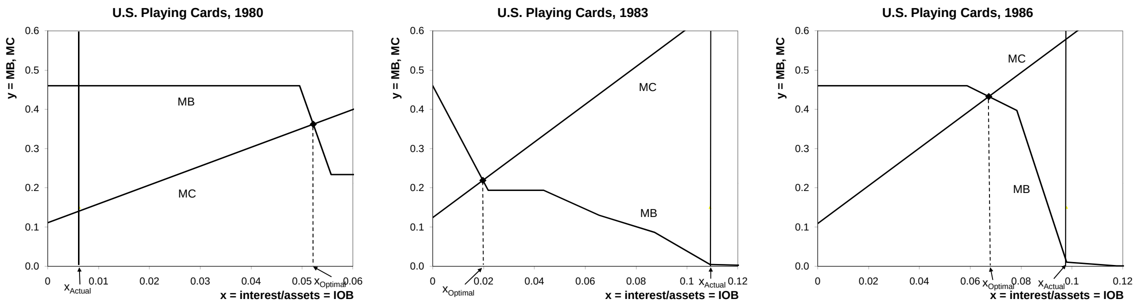

FIGURE 2.19: Marginal benefit and marginal cost curves for U.S. Playing Cards in 1990, 1997, and 2006. The solid vertical line reflects the actual debt usage. The dotted vertical line reflects the optimal capital structure.

position, there are tax benefits to LBOs, and the leverage is eventually paid down.

2.5 Summary

We directly simulate marginal tax benefit functions for thousands of public companies. We use variation in these benefit curves to infer a cost of debt function that is consistent with the observed capital structure choices made by firms that are neither financially distressed nor financially constrained.

The intersection of the benefit and cost curves for any given firm tells us the optimal amount debt for this firm, given its characteristics. We can tell if firms are correctly levered, underlevered, or overlevered. Moreover, we can determine the net benefit of using debt optimally, or the cost of using suboptimal debt. The average capitalized net benefit of debt for firms operating at the optimal capital structure is 4.5% of book value and 5.6% of firm value and as high as 11% of book value for some firms. The cost of using too little debt is less than the cost of using too much debt, which may explain why some firms use so little debt.

Table 2.1: Summary statistics for benefits and costs of debt. Cost measures are based on equation (1.12). The observed (equilibrium) gross benefits of debt, GBD_o (GBD_e), is the area under the marginal benefit curve up to the observed (equilibrium) level of interest over book value (IOB). The observed (equilibrium) cost of debt, CD_o (CD_e), is the area under the marginal cost curve up to the observed (equilibrium) level of IOB. The observed (equilibrium) net benefits of debt, NBD_o (NBD_e), is the area under the marginal benefit curve minus the area under the marginal cost curve up to the observed (equilibrium) IOB. Observed is defined as the actual IOB that the firm employs. Equilibrium is defined as the intersection of the marginal benefit and cost curves. The cost of being overlevered, DW_o, is the deadweight loss from additional costs due to observed IOB being greater than the equilibrium. The cost of being underlevered, DW_u, is the deadweight loss from lower benefits due to observed IOB being below the equilibrium.

Panel A: All Firms

	No. Obs.	Mean	Std. Dev.	1%	10%	25%	Median	75%	90%	99%
Observed:										
Gross benefits (GBD_o)	78398	0.0900	0.0796	0.0000	0.0056	0.0274	0.0729	0.1308	0.1964	0.3485
Costs (CD_o)	78398	0.0791	0.0860	-0.0207	0.0052	0.0226	0.0567	0.1066	0.1776	0.4098
Net benefits (NBD_o)	78398	0.0109	0.0577	-0.2180	-0.0387	0.0000	0.0158	0.0375	0.0622	0.1154
Equilibrium:										
Gross benefits (GBD_e)	78398	0.1039	0.0781	0.0000	0.0000	0.0309	0.1034	0.1616	0.2076	0.2902
Costs (CD_e)	78398	0.0688	0.0536	-0.0305	0.0000	0.0163	0.0733	0.1124	0.1371	0.1774
Net benefits (NBD_e)	78398	0.0352	0.0333	0.0000	0.0000	0.0083	0.0278	0.0530	0.0798	0.1392

Panel B: Financially Distressed and/or Constrained Firms

	No. Obs.	Mean	Std. Dev.	1%	10%	25%	Median	75%	90%	99%
Cost of overlevering (DW_o)	31881	0.0379	0.0635	0.0000	0.0003	0.0024	0.0130	0.0452	0.1057	0.3008
Cost of underlevering (DW_u)	34045	0.0140	0.0181	0.0000	0.0002	0.0018	0.0076	0.0194	0.0359	0.0812

Table 2.2: Among firms that operate within 5% of equilibrium, the hypothetical benefits and costs of debt if they were to operate out of equilibrium. Cost measures are based on equation (2.1). The gross benefits of debt, GBD, is the area under the marginal benefits curve up to the indicated level of interest over book value (IOB). The cost of debt, CD is the area under the marginal cost curve up to the indicated level of IOB. The net benefits of debt, NBD, is the area under the marginal benefits curve minus the area under the marginal cost curve up to the indicated IOB. Equilibrium is defined as the intersection of the marginal benefit and cost curves. The cost of being overlevered, DW_o, is the deadweight loss from additional costs due to having IOB above the equilibrium. The cost of being underlevered, DW_u, is the deadweight loss from lower benefits due to having IOB below the equilibrium.

	Panel A: All Firms					
	N	GBD	CD	NBD	DW_o	DW_u
0% of equilibrium IOB	3497	0.0000	0.0000	0.0000		0.0447
20% of equilibrium IOB	3497	0.0272	0.0116	0.0156		0.0291
40% of equilibrium IOB	3497	0.0543	0.0264	0.0279		0.0168
60% of equilibrium IOB	3497	0.0812	0.0443	0.0369		0.0078
80% of equilibrium IOB	3497	0.1079	0.0654	0.0425		0.0021
at equilibrium IOB	3497	0.1342	0.0896	0.0446		
120% of equilibrium IOB	3497	0.1588	0.1169	0.0419	0.0028	
160% of equilibrium IOB	3497	0.2026	0.1811	0.0215	0.0232	
200% of equilibrium IOB	3497	0.2405	0.2579	-0.0174	0.0621	
300% of equilibrium IOB	3497	0.3117	0.5050	-0.1933	0.2379	
400% of equilibrium IOB	3497	0.3575	0.8309	-0.4734	0.5181	

	Panel B: Investment Grade Firms					
	N	GBD	CD	NBD	DW_o	DW_u
0% of equilibrium IOB	547	0.0000	0.0000	0.0000		0.0258
20% of equilibrium IOB	547	0.0237	0.0146	0.0091		0.0167
40% of equilibrium IOB	547	0.0473	0.0311	0.0162		0.0096
60% of equilibrium IOB	547	0.0709	0.0496	0.0213		0.0044
80% of equilibrium IOB	547	0.0945	0.0700	0.0245		0.0012
at equilibrium IOB	547	0.1180	0.0923	0.0257		
120% of equilibrium IOB	547	0.1407	0.1166	0.0241	0.0016	
160% of equilibrium IOB	547	0.1830	0.1709	0.0121	0.0136	
200% of equilibrium IOB	547	0.2222	0.2331	-0.0109	0.0366	
300% of equilibrium IOB	547	0.3037	0.4222	-0.1186	0.1443	
400% of equilibrium IOB	547	0.3630	0.6599	-0.2969	0.3226	

	Panel C: Speculative Firms					
	N	GBD	CD	NBD	DW_o	DW_u
0% of equilibrium IOB	323	0.0000	0.0000	0.0000		0.0592
20% of equilibrium IOB	323	0.0356	0.0148	0.0208		0.0384
40% of equilibrium IOB	323	0.0710	0.0339	0.0371		0.0221
60% of equilibrium IOB	323	0.1062	0.0572	0.0489		0.0102
80% of equilibrium IOB	323	0.1411	0.0848	0.0563		0.0029
at equilibrium IOB	323	0.1757	0.1167	0.0591		
120% of equilibrium IOB	323	0.2079	0.1528	0.0552	0.0040	
160% of equilibrium IOB	323	0.2633	0.2377	0.0256	0.0336	
200% of equilibrium IOB	323	0.3079	0.3397	-0.0318	0.0910	
300% of equilibrium IOB	323	0.3794	0.6692	-0.2898	0.3490	
400% of equilibrium IOB	323	0.4173	1.1052	-0.6878	0.7470	

Table 2.3: Key financial characteristics for Hasbro, Inc., Black & Decker, Home Depot, and U.S. Playing Cards. TA is total assets expressed in thousands of 2000 dollars, D/E is the debt to equity ratio, COL is collateralizable assets over total book assets, BTM is the book equity to market equity ratio, INTANG is intangible assets over total book assets, CF is net cashflow over total book value, and DIVIDENDS is total dividend payout over total book assets. Both decile rankings within the sample and actual values for each firm and year are provided.

	Hasbro, Inc.					
	1990		1999		2007	
	Decile	Value	Decile	Value	Decile	Value
TA	9	1693.5	10	4614.0	9	2688.5
D/E	3	0.0443	5	0.0942	8	0.2192
COL	2	0.2386	2	0.1630	2	0.1381
BTM	7	0.9563	5	0.5090	4	0.3470
INTANG	10	0.1835	10	0.3934	9	0.2958
CF	8	0.1736	7	0.1586	9	0.2120
DIVIDENDS	8	0.0089	9	0.0105	10	0.0303
	Black & Decker					
	1990		1999		2007	
	Decile	Value	Decile	Value	Decile	Value
TA	10	7763.1	9	4148.2	9	4493.9
D/E	10	0.4679	7	0.2111	7	0.2179
COL	2	0.2838	4	0.3715	5	0.3219
BTM	9	1.6073	2	0.1762	4	0.3257
INTANG	3	0.0000	5	0.0000	9	0.2751
CF	6	0.1183	8	0.1735	7	0.1471
DIVIDENDS	7	0.0041	9	0.0104	9	0.0201
	Home Depot					
	1990		1999		2007	
	Decile	Value	Decile	Value	Decile	Value
TA	10	2151.4	10	17618.7	10	36686.0
D/E	9	0.3237	4	0.0439	8	0.2568
COL	10	0.8464	10	0.9201	10	0.8846
BTM	1	0.1308	1	0.0971	3	0.3127
INTANG	7	0.0131	6	0.0182	4	0.0295
CF	8	0.1821	10	0.2493	9	0.2038
DIVIDENDS	7	0.0078	9	0.0149	10	0.0386
	U.S. Playing Cards					
	1980		1983		1986	
	Decile	Value	Decile	Value	Decile	Value
TA	3	28.4	6	112.6	6	133.3
D/E	2	0.0284	10	0.4530	9	0.3687
COL	5	0.5646	6	0.6227	7	0.6325
BTM	6	0.9710	1	0.2708	3	0.4193
INTANG	5	0.0000	7	0.0000	5	0.0000
CF	4	0.1223	5	0.1095	5	0.0902
DIVIDENDS	0	0.0000	0	0.0000	0	0.0000

3

Financing Constraints and Capital Structure

In the world of Modigliani and Miller (1958), corporate financial structures are independent of real investment decisions, and the choice between debt and equity is irrelevant. When frictions exist that create a wedge between the cost of external capital and the cost of internal capital, firms may no longer be able to fund all profitable investment projects. Additionally, when these frictions cause the cost of external debt to deviate from the cost of external equity, the capital structure choice and investment decisions are no longer mutually independent. That is, frictions in the market can lead to circumstances in which the irrelevance of capital structure no longer hold and the capital structure decision itself interacts with the broader environment of corporate investment.

In the previous chapters, I study the cost of debt and how it is used along with the benefits of debt to determine and analyze optimal capital structure. Firms are at their optimal capital structure when they use the amount of leverage that equates (intersects) the marginal benefits of debt to the marginal costs of debt.

In this chapter, I examine the relevance of the capital structure decision by studying how financing constraints create a joint relationship between investment and capital structure. Understanding the role of frictions on investment and financing decisions is important to understanding the larger picture of how corporate capital structure and investment choices link together. By financing constraints, I refer to the subset of frictions that restrict firms from accessing capital markets. The main difficulty in studying financial constraints is that they are unobserved in reality and usually proxied in the literature by using observable characteristics. So, in order to understand the impact of financing constraints on corporate decisions, two important questions must be asked: what is the theoretical relationship between financing constraints and corporate decisions and, based on observed choices, do firms behave as if they face financial constraints (and if so, what are the implied characteristics and magnitudes of the constraints)?

To address these questions, I introduce and estimate a structural model of capital investment that extends the neoclassical investment framework in Whited (1992) and Whited and Wu (2006) to include two separate financing constraints: one to restrict equity issuance and one to restrict debt issuance. Having two separate financing constraints for equity and debt creates a wedge between the cost of external equity and the cost of external debt, adding a capital structure dimension to the model. This endogenizes the capital investment and capital structure decisions of the firm, requiring both to be jointly and simultaneously (rather than sequentially) determined.

In my model, firms maximize value by choosing the amount of capital to invest and the amount of debt to issue. Firms are faced with two financing constraints: 1) a dividend non-negativity constraint that restricts them from issuing equity and 2) a debt capacity constraint that restricts them from issuing debt. The Lagrange multiplier on the first constraint measures the shadow value of issuing equity and the Lagrange multiplier on the second constraint measures the shadow value of issuing debt. These shadow values capture the marginal value added to the firm from relaxing the constraints to issuing an additional unit of equity or debt, respectively. In other words, the higher the shadow values, the more constrained the firm from accessing funds for investment. The first order conditions from the structural model provide the Euler equations necessary to estimate the model and obtain coefficients on the shadow values of the two financing constraints.

I find that the shadow values of both financing constraints on issuing equity and issuing debt are positive and significant, providing evidence that both constraints are important to corporate investment and financing decisions. Furthermore, my estimation framework allows me to parameterize the two constraints conditional on firm-specific characteristics. I find that the financing constraints relate to firm characteristics in ways that are intuitively sensible (e.g., illiquidity of equity increases the financing constraint to issuing equity and collateral decreases the financing constraint to issuing debt). I test the financing predictions of the model related to debt issuances, equity issuances, debt reductions, and equity reductions and find results consistent with observed capital structure behavior. Specifically, the firms with high equity constraints and low debt constraints are more likely to both issue and reduce debt; firms with high debt constraints and low equity constraints are more likely to issue equity. Only firms with low debt constraints are more likely to repurchase shares.

Having estimated two separate financing constraint measures for debt and equity, I collapse the two quantities into one overall financial constraint measure. Firms are defined to be overall financially constrained if they are restricted in obtaining both debt and equity today. This gives me three metrics for financing constraints: one for equity financing, one for debt financing, and an overall measure that combines the first two separate measures. I sort on these three measures and find that the limiting constraint is the constraint on debt issuance. In other words, the firm's financing decision is driven by its constraints on contemporaneous capital structure. This provides evidence that, all else equal, firms care about preserving their debt capacity and financial slack. This is precisely due to optimal capital investment being impacted by financing considerations. Specifically, capital investment requires funds today but increases next period's debt capacity. Vice versa, if the firm chooses to defer investment, they preserve financial slack today, but forego profits in the future.

Numerous papers examine financial constraints and the effects they have on corporate policies. Fazzari, Hubbard, and Petersen (1988), Kaplan and Zingales (1997), and others consider financing constraints through the relationship between investment and cash flow sensitivity. Kaplan and Zingales (1997), Cleary (1999), and Whited and Wu (2006) use empirical analysis to explain and identify financially constrained firms based on firm-specific characteristics. Lamont, Polk, and Saò-Requejo (2001), Whited and Wu (2006), Gomes, Yaron, and Zhang (2006), and Livdan, Sapriza, and Zhang (2009) consider whether financial constraints are priced in the equity market. Most of this literature emphasizes the effects that constraints on external financing have on investment decisions while shutting down the capital structure decision. Yet, the vast capital structure literature indicates that the type of financing and therefore the type of financing constraint matters. For example, Myers' (1977) debt overhang story suggests that using debt prevents firms from making positive NPV investments. Jensen and Meckling (1976)'s agency cost story and Jensen's (1986) theory of free cash flow suggests that leverage can discipline management to limit personal consumption and empire building through its monitoring benefits.

This chapter makes three primary contributions. First, I introduce and empirically estimate a model that endogenizes the investment and financing decisions through two separate financing constraints on equity and debt. This allows me to provide a theoretical relationship between financing constraints and corporate decisions. In doing so, I disentangle the intertemporal investment decision into two financing considerations: intertemporal equity financing and contemporaneous capital structure. Second, I provide empirical indices for measuring the financing constraint of issuing equity, issuing debt, and an overall measure that incorporates the financing constraints of both equity and debt. Third, I provide evidence that my model captures observed corporate financing behavior in ways that are consistent with extant literature. Furthermore, I find that between the intertemporal equity financing constraint and the contemporaneous debt to equity constraint, firms act as if the latter is the limiting constraint. Specifically, firms care about financial flexibility and preservation of financial slack (as measured by the debt capacity). This is consistent with Kisgen (2006). He finds that credit ratings affect capital structure decisions due to their usefulness in providing access to capital markets and their consideration by investors in providing external funds. Similarly, the CFO survey findings of Graham and Harvey (2001) find that financial flexibility is the top consideration by financial managers in their determination of capital structure.

This chapter builds upon previous work. Whited (1992) develops a model that links financing constraints to investment and finds that an Euler equation that accounts for financing constraints fares better than one without financing constraints. Whited and Wu (2006) extends Whited (1992) by estimating the intertemporal (equity) financing constraint and exploring whether this constraint measure is priced in the equity market. My model differs from Whited (1992) and Whited and Wu (2006) in that I include both the intertemporal equity financing constraint and the contemporaneous capital structure constraint. This allows me to distinguish and estimate two separate measures for the constraint on equity and the constraint on debt and explore the relative importance between the two. Hennessey and Whited (2005) model dynamic capital structure and investment decisions in a general equilibrium framework that features taxation, corporate savings, and path dependency of optimal capital structure. Calibrating and simulating their model, the authors find that corporate leverage choice is path dependent and there are no target leverage ratios. Like Hennessey and Whited (2005), my model finds that preservation of financial slack is an important consideration for the firm. I differ from Hennessey and Whited (2005) in that in my framework there is an optimal leverage ratio and optimal capital investment, both of which are influenced by the tradeoff between profits from investment and preservation of financial flexibility. In addition, I differ from Hennessey and Whited in focus. Hennessey and Whited (2005) explore debt dynamics through a general equilibrium framework whereas I study the impact of financing constraints on investment and financing decisions. Given our different foci, it is reassuring our results are consistent. My simplified framework allows me to calculate analytical first order conditions that I use as moment conditions in GMM estimation. This allows me to directly capture the shadow values of financing constraints and map them to firm characteristics. Ultimately, this chapter empirically estimates a structural model that links investment and financing decisions through the existence of financing frictions.

The rest of the chapter is organized as follows. Section 3.1 discusses the general theoretical framework, parametrization, and estimation of the model. Section 3.2 describes the data and presents summary statistics of the variables used in estimation. Section 3.3 discusses the results from the estimation of the model and financing constraint measures. Section 3.4 tests the implications of the model and the validity of the financing constraint indices. I also propose an overall financing constraint measure and examine the impact of the two individual constraint measures against the overall measure. Finally, section 3.5 summarizes the main findings.

3.1 Model

This section introduces a dynamic structural model of capital investment that extends the neoclassical investment framework in Whited (1992) and Whited and Wu (2006). The model includes separate financing constraints for external equity and for debt. Financial constraints to issuing equity is measured by the shadow cost on a dividend non-negativity restriction and financial constraints to issuing debt is captured by the shadow value of a debt capacity restriction. The model is then estimated using generalized method of moments (GMM). Section 3.1.1 provides the theoretical framework. Section 3.1.2 specifies the simplifying assumptions and parametrization of the model. Finally, Section 3.1.3 describes the identification and estimation of the model using GMM.

3.1.1 Theory

The objective of the firm is to maximize the expected present value of its dividend stream, by choosing the next period capital investment, $K_{i,t+1}$ and debt issuance, $B_{i,t+1}$. That is, each firm, i, solves the following optimization problem:

$$V_{i,0} = \max_{K_{i,t+1}, B_{i,t+1}} E_{i,0} \sum_{t=0}^{\infty} M_{0,t} D_{i,t} \tag{3.1}$$

where $E_{i,0}$ is the expectation operator for firm i based on the information set at time 0. $M_{0,t}$ is the stochastic discount factor between time 0 and time t. $D_{i,t}$ is the value of the dividends for firm i at time t. Implicit in the model is the assumption that all debt (and interest) are paid off at the end of each period and all net cash flows are paid out as dividends at the end of each period to the shareholders.

The firm's maximization problem follows three identities. Per period dividends, $D_{i,t}$, are defined as

$$\begin{aligned} D_{i,t} \equiv &(1-\tau_{i,t})[\pi(K_{i,t},\nu_{i,t})-\phi(K_{i,t},I_{i,t})]-I_{i,t}-[1+R(K_{i,t},B_{i,t})]B_{i,t}+B_{i,t+1} \\ &+\tau_{i,t}[\delta_{i,t}K_{i,t}+R(K_{i,t},B_{i,t})B_{i,t}], \end{aligned} \tag{3.2}$$

where $\tau_{i,t}$ is the marginal corporate tax rate that the firm faces. π is the firm's operating profit as a function of capital stock at the beginning of period t, $K_{i,t}$, and a shock the firm faces during the period, $\nu_{i,t}$. ϕ is the adjustment cost to capital as a function of $K_{i,t}$ and the amount of investment over the period, $I_{i,t}$; ϕ is convex in $I_{i,t}$. $R_{i,t}$ is the interest rate applicable to the firm's debt as a function of $K_{i,t}$ and debt at the beginning of period t, $B_{i,t}$. $\delta_{i,t}$ is the depreciation rate of capital over period t. Profits are shielded from taxes via depreciation of capital and interest payments on debt as expressed by the last term in equation (3.2).

Per period investments are defined as

$$I_{i,t} \equiv K_{i,t+1}-(1-\delta_{i,t})K_{i,t}. \tag{3.3}$$

Firm-specific interest rates on debt are defined as

$$R_{i,t} \equiv r_t+\omega(K_{i,t},B_{i,t}) \tag{3.4}$$

where r_t is the riskfree rate, ω is the firm-specific cost as a function of $K_{i,t}$ and $B_{i,t}$; ω is convex in $B_{i,t}$.

This identity warrants a brief discussion. In the model, debt is issued each period and repaid the next period along with interest. Although the debt is repaid in full and therefore default-free, I assume the lender cannot costlessly collect repayment due to default prevention or agency costs that require monitoring of the debt and enforcement of repayment.[1] In essence, an additional firm-specific cost is incurred to prevent the firm from defaulting. This additional cost is passed along to the firm and is captured in the model by $\omega(K_{i,t}, B_{i,t})$. As more debt is issued, relative to the amount of capital stock or collateral that the firm has, the costlier it is to monitor and to enforce repayment. Due to collateral restrictions discussed below, in equilibrium, the firm will always repay the debt in full, but at a cost above the riskfree rate.[2]

In addition to the three identities above, the firm's maximization problem is also subject to two financing constraints. The first is a non-negative dividends, or solvency, constraint, given by:

$$D_{i,t} \geq 0 \tag{3.5}$$

Let λ be the Lagrange multiplier on this condition. When dividends hit this lower boundary, instead of paying out, the firm would like to issue equity but is restricted from doing so. That is, λ measures the shadow value of an additional unit of external equity financing, or the shadow cost from not being able to obtain an additional unit of external equity financing. In other words, λ is the implicit value of the constraint to issuing an additional unit of external equity.

Second, the firm faces a debt repayment constraint that is conditional upon the firm's ability to collateralize its capital stock. To the extent that a firm can only collateralize θ of its capital stock and therefore can only secure that amount of its debt repayment, this constraint represents the firm's capacity to honor its debt.

$$(1 + R_{i,t+1})B_{i,t+1} \leq \theta_{i,t+1}K_{i,t+1}.$$

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[1] Jensen and Meckling (1976) suggests that managers take excessively risky projects when leverage is high, requiring the need for incurring monitoring costs to prevent bankruptcy. An alternative interpretation is that due to limited enforcement there is costly repossession of capital (Rampini and Viswanathan, 2009).

[2] Given firm-specific costs, in order for the lender to participate in the market, it must be that

$$E_{t-1}\left[-B_{i,t} + M_{t-1,t}(1 + R_{i,t})B_{i,t} - M_{t-1,t}\omega(K_{i,t}, B_{i,t})B_{i,t}\right] = 0.$$

Rearranging and under the assumption $E[M] = \frac{1}{1+r_t}$, this derives equation (3.4).

When $\theta_{i,t+1}$ represents the firm's ability to liquidate its capital, the debt is default-free. This constraint can be rewritten to represent the debt capacity of the firm:

$$B_{i,t+1} \leq \frac{\theta_{i,t+1} K_{i,t+1}}{1 + R_{i,t+1}}. \tag{3.6}$$

Let γ be the Lagrange multiplier on this condition. When firms hit the upper boundary enforced by the constraint, i.e., when firms have reached their debt capacity, they would like to issue more debt but are prevented from doing so. That is, γ captures the shadow value of an additional unit of debt financing.

Using the three identities in equations (3.2), (3.3), and (3.4), and the two constraints in equations (3.5) and (3.6), the firm chooses the next period capital level, $K_{i,t+1}$, and debt issuance, $B_{i,t+1}$, that maximizes the firm's objection function in equation (3.1).

Maximizing, the first order condition with respect to $K_{i,t+1}$ is:

$$\begin{aligned} E_t \Bigg\{ M_{t,t+1} \Bigg\{ \frac{(1+\lambda_{i,t+1})}{(1+\lambda_{i,t})} \frac{(1-\tau_{i,t+1})}{(1-\tau_{i,t})} \left[\pi^K_{i,t+1} - \phi^K_{i,t+1} + (1-\delta_{i,t+1})\phi^I_{i,t+1} - \delta_{i,t+1} - \omega^K_{i,t+1} B_{i,t+1} + \frac{1-\delta_{i,t+1}}{1-\tau_{i,t+1}} \right] \Bigg\} \\ + \frac{\gamma_{i,t}}{(1+\lambda_{i,t})} \frac{1}{(1-\tau_{i,t})} \left[\frac{\theta_{i,t+1} \left(1 + r_{t+1} + \omega_{i,t+1} - K_{i,t+1}\omega^K_{i,t+1} \right)}{(1 + r_{t+1} + \omega_{i,t+1})^2} \right] \Bigg\} = \phi^I_{i,t} + \frac{1}{1-\tau_{i,t}} \end{aligned} \tag{3.7}$$

where $M_{t,t+1} \equiv \frac{M_{0,t+1}}{M_{0,t}}$ is the one period stochastic discount factor between time t and $t+1$. For notational ease, let $\pi^K_{i,t+1} \equiv \frac{\partial \pi_{i,t+1}(K_{i,t+1}, \nu_{i,t+1})}{\partial K_{i,t+1}}$, which is the marginal product of capital. Similarly, $\phi^K_{i,t+1} \equiv \frac{\partial \phi_{i,t+1}(K_{i,t+1}, I_{i,t+1})}{\partial K_{i,t+1}}$ and $\phi^I_{i,t+1} \equiv \frac{\partial \phi_{i,t+1}(K_{i,t+1}, I_{i,t+1})}{\partial I_{i,t+1}}$ are the marginal cost of investment with respect to capital and investment, respectively. Finally, $\omega^K_{i,t+1} \equiv \frac{\partial \omega(K_{i,t}, B_{i,t})}{\partial K_{i,t}}$ is the marginal interest rate with respect to existing capital, and $\omega_{i,t+1} \equiv \omega(K_{i,t+1}, B_{i,t+1})$.

Equation (3.7) is the Euler equation that sets the expected marginal benefit (left hand side) equal to the marginal cost (right hand side) of making a capital investment today. The firm will invest today if the benefits from doing so exceed the costs; otherwise, the firm will defer the investment decision. The cost of investment today is simply the unit plus marginal adjustment costs of new capital. The benefit of investment *today* translates into the marginal product of capital, a decrease in marginal adjustment costs of capital, and an increase in marginal debt capacity *tomorrow*. Thus, the intertemporal investment decision depends upon the stochastic discount factor, $M_{t,t+1}$, and three idiosyncratic factors: the relative tax rates, the intertemporal equity constraint, and contemporaneous capital structure constraint.

The relative tax rate factor, $\frac{1-\tau_{i,t+1}}{1-\tau_{i,t}}$ is the rate associated with the risk in changing marginal tax rates. The marginal tax rates change when the expected profitability, and therefore the expected amount of taxable income, change. If the expected marginal tax rate tomorrow is higher than the marginal tax rate today, then $\frac{1-\tau_{i,t+1}}{1-\tau_{i,t}} < 1$, making each dollar of profit tomorrow less valuable since less of it is retained. Under this logic, the firm would want to shift any investment spending to the next period, holding all else equal. When there are no financing constraints, that is when $\lambda_{i,t}$, $\lambda_{i,t+1}$, and $\gamma_{i,t}$ are all zero, only the stochastic discount factor and relative tax rates drive the investment decision. When financing constraints exist, the investment decision depends additionally on both the intertemporal equity financing constraint and the contemporaneous capital structure constraint. The intertemporal shadow value of equity financing, $\frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}$, measures the risk in changes to the firm's ability to obtain equity financing tomorrow versus the firm's ability to obtain equity financing today. If the expected shadow cost of obtaining equity financing tomorrow is less expensive than that of today, then $\frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}} < 1$, making each dollar of investment today using equity more costly and the firm will defer financing (and therefore investment) to the next period, holding all else constant. That is, this drives the decision between equity financing today versus tomorrow. Since financing is required for investment, this also equates to the investment decision as well. Finally, the contemporaneous capital structure constraint, $\frac{\gamma_{i,t}}{1+\lambda_{i,t}}$, drives the decision between debt and equity choice. In the model, capital investment affects the capital structure decision through the determination of next period's debt capacity, or through the marginal effect on financial slack. As debt becomes more constrained relative to equity, the firm becomes more concerned with its financial flexibility and would rather issue equity to preserve its financial slack.[3] As debt becomes less constrained relative to equity, the financial slack is less of a concern and the firm would prefer to issue debt, all else equal.

The first order condition with respect to $B_{i,t+1}$ is:

$$E_t\left\{M_{t,t+1}\left\{\frac{(1+\lambda_{i,t+1})}{(1+\lambda_{i,t})}\frac{(1-\tau_{i,t+1})}{(1-\tau_{i,t})}\left[\omega^B_{i,t+1}B_{i,t+1}+r_{t+1}+\omega_{i,t+1}+\frac{1}{1-\tau_{i,t+1}}\right]\right\}\right.$$
$$\left.+\frac{\gamma_{i,t}}{(1+\lambda_{i,t})}\frac{1}{(1-\tau_{i,t})}\left[1+\frac{\theta_{i,t+1}K_{i,t+1}\omega^B_{i,t+1}}{(1+r_{t+1}+\omega_{i,t+1})^2}\right]\right\}=\frac{1}{1-\tau_{i,t}} \tag{3.8}$$

where $\omega^B_{i,t+1}\equiv\frac{\partial\omega(K_{i,t},B_{i,t})}{\partial B_{i,t}}$ is the marginal interest rate with respect to existing debt.

Equation (3.8) is the Euler equation that sets the expected marginal cost (left hand side) equal to the marginal benefit (right hand side) of issuing debt today. The firm will issue debt today when the benefits of doing so exceed the costs. The benefit of issuing debt is the after-tax value on each marginal dollar of debt financing obtained *today*. The cost of issuing debt is the marginal interest payment and a decrease in marginal debt capacity *tomorrow*. Like the capital investment decision, the capital structure decision depends upon the stochastic discount factor, relative tax rates, the intertemporal equity financing constraint, and the contemporaneous capital structure constraint. When the expected marginal tax rate tomorrow is high

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[3] Financial slack is defined as having access to cash or spare debt capacity.

relative to today, the cost of interest payments in the next period are lower due to the increased value of the tax shield from interest deduction, i.e., the benefits to using debt are higher, prompting the firm to issue more debt today. Similarly, when equity financing is more constrained in the next period relative to equity today, all else equal, internal funds are more valuable in the next period due to the difficulty of obtaining equity. When using debt, these valuable internal funds are used to repay the debt and interest, increasing the cost of debt. As a result, the firm issues less debt today, prompting the firm to issue equity today. Finally, when debt financing is more constrained relative to equity, financial slack is more valuable and the firm has less incentive to issue debt in order to preserve financial flexibility.

The firm's optimal capital investment and capital structure policies are then determined jointly based on the two Euler equations above. These two first order conditions rely on the stochastic discount factor, the relative tax rates, and under financing constraints, the intertemporal equity constraint and contemporaneous debt to equity constraint. Together, the two equations (3.7) and (3.8) provide the theoretical framework for corporate investment and capital structure decisions. It should be noted here that the model captures *relative* financing constraints. That is, the model depends upon the financial constraint of equity tomorrow *relative* to equity today and the financial constraint of debt today *relative* to equity today, treating the financial constraint on issuing equity today as the base case against which corporate decisions are made.[4]

3.1.2 Parametrization of the Model

The previous section provided the general theoretical framework and intuition. In order to estimate the model, I make the following assumptions and parameterize the

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[4] Theoretically, this is motivated by the standalone principle that firms base their decisions on a base case that reflects opportunity cost. In the model, the base case is issuing equity cost. Statistically, this lowers the degrees of freedom and allows identification of the model.

model based on prior literature.

Following the extant literature such as Whited and Wu (2006), I define the marginal product of capital as,

$$\pi_{i,t}^{K} = \frac{Y_{i,t} - \mu C_{i,t}}{K_{i,t}}$$

where $Y_{i,t}$ is the firm's output, $C_{i,t}$ is the operating costs, and μ is the cost markup factor.

Using the standard form for adjustment cost of capital, I define

$$\phi(K_{i,t}, I_{i,t}) = \left[a_1 + \frac{1}{2} a_2 \left(\frac{I_{i,t}}{K_{i,t}} \right)^2 + \frac{1}{3} a_3 \left(\frac{I_{i,t}}{K_{i,t}} \right)^3 \right] K_{i,t},$$

which is convex in $I_{i,t}$. Similar to the adjustment cost of capital, I make the following simplifying assumption and define the functional form for the firm specific interest rate as

$$\omega(K_{i,t}, B_{i,t}) = \frac{1}{2} b_1 \left(\frac{B_{i,t}}{K_{i,t}} \right) + \frac{1}{3} b_2 \left(\frac{B_{i,t}}{K_{i,t}} \right)^2,$$

which is convex in $B_{i,t}$. This has the feature that default prevention costs are higher when more leverage is issued; this cost is mitigated by having more capital stock which can be used as collateral, alleviating the need for monitoring and enforcement of repayment.

Following Fama and French (2002), I parameterize the stochastic discount factor as,

$$M_{t,t+1} = m_0 + m_1 MKT_{t+1} + m_2 SMB_{t+1} + m_3 HML_{t+1}$$

where MKT is the return on the market, SMB is the return on a portfolio that holds small firms and shorts large firms, and HML is the return on a portfolio that holds high book to market firms and shorts low book to market firms.

Finally, I parameterize the intertemporal equity financing constraint, $\Lambda_{i,t+1} \equiv \frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}$, as

$$\begin{aligned} \Lambda_{i,t+1} = l_0 &+ l_1\text{LTA}_{i,t+1} + l_2\text{DDIV}_{i,t+1} + l_3\text{COL}_{i,t+1} + l_4\text{LEV}_{i,t+1} \\ &+ l_5\text{INDLEV}_{i,t+1} + l_6\text{CF}_{i,t+1} + l_7\text{CFVOL}_{i,t+1} + l_8\text{CASH}_{i,t+1} \\ &+ l_9\text{LIQV}_{i,t+1} + l_{10}\text{ILLIQ}_{i,t+1} + l_{11}\text{ANEST}_{i,t+1} + l_{12}\text{BTM}_{i,t+1} \end{aligned} \tag{3.9}$$

and the contemporaneous debt to equity financing constraint, $\Gamma_{i,t} \equiv \frac{\gamma_{i,t}}{1+\lambda_{i,t}}$, as

$$\begin{aligned} \Gamma_{i,t} = g_0 &+ g_1\text{LTA}_{i,t} + g_2\text{DDIV}_{i,t} + g_3\text{COL}_{i,t} + g_4\text{LEV}_{i,t} \\ &+ g_5\text{INDLEV}_{i,t} + g_6\text{CF}_{i,t} + g_7\text{CFVOL}_{i,t} + g_8\text{CASH}_{i,t} \\ &+ g_9\text{LIQV}_{i,t} + g_{10}\text{ILLIQ}_{i,t} + g_{11}\text{ANEST}_{i,t} + g_{12}\text{BTM}_{i,t} \end{aligned} \tag{3.10}$$

where LTA is the log of total assets, DDIV is a dummy variable for dividend paying firms, COL is the ratio of collateralizable assets (plants, property, and equipment and inventory) of the firm to total assets, LEV is the ratio of long term debt to total assets, INDLEV is the amount of long term debt of the firm's 3-digit SIC industry to the total assets of the industry, CF is the ratio of cash flows to total assets as a measure of profitability, CFVOL is the three year cash flow volatility (normalized by the mean of the cash flows in those three years) as a measure of firm risk, CASH is the ratio of cash holdings to total assets, LIQV is the liquation ratio of the firm's book equity to total book equity, ILLIQ is the bid-ask spread on the firm's stock normalized by the stock price as a measure for illiquidity of equity, ANEST is the number of analyst estimates made for the period as a measure of information asymmetry, and BTM is the ratio of book equity to market equity as a measure for growth opportunities. This set of variables is determined based on variables that have been shown in the literature to influence either or both financing constraints and capital structure (e.g., Frank and Goyal, 2005). Both $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$ are parameterized using the same firm characteristics. This allows the analysis to find the significant characteristics that matter for each constraint.

Finally, I refer to $\Lambda_{i,t+1}$ as the intertemporal equity financing constraint and the financing constraint on equity interchangeably. Similarly, I refer to $\Gamma_{i,t}$ as the contemporaneous capital structure constraint, or the debt to equity constraint, or more simply the debt constraint interchangeably. It is important to keep in mind that $\Lambda_{i,t+1}$ is the financing constraint of equity tomorrow *relative* to equity today and $\Gamma_{i,t}$ is the financing constraint of debt today *relative* to equity today. That is, the base situation underlying the model is equity today. Both the intertemporal investment decision and the capital structure decision are relative to equity today, i.e., normalized by financing constraints to issuing equity today. In other words, the firm decides whether to issue debt today or defer the investment to the next period based on the current equity financing environment.

3.1.3 GMM

To estimate the parameters of the model in equations (3.7) and (3.8), I use generalized method of moments (GMM).

Incorporating the definitions above and removing the expectations operator, equation (3.7) can be rewritten as

$$\begin{aligned}
M_{t,t+1} \Bigg\{ \Lambda_{i,t+1} \frac{1-\tau_{i,t+1}}{1-\tau_{i,t}} \Bigg\{ \frac{Y_{i,t}-\mu C_{i,t}}{K_{i,t}} - \left[a_1 - \frac{1}{2} a_2 \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right)^2 - \frac{2}{3} a_3 \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right)^3 \right] - \delta_{i,t+1} + \frac{1}{1-\tau_{i,t+1}} \\
+ (1+\delta_{i,t+1}) \left[a_2 \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right) + a_3 \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right)^2 \right] + \left[\frac{1}{2} b_1 \left(\frac{B_{i,t+1}}{K_{i,t+1}} \right)^2 + \frac{2}{3} b_2 \left(\frac{B_{i,t+1}}{K_{i,t+1}} \right)^3 \right] \Bigg\} \Bigg\} \\
+ \Gamma_{i,t} \frac{1}{1-\tau_{i,t}} \left\{ \frac{\theta_{i,t+1} \left[1 + r_{t+1} + b_1 \left(\frac{B_{i,t+1}}{K_{i,t+1}} \right) + b_2 \left(\frac{B_{i,t+1}}{K_{i,t+1}} \right)^2 \right]}{\left[1 + r_{t+1} + \frac{1}{2} b_1 \left(\frac{B_{i,t+1}}{K_{i,t+1}} \right) + \frac{1}{3} b_2 \left(\frac{B_{i,t+1}}{K_{i,t+1}} \right)^2 \right]^2} \right\} \\
- a_2 \left(\frac{I_{i,t}}{K_{i,t}} \right) - a_3 \left(\frac{I_{i,t}}{K_{i,t}} \right)^2 - \frac{1}{1-\tau_{i,t}} = \epsilon^K_{i,t+1}
\end{aligned} \tag{3.11}$$

where $\epsilon^K_{i,t+1}$ is the error term associated with the Euler equation of $K_{i,t+1}$.

Similarly, equation (3.8) can be rewritten as

$$\begin{aligned} & M_{t,t+1}\left\{\Lambda_{i,t+1}\frac{1-\tau_{i,t+1}}{1-\tau_{i,t}}\left[r_{t+1}+b_1\left(\frac{B_{i,t+1}}{K_{i,t+1}}\right)+b_2\left(\frac{B_{i,t+1}}{K_{i,t+1}}\right)^2+\frac{1}{1-\tau_{i,t+1}}\right]\right\} \\ & \quad +\Gamma_{i,t}\frac{1}{1-\tau_{i,t}}\left[1+\frac{\theta_{i,t+1}\left[\frac{1}{2}b_1+\frac{2}{3}b_2\left(\frac{B_{i,t+1}}{K_{i,t+1}}\right)\right]}{\left[1+r_{t+1}+\frac{1}{2}b_1\left(\frac{B_{i,t+1}}{K_{i,t+1}}\right)+\frac{1}{3}b_2\left(\frac{B_{i,t+1}}{K_{i,t+1}}\right)^2\right]^2}\right] \\ & \quad -\frac{1}{1-\tau_{i,t}}=\epsilon^B_{i,t+1} \end{aligned} \tag{3.12}$$

where $\epsilon^B_{i,t+1}$ is the error term associated with the Euler equation of $B_{i,t+1}$. Implicit in equations (3.7) and (3.8) is the assumption that $E_t[\epsilon^Z_{i,t+1}] = E_t[\epsilon^B_{i,t+1}] = 0$, providing first moment conditions for GMM estimation.

Following standard GMM procedure, moment conditions are obtained by interacting the error terms from equations (3.11) and (3.12) with a set of instruments. For instruments, I use lagged versions of the variables in the model. Furthermore, I include lagged versions of total depreciation, tax expenses, interest expenses, inventories, current assets, current liabilities, total dividends, investment tax credits, and the moving average of cash flows from the last three years all normalized by total assets. These instruments capture the profitability status of the firm as well as its potential benefits to using debt.[5] Finally, to remove fixed effects, I take the first difference of (3.11) and (3.12). Let $\epsilon \equiv \{\epsilon^K, \epsilon^B\}$. Then, for a given set of instrumental variables, z, the moment conditions are defined as

$$E_{t-1}[(\epsilon_{i,t+1} - \epsilon_{i,t}) \otimes z_{i,t-1}] = 0. \tag{3.13}$$

When focusing only on estimation of the financing constraint measures, the two equations above provide identification for $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$. Note that it would be

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[5] For example, if a firm has large amounts of depreciation tax shields and investment tax credits, the tax benefits from using debt are lessened.

impossible for the model to jointly determine equity financing constraints tomorrow ($\lambda_{i,t+1}$), debt constraints today ($\gamma_{i,t}$), *and* equity financing constraints today ($\lambda_{i,t}$) since there are more degrees of freedom than can be identified.

When estimating the entire model with all parameters, the model is highly nonlinear with interaction terms between the stochastic discount factor (m's), financing constraints (l's and g's), and internal model parameters (μ, a's, and b's). Due to this nonlinearity, additional restrictions are necessary in order to identify the model. First, following the literature, I restrict the unconditional mean of the stochastic discount factor, $E[M_{t,t+1}]$ to be equal to the unconditional mean of the riskfree rate, $E\left[\frac{1}{1+r_{t+1}}\right]$. This provides me with an additional moment condition that pins down the stochastic discount factor and allows the identification of other model parameters. Second, since $\lambda_{i,t}$ and $\gamma_{i,t}$ are the shadow values on the constraints in equations (3.5) and (3.6), respectively, they must either be zero when non-binding or positive when binding. Therefore, I require that the unconditional mean of the two financing constraint measures, $E[\Lambda_{i,t+1}]$ and $E[\Gamma_{i,t}]$, to be positive. This gives me two additional moment conditions that aid in pinning down μ, a_1, a_2, a_3, b_1, and b_2, allowing identification to focus on $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$. Finally, I restrict the unconditional mean of the firm specific portion of the interest for debt, $E\left[\omega_{i,t+1}\right]$, to equal to the unconditional mean of the marginal cost of debt as estimated in van Binsbergen, Graham, and Yang (2009) in excess of the riskfree rate, $E\left[MC_{BCY i,t+1} - r_{t+1}\right]$. Although this last restriction is not necessary for identification, it aids in the estimation by providing more empirical structure on firm specific interest rate.

3.2 Data and Summary Statistics

3.2.1 Financial Data

Corporate financial statement data are obtained from Standard & Poors COMPUSTAT annual database for fiscal years of 1980 to 2007.[6] Returns for the riskfree asset, market, SMB, and HML portfolios are obtained from Kenneth French's website and annualized for years 1980 to 2008.[7] Analyst forecasts are obtained from Thompson's I/B/E/S database from 1980 to 2008. Combining, this results in a starting sample of 243,236 firm-year observations. Although most if not all distressed firms are very likely to be constrained from the capital market, it does not follow that most constrained firms are likely to be distressed (e.g., young, small firms). To isolate the influence of financial constraints from the effects of financial distress, I remove financially distressed firms. To this extent, I remove all firm-years with negative book asset value, common equity, sales, capital stock, liquidation values, or dividends. Such firms either have unreliable COMPUSTAT data are likely to be distressed or severely unprofitable. Next, I delete all firms in the financial and insurance, utilities, and public administration industries as they tend to be regulated. Following the literature, I then delete all firms that are involved in substantial M&A activity, defined as acquisitions amounting to over 15 percent of total assets. Finally, I remove outliers defined as firm-year observations that are in the first and 99th percentile tails for any variables. This results in a total of 181,659 firm-year observations remaining in the sample.

Finally, I make two model specific requirements on the sample. First, since the model uses default-free debt financing, I drop all firm-year observations which have Altman (1968) ZSCORE's in the bottom quartile.[8] Second, since the model

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[6] This implies actual reporting dates of June 1980 through May 2008.

[7] Kenneth French's Website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[8] Altman's (1968) ZSCORE is a firm-specific measure that captures the health of the firm's debt

captures relative financing constraints and uses lagged instruments, I require firms in the sample to have at least three consecutive years of data for all relevant variables. Finally, restricting the sample to only firms that have non-missing data for all relevant variables, this brings the final sample down to 20,813 firm-year observations which are spanned by 3,677 firms over the fiscal years 1982 to 2007. Table 3.1 presents the summary statistics for all relevant variables of the model. Appendix 3.A provides detailed definitions for all variables used in the analysis.

3.2.2 Marginal Tax Rate and Firm Specific Interest Rates

The model requires the use of marginal tax rates, which is the applicable tax rate for the next dollar of taxable income that the firm faces. I use the marginal tax rates provided by John Graham in my analysis. Graham (2000) simulates marginal tax rates for firms in the COMPUSTAT database. The simulated marginal tax rates measures the tax savings associated with deducting the next dollar of interest considering the probability the firm is in tax paying status in any given state of the world, combined with the tax code features that allow firms to move losses through time.

To estimate the firm specific portion of the interest rate, $\omega_{i,t+1}$, I use the marginal cost of debt as estimated in van Binsbergen, Graham, and Yang (2010) and Chapter 1, MC_{BGY}, and impose the restriction that $E[\omega_{i,t+1}] = E[\mathrm{MC}_{BGY i,t+1} - r_{t+1}]$. The marginal cost of debt curve is estimated via GMM by exogenous shifts in the marginal benefits of debt (see van Binsbergen, Graham, and Yang, 2009). The implied marginal cost of debt for the next dollar of interest that the firm uses is given

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through its estimated probability of default. The higher the ZSCORE, the lower the probability of default.

by

$$\begin{aligned}
&MC_{BGY}(IOB) = \alpha + \beta * IOB \\
&\alpha \quad = 0.169 \\
&\beta \quad = 4.996 - 1.194 \text{ COL} + 0.591 \text{ LTA} - 0.329 \text{ BTM} - 0.847 \text{ INTANG} + 1.554 \text{ CF} \\
&\qquad + 0.811 \text{ DDIV}
\end{aligned} \tag{3.14}$$

where each of the control variables is standardized (demeaned and divided by the standard deviation) using the data provided in the table below:

	COL	LTA	BTM	INTANG	CF	DDIV
Mean	0.496	5.041	0.770	0.061	0.097	0.389
Std. Dev.	0.231	2.153	0.639	0.119	0.141	0.488

COL is collateral and is the sum of physical assets and inventories divided by total book assets for a firm. LTA is the log of total book assets. BTM is the ratio of book equity to market equity. INTANG is the ratio of intangible assets to total book assets. CF is the net cashflows over total book assets. DDIV has a value of "1" if the firm pays dividends and otherwise is "0." Finally, IOB is interest expense over total book assets for a firm.

3.3 Estimation Results

The results from GMM estimation of the model in Section 3.1 are presented and discussed here. At time t, the firm decides how much capital to invest and how much debt to issue. In the model, these decisions are based on the restrictiveness of $\Lambda_{i,t+1} \equiv \frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}$, the intertemporal equity financing constraint, and $\Gamma_{i,t} \equiv \frac{\gamma_{i,t}}{1+\lambda_{i,t}}$, the contemporaneous debt to equity financing constraint.

3.3.1 Financing Constraints

The parameterizations of $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$ given in equations (3.9) and (3.10), respectively, allow me to describe financing constraints as a function of firm characteristics.

However, before estimating equations (3.9) and (3.10), I first explore whether financing constraints are important to the big picture. To do this, I initially estimate the model by parameterizing $\Lambda_{i,t+1} \equiv l_0$ and $\Gamma_{i,t} \equiv g_0$. This allows me to capture the overall mean effect of the two financing constraint measures and whether they are significant and binding on average. Table 3.2 provides results from the initial GMM estimation of the model.

Column (i) of Table 3.2 provides the estimated parameters of the model under the assumption that financing constraints do not exist ($\Lambda_{i,t+1} \equiv 1$ and $\Gamma_{i,t} \equiv 0$). As expected, markup factor (μ) is close to one, the cost adjustment parameters (a_1, a_2, and a_3) indicate a convex adjustment cost function, and the firm-specific interest rate parameters (b_1 and b_2) reflect a convex interest rate function. Column (ii) estimates the model under the assumption that equity is constrained but debt issuance is unrestricted ($\Gamma_{i,t} \equiv 0$). This results in a positive coefficient on l_0 of 0.986. This implies that when only including $\Lambda_{i,t+1}$ (and excluding $\Gamma_{i,t}$) in the estimation, on average, the financing constraint on equity financing tomorrow is about the same as the constraint on equity today. Column (iii) estimates the model under the assumption that debt is constrained but equity issuance is unrestricted ($\Lambda_{i,t+1} \equiv 1$). This results in a positive coefficient on g_0 of 0.007. This implies that when only including $\Gamma_{i,t}$ (and excluding $\Lambda_{i,t+1}$) in the estimation, on average, the financing constraint on debt today relative to equity today is almost zero. Finally, column (iv) estimates the model under the assumption that there are constraints on both equity issuance and debt issuance. The coefficient on l_0 is 0.693 and the coefficient on g_0 is 0.395. Both coefficients are positive, significant and different from one and zero, respectively. This implies that when we allow for both equity and debt to be constrained, we see evidence that firms do face constraints on issuing both equity and debt. Furthermore, some weight shifts from l_0 to g_0, suggesting that there is an inherent tradeoff between equity and debt.

This tradeoff however is not one to one, as l_0 does not drop by the same amount that g_0 increases. This exercise highlights the importance of including both equity and debt constraints in the model.

3.3.2 Full Estimation Results

Now, I parameterize $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$ as specified in equations (3.9) and (3.10), respectively. This allows me to include and control for firm characteristics in the two financing constraint measures. The firm characteristics are standardized to have a mean of zero and a standard deviation of one. This gives the estimation coefficients on each firm variable a one-standard-deviation interpretation. The results from GMM estimation of the model are presented in Table 3.3. Column (i) estimates the full model with all firm characteristics. Column (ii) re-estimates the model based on significant $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$ coefficients from column (i).

Column (i) shows that $\Lambda_{i,t+1}$ decreases with firm size (LTA), when firms pay dividends (DDIV), collateralizability (COL), cash flows (CF), and liquidation value of equity (LIQV), and increases with cash holdings (CASH), and illiquidity of stock (ILLIQ). The results are intuitive and consistent with existing findings in the literature. Larger firms have less asymmetric information. Firms with more collateralizable assets and liquidation value are more likely to have residual value remaining after debt. Likewise, firms with more liquid stock, higher cash flows, and that pay dividends have more favorable equity environments. Table 3.3 column (ii) re-estimates the model using only these significant variables to define $\Lambda_{i,t+1}$. These results are qualitatively identical and quantitatively similar to those in column (i).

Since $\Lambda_{i,t+1}$ is the intertemporal equity financing constraint measure, magnitudes of the estimation coefficients have a percentage interpretation. For example, the coefficient on DDIV, l_2, of -0.0477 in column (ii) means that, holding all else constant, the financing constraint to issuing equity tomorrow relative to equity today is 4.77% lower for a firm which pays dividends than a non-dividend paying firm. Similarly, LTA has a coefficient of -0.0540. This means that a firm that is one standard deviation larger than the average is 5.40% less constrained in equity tomorrow relative to today and, all else equal, would prefer to defer investment (and financing) to the next period.

Equation (3.10) gives the parametrization of $\Gamma_{i,t}$, the contemporaneous debt to equity constraint measure. Table 3.3 columns (i) and (ii) show that $\Gamma_{i,t}$ decreases with firm size (LTA), collateralizable assets (COL), industry level of leverage (INDLEV), cash flows (CF), cash flow volatility (CFVOL), cash holdings (CASH), liquidation value (LIDV), analyst coverage (ANEST), and firms with higher book-to-market (BTM), and increases with firm leverage (LEV). That is, firms with more existing debt face higher constraints to issuing debt while large firms with more collateral, better cash flows, more cash on hand, liquidation value, analyst coverage, and higher book equity relative to market equity have fewer constraints to issuing debt.

Like $\Lambda_{i,t+1}$, the coefficients on $\Gamma_{i,t}$ have a percentage interpretation. For example, a firm that has one standard deviation more collateralizable assets than the average faces financing constraints to debt relative to equity of 7.24% less than the average firm (the coefficient on g_3 in column (ii)). On the other hand, a firm with an existing leverage ratio one standard deviation higher than the average is 9.24% more constrained in debt relative to equity.

Certain characteristics such as firm size, collateralizability, cash flows, and liquidation value affect both $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$ similarly and significantly. Moreover, $\Lambda_{i,t+1}$ is impacted by the illiquidity of equity, and $\Gamma_{i,t}$ is affected by existing and industry leverage. Finally, although cash holdings influence both $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$, having more cash on hand increases financing constraints to equity while decreases financing constraints to debt. Large cash holdings may be a signal of poor managerial use of funds, lack of profitable investments projects, or indication of high expected financing constraints that require large amounts of cash holdings. These issues impact the equity environment negatively, resulting in increased financing constraints to equity due to cash holdings. On the other hand, having cash on hand means having available funds to pay off debt and interest and adds directly to financial flexibility. These reasons influence the debt environment favorably, resulting in decreased financing constraint to debt due to cash on hand. The results from the estimation indicate that although there are fundamentals that affect the overall investment and financing environment of the firm similarly, the two financing constraints capture separate and distinct differences and influences between equity and debt.

3.4 Financing Constraints and Financing Behavior

The GMM estimation results from Table 3.3 can be summarized into two separate indices: 1) the intertemporal equity constraint, or the financing constraint of equity tomorrow relative to equity today, given by

$$\begin{aligned}\Lambda_{i,t+1} = 2.0690 - 0.0540 * LTA_{i,t+1} - 0.0477 * DDIV_{i,t+1} - 0.0345 * COL_{i,t+1} - 0.0210 * CF_{i,t+1} \\ + 0.0215 * CASH_{i,t+1} - 0.5915 * LIQV_{i,t+1} + 0.0029 * ILLIQ_{i,t+1}\end{aligned} \tag{3.15}$$

and 2) the contemporaneous capital structure constraint, or the financing constraint of debt today relative to equity today, given by

$$\begin{aligned}\Gamma_{i,t} = 0.0137 - 0.2547 * LTA_{i,t} - 0.0295 * DDIV_{i,t} - 0.0724 * COL_{i,t} + 0.0924 * LEV_{i,t} \\ - 0.0068 * INDLEV_{i,t} - 0.0138 * CF_{i,t} - 0.0115 * CFVOL_{i,t} - 0.0099 * CASH_{i,t} \\ - 0.0412 * LIQD_{i,t} - 0.0030 * ANEST_{i,t} - 0.0141 * BTM_{i,t}\end{aligned} \tag{3.16}$$

where each firm characteristic is standardized to have a mean of zero and a standard deviation of one. I calculate the two indices in the full COMPUSTAT sample for firms with non-missing characteristics. As mentioned above, the indices have a relative interpretation since both constraints are normalized by constraints to issuing equity today. This relative interpretation is convenient as it allows me to directly measure firm sensitivities to the financing constraints. For example, if Firm A has a higher $\Lambda_{i,t+1}$ than Firm B, then it means that Firm A is more sensitive to its intertemporal equity financing constraint than Firm B even if Firm B might have a higher absolute level of $\lambda_{i,t+1}$. (Indeed, although potentially useful and interesting, absolute values have no direct interpretation here since at the same absolute value of financing constraints, Firm A may find it more or less restrictive than Firm B given their current financing situations.)

3.4.1 Model Predictions

To test whether the two estimated financing constraint indices, Λ and Γ, indeed represent being constrained in equity and debt, respectively, and to test the predictions of the model, I run a probit analysis of corporate financing behavior on Λ and Γ, according to

$$Pr(X=1)_{i,t+1} = \beta_0 + \beta_1 \Lambda_{i,t} + \beta_2 \Gamma_{i,t} + \varepsilon \tag{3.17}$$

where X is a binary variable for whether the firm has made: A) a debt issuance, B) an equity issuance, C) a debt reduction, or D) an equity reduction. I use lagged versions of the financing constraints and observe whether the respective constraints have impact on the probability that the firm will issue equity or debt over the next period. Note that the interpretation of $\Lambda_{i,t}$ is the relative equity financing constraints between the end of period t relative to the end of period $t-1$. Table 3.4 presents these results.

The model implies that in the case where $\Lambda_{i,t}$ is high, that is, when the financing constraint on equity is high at the end of period t, firms will likely turn to debt in the next period and we should observe more debt issuances. Similarly, in the case where $\Gamma_{i,t}$ is low, firms will naturally use more debt over the next period. Indeed, panel

A of Table 3.4 show that firms are more likely to issue debt when $\Lambda_{i,t}$ is high and when $\Gamma_{i,t}$ is low. Similar logic applies to equity issuances. When $\Lambda_{i,t}$ is low and when $\Gamma_{i,t}$ is high, firms would more likely issue equity in the next period. Panel B of the table presents the results for equity issuance and indeed we see that the probability of firms issuing equity increases when equity is less constrained and decreases when debt is less constrained.

Firms not only issue debt and equity but also pay down debt and repurchase shares. Firms reduce their equity and debt in order to preserve their financial slack, improve their financial flexibility, lower interest, and adjust their capital structure to take advantage of the cheaper security. In order to do so, firms must have available funds or not be constrained from raising necessary funds. If a firm is constrained financially, then they will be prevented from reducing their debt and equity positions.[9] Panel C of Table 3.4 presents the results for debt reductions and panel D for equity reductions. Indeed, when firms are more debt constrained, they are less likely to reduce debt and equity, suggesting that they are unable to do so due to being fully constrained. However, when firms are more equity constrained, they are less likely to repurchase shares, but are more likely to reduce debt. This suggests that when firms are equity constrained, they feel pressured to improve financial flexibility and lower the cost of equity by paying down debt and are able to do so. The results above indicate that the two financing constraint measures are indeed capturing the state of being equity and debt constrained.

3.4.2 Overall Financing Constraints

Equipped with the two separate measures for financial constraints, I propose a measure for being overall constrained. Recall that at any point in time, the firm makes

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[9] The model in the chapter assumes that all funds are raised externally for the purpose of investment. However, if a firm is constrained from investment, then it will be constrained from adjusting their capital structure.

two decisions: the amount of capital investment and the amount of debt issuance. These decisions depend on $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$. At time t, the higher the $\Lambda_{i,t+1}$, the more constrained tomorrow's equity is relative to today, or the less constrained today's equity is relative to tomorrow's equity. That is, the financing constraint of equity today relative to tomorrow is $\frac{1}{\Lambda_{i,t+1}}$. Logically, if equity tomorrow is more constrained relative to today, then the firm would choose to invest today. However, whether the firm invests using equity or debt depends upon whether debt is more constrained or not compared to equity. So, for a firm to be overall constrained, i.e., constrained in both debt and equity and unable to obtain any financing today, it would have to be the case that the firm is constrained in today's debt, i.e., $\Gamma_{i,t}$ is high, *and* the firm is constrained in today's equity, i.e., $\frac{1}{\Lambda_{i,t+1}}$ is high. That is, the firm is overall constrained if the following measure is high:

$$FC_{i,t} \equiv \frac{\Gamma_{i,t}}{\Lambda_{i,t+1}} = \frac{\gamma_{i,t}}{1+\lambda_{i,t+1}}. \tag{3.18}$$

Equation (3.18) represents the financing constraint of debt relative to equity *tomorrow*. Given the current equity condition, the corporate decisions on capital investment and debt issuance collapse to whether it is more worthwhile to issue debt or to defer financing and investment entirely to the next period. That is, the firm's choices are summarized by one overall financial constraint measure. If $FC_{i,t}$ is high, then firms would choose to defer procurement of funds and investment; on the other hand, if $FC_{i,t}$ is low, firms would issue debt today. Altogether, this gives me three financing constraint measures, the two separate measures for equity and debt, and the overall measure that summarizes the two.

One Way Sorts

Table 3.5 sorts the three financing constraint measures independently into three bins (LOW, MED, HIGH) and compares the firm characteristics of financially unconstrained firms (LOW) against those of financially constrained firms (HIGH). To the extent that credit ratings and equity rankings are sufficient statistics for the firm's worthiness of receiving debt and equity, respectively, there should be a relationship between the credit ratings and financial constraints. The variable, SPCR, groups the S&P long term credit rating into ten categories based on the rating. For example, AAA firms are recorded as having a SPCR value of 1; AA+, AA, AA- firms are recorded as having a SPCR value of 2, A+,A,A- firms are recorded as having a SPCR value of 3, and so on. Similarly, SPSR groups the S&P's ranking on equity into nine groups with A+ firms receiving a value of 1, A firms receiving a value of 2, and so on. Furthermore, there is a distinction between firms that are in the best rating categories and firms in other rating categories. HASACR and HASASR are dummy variables that take the value of 1 if the firm has an AAA, AA, or A rating in debt and a A+, A, or A- ranking on equity, respectively. Additionally, firm size is a popular measure for financially constrained firms. Total assets, TA, measure firm size. Market capitalization, MKEQT, measures total equity position of the firm and total long term debt, LTD, measures total debt position of the firm. Next, I check whether firms that are more financially constrained are indeed investing less due to unavailability of funds. I/A is capital expenditure over total book assets. RD&AD is a measure that reflects investment in research and development and advertising. DDIV is an indicator for whether the firm pays dividends. Finally, DISS, DRED, EISS, and ERED measure debt issuances, debt reductions, equity issuances, and equity reductions, respectively. Detailed descriptions of the variables are provided in 3.A.

The first three columns of Table 3.5 sort on the overall financing constraint measure, $FC_{i,t}$. As expected, the results indicate that, compared to unconstrained firms, constrained firms have worse credit ratings, equity rankings, and are less likely to have top ("A" range) ratings and rankings. Furthermore, constrained firms have lower total assets, market capitalization, and long term debt. That is, constrained firms are smaller in asset size and have smaller equity and debt positions. Next, constrained firms do invest less, with an investments to asset ratio of 5.6%, compared to the 8.0% investments to asset ratio of unconstrained firms. Likewise, constrained firms invest less in research and development and advertising. Finally, constrained firms issue less debt and equity, pay back less debt, and repurchase less equity. These findings are all consistent with characteristics believed of financially constrained firms and validates $FC_{i,t}$ as measuring overall financial constraints.

The middle three columns of Table 3.5 sort on equity constraints today relative to equity constraints tomorrow, $\Lambda^{-1}_{i,t+1}$. Reassuringly, high equity constrained firms are smaller in size, with lower market capitalization and long term debt positions. They also issue less debt and equity, pay back less debt, and buy back less equity. However, counterintuitively, the results also indicate that firms that are equity constrained today have better credit ratings and constant equity rankings across the bins. Furthermore, although equity constrained firms do invest less in R&D and advertising, their investments to assets ratios are constant across the LOW, MED, HIGH groups. These findings suggest that firms with high equity constraints are not completely restricted from accessing external funds. In other words, the equity constraint is not the limiting constraint for firms.

Finally the last three columns of Table 3.5 sort on debt constraints today relative to equity constraints today, $\Gamma_{i,t}$. Unambiguously, firms that are debt constrained have worse credit ratings, equity rankings, and fewer firms with top credit ratings and equity rankings. Debt constrained firms are smaller in total assets and market capitalization and fewer of them pay dividends. Firms constrained in debt make fewer R&D investments and incur fewer advertising expenses. They also issue less debt, equity, and make fewer debt and equity reductions. Finally, debt constrained firms make less capital expenditure investments. These results are strikingly similar to the sort on $FC_{i,t}$ despite containing only contemporaneous capital structure considerations and excluding the intertemporal financing decision. This means that between $\Lambda^{-1}_{i,t+1}$ and $\Gamma_{i,t}$, firms behave as if the limiting constraint is the restriction on debt capacity. That is, preserving debt capacity is an important concern for firms and, all else equal, firms are reluctant to use up financial slack.

Two Way Sorts

To further examine the impact of $\Lambda_{i,t+1}$ and $\Gamma_{i,t}$ on investment and the overall financing constraint, $FC_{i,t}$, I perform two way sorts on the three financing constraint measures in Table 3.6. In particular, I look at the mean of capital expenditure (I/A), and the means of the three financing constraint measures.

In panel A of Table 3.6, I first sort $\Lambda^{-1}_{i,t+1}$ (across the columns) into three bins (LOW, MED, and HIGH). Then, within each bin I sort on $\Gamma_{i,t}$ (down the rows). The first block of results in panel A examines the mean investment to asset ratio for each bin. When the constraints to equity today is low relative to equity tomorrow (LOW $\Lambda^{-1}_{i,t+1}$), as debt constraints increase, the investment to asset ratio drops slightly, but for the most part remains stable. When equity constraints are high, increasing debt constraints restrict investment. These results make intuitive sense since in the former case, firms still have access to equity, and in the latter case, firms are unable to obtain either security. On the other hand, although equity constraints increase across the LOW to HIGH bins, firms with the lowest debt constraints in each equity constraint bin are actually increasing investment. Only the firms with the highest debt constraints across each equity bin that are increasingly prohibited from investment as equity constraints increase. This reinforces the result above that it is the debt constraint and not the equity constraint that is the limiting factor on investment. (In fact, as shown above in the one-way sort, I/A is level when averaging across each $\Lambda_{i,t+1}^{-1}$ bin.)

The second block of results present the mean values of $\Lambda_{i,t+1}^{-1}$, the inverse of the intertemporal equity constraint. By construction, $\Lambda_{i,t+1}^{-1}$ increases across the columns. However, the values are constant down the rows. This suggests that the correlation between $\Lambda_{i,t+1}^{-1}$ and $\Gamma_{i,t}$ is low; indeed the correlation between the two measures is only 8.1%. The third block of results present the mean values of $\Gamma_{i,t}$, the contemporaneous debt to equity constraint. By construction, $\Gamma_{i,t}$ increases down the rows and, by the low correlation with the intertemporal equity constraint, is scattered across the columns.

The last block of results present the mean values of $FC_{i,t}$, the overall financing constraint. If $FC_{i,t}$ is influenced more by $\Lambda_{i,t+1}^{-1}$, we should see value patterns similar to the second block; if $FC_{i,t}$ is influenced more by $\Gamma_{i,t}$, we should see value patterns similar to the third block. $FC_{i,t}$ increases down the rows and is scattered across the columns, consistent with the results for $\Gamma_{i,t}$. In other words, $FC_{i,t}$ is influenced more by $\Gamma_{i,t}$.

Since two-way sorts are sensitive to the order of sorting, in panel B of Table 3.6, I first sort on $\Gamma_{i,t}$ and then on $\Lambda_{i,t+1}^{-1}$. In the first block of results, when constraints to debt today is low relative to equity today (LOW $\Gamma_{i,t}$), increasing equity constraints do not deter investment. In fact, I/A actually increases from 6.7% to 9.0%. When debt constraints are high, increasing equity constraints become binding and investment decreases. Averaging down the rows, we see that increasing debt constraints decreases investment. However, averaging across the columns, we see that after controlling for debt constraints, equity constraints have little to no additional impact on investment. The second and third blocks of results present the mean values of $\Lambda_{i,t+1}^{-1}$ and $\Gamma_{i,t}$, respectively. The fourth block gives the mean values for the overall financing constraint, $FC_{i,t}$. Again, we see that $FC_{i,t}$ follows closely to $\Gamma_{i,t}$. However, after controlling for $\Gamma_{i,t}$, we see that $FC_{i,t}$ increases with $\Lambda_{i,t+1}$. This indicates that although $FC_{i,t}$ is mainly driven by the debt to equity constraint, the intertemporal equity constraint does contribute to the overall constraint.

In summary, the limiting financing constraint that firms face is the contemporaneous debt to equity constraint ratio, not the intertemporal equity constraint ratio. That is, when the relative debt to equity constraint is not binding, the intertemporal equity constraint does not bind. However, when $\Gamma_{i,t}$ is binding, $\Lambda_{i,t+1}^{-1}$ does add additional pressure to the overall constraint. These results indicate that all else equal, preserving debt capacity and financial slack is a major corporate concern since debt is the last resort security. That is, when debt is constrained, firms act as if they are constrained overall, yet when equity is constrained, firms can still turn to debt. The financial slack story adds insight on why empirically firms use less debt than hypothesized based on tax benefits. That is, a model with debt capacity restrictions and financial slack considerations appear to describe the observed financing behaviors of firms fairly well.

3.5 Summary

The link between financing constraints and investment is a well studied one, as is the link between capital structure and investment. However, existing literature tends to focus on one or the other. This chapter attempts to study both effects jointly and measures the financing constraint for intertemporal equity financing and contemporaneous debt to equity financing. Firm specific financing constraint measures are empirically estimated using GMM based on a structural model with separate equity and debt restrictions. Specifically, firms are restricted from issuing external equity and unsecured debt, i.e., any risk form of financing. The shadow costs on these restrictions provide the theoretical basis for the estimation of the financing constraint measures. The results show that the estimated constraint measure relate to firm characteristics in intuitive ways. Additionally, the estimated financing constraint measures capture observed corporate financing behavior. Using the two financing constraint measures for debt and equity, I propose an overall constraint measure that captures features expected of financially constrained firms. I find that between the intertemporal equity constraint and the contemporaneous capital structure constraint, the latter is the limiting constraint faced by firms due to a concern for preserving financial slack. In other words, a model with separate financing constraints for equity and debt provides an explanation of observed capital structure decisions by capturing corporate concerns for preserving financial slack. This holds potential for future research and policy work towards analyzing corporate financing decisions.

3.A Appendix: Variable Definitions

A detailed description on the construction of the variables used in the chapter follows. Numbers in parentheses indicate the corresponding COMPUSTAT annual industrial data items in their legacy database. All variables are obtained from the S&P COMPUSTAT database with the exception of ILLIQ and ANEST, which come from Center for Research in Security Price (CRSP) and Thompsons I/B/E/S respectively.

Output, $\text{Y} = \frac{\text{Net Sales (12)}}{\text{Total Assets (6)}}$

Cost of goods sold, $\text{C} = \frac{\text{Cost of Goods Sold (41)}}{\text{Total Assets (6)}}$

Capital stock (beginning of period), $\text{K} = lag\left(\frac{\text{Property, Plant, and Equipment - Gross (7)}}{\text{Total Assets (6)}}\right)$

Capital expenditure, $\text{I} = \frac{\text{Capital Expenditure (128)}}{\text{Total Assets (6)}}$

Debt (beginning of period), $\text{B} = lag\left(\frac{\text{Long-term Debt - Total (9)}}{\text{Total Book Assets}}\right)$

Risk-free Rate, r = Annualized 1-month Treasury bill

Log of total assets, $\text{LTA} = \log\left(\text{Total Assets (6)} * \text{Adjustment to 2000 Dollars}\right)$

Dividend paying firms, $\text{DDIV} = \begin{cases} 1 & \text{if Common Dividends (21)} > 0 \\ 0 & \text{if Common Dividends (21)} = 0 \end{cases}$

Collateral, $\text{COL} = \frac{\text{Total Inventories (3)} + \text{Net Plants, Property, and Equipment (8)}}{\text{Total Assets (6)}}$

Long-term debt, $\text{LEV} = \frac{\text{Long-term Debt - Total (9)}}{\text{Total Assets (6)}}$

$$\text{Industry debt (3 digit SIC), INDLEV} = \frac{\sum\limits_{i \in \text{SIC3 Industry}}^{N} \text{Long-term Debt - Total (9)}}{\sum\limits_{i \in \text{SIC3 Industry}}^{N} \text{Total Book Assets}}$$

$$\text{Cash flow, CF} = \frac{\text{Operating Income Before Depreciation (13)}}{\text{Total Assets (6)}}$$

$$\text{Cash flow volatility (3 year), CFVOL} = \frac{\text{Standard Deviation}\{CF_{i,t}, CF_{i,t-1}, CF_{i,t_2}\}}{\text{Mean}\{CF_{i,t}, CF_{i,t-1}, CF_{i,t-2}\}}$$

$$\text{Cash stock, CASH} = \frac{\text{Cash and Short Term Investments (1)}}{\text{Total Assets (6)}}$$

$$\text{Liquidation ratio, LIQV} = \frac{\text{Common Equity - Liquidation Value (235) + Preferred Stock - Liquidation Value (10)}}{\text{Total Assets (6)}}$$

$$\text{Illiquidity, ILLIQ} = \frac{\text{ASK - BID}}{\text{PRC}}$$

Number of analyst estimates, ANEST = Number of all analyst estimates made for firm i for time t.

$$\text{Book equity to market equity, BTM} = \frac{\text{Total Common Equity (60)}}{\text{Fiscal Year Close Price (199) * Common Shares Outstanding (54)}}$$

S&P credit rating, SPCR = S&P Current Long-Term Debt Rating (280) organized into ten groups:
1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C, 10=D

S&P equity ranking, SPSR = S&P Common Stock Ranking (282) organized into nine groups:
1=A+, 2=A, 3=A-, 4=B+, 5=B, 6=B-, 7=C, 8=D, 9=LIQ

$$\text{Altman's ZSCORE} = \frac{\text{3.3*Pretax Income (170) + 1.0*Net Sales (12) + 1.4*Retained Earnings (36) + 1.2*Working Capital (179)}}{\text{Total Assets (6)}}$$

Table 3.1: Summary statistics of variables used in Euler equations (3.11) and (3.12). Y is output expressed as sales over total book assets, C is cost of goods sold over total book assets, K is the beginning of the period capital stock over book assets, I is capital expenditures over total book assets, and B is the beginning of the period long term debt over book assets. r is the annualized one month Treasury bill, MKT is the annualized return on the market, SMB is the annualized return on the small minus big portfolio, and HML is the annualized return on high minus low portfolio. δ is the firm specific depreciation rate defined as two times the total depreciation expense over K. LTA is the log of total assets, DDIV is a indicator for dividend paying firms, COL is plants, properties, and equipment plus inventories over total book assets, LEV is the firm's long term debt over total book assets, INDLEV is the industry's total long term debt over total book assets, CF is the firm's cash flow over total book assets, CFVOL is the five year trailing standard deviation of cash flows divided by the five year trailing mean of cash flows, CASH is cash holdings over total book assets, LIQV is the liquidation value of the firm over total book assets, ILLIQ is the bid-ask spread on the firm's equity over the stock price, ANEST is the number of analyst estimates, and BTM is the ratio of book equity to market equity. Appendix 3.A provides detailed definitions on each variable.

	No. Obs.	Mean	Std. Dev.	Min	Med	Max
Y	20813	1.3314	0.6914	0.0021	1.1975	4.8287
C	20813	0.8963	0.6147	0.0018	0.7656	4.1885
K	20813	0.5406	0.3281	0.0112	0.4785	2.0960
I	20813	0.0730	0.0625	0.0000	0.0559	0.7243
B	20813	0.1555	0.1375	0.0000	0.1336	0.7330
r	20813	0.0482	0.0213	0.0088	0.0485	0.1353
δ	20813	0.1813	0.0988	0.0354	0.1560	1.1602
Y/K	20813	4.0394	4.9099	0.0110	2.6398	57.9455
C/K	20813	2.6758	3.8261	0.0050	1.5980	46.1735
I/K	20813	0.1672	0.1667	0.0000	0.1193	2.7969
$(I/K)^2$	20813	0.0557	0.2024	0.0000	0.0142	7.8228
$(I/K)^3$	20813	0.0378	0.3653	0.0000	0.0017	21.8797
B/K	20813	0.3636	0.4779	0.0000	0.2389	5.3969
$(B/K)^2$	20813	0.3606	1.3178	0.0000	0.0571	29.1260
$(B/K)^3$	20813	0.6807	4.7429	0.0000	0.0136	157.1890
MKT	20813	0.1405	0.1579	-0.2978	0.1584	0.6689
SMB	20813	0.0068	0.1042	-0.2611	-0.0113	0.5150
HML	20813	0.0447	0.1437	-0.3286	0.0454	0.7004
LTA	20813	6.2642	1.8333	1.3000	6.0627	12.9889
DDIV	20813	0.5411	0.4983	0.0000	1.0000	1.0000
COL	20813	0.4967	0.2119	0.0042	0.5051	0.9815
LEV	20813	0.1627	0.1404	0.0000	0.1452	0.6881
INDLEV	20813	0.2042	0.0827	0.0583	0.1850	0.5109
CF	20813	0.1519	0.0817	-1.1474	0.1488	0.4383
CFVOL	20813	0.0063	0.0384	0.0000	0.0005	1.2730
CASH	20813	0.1243	0.1471	0.0000	0.0650	0.9934
LIQV	20813	0.5216	0.1877	0.0422	0.5103	0.9731
ILLIQ	20813	0.1334	0.2261	-2.0556	0.1173	1.8798
ANEST	20813	7.6839	7.8406	0.0000	5.0000	50.0000
BTM	20813	0.6114	0.4485	0.0284	0.5016	4.5427

Table 3.2: Initial GMM estimation of Euler equations (3.7) and (3.8). The financing constraints are parameterized as follows: $\Lambda_{i,t+1} = l_0$ and $\Gamma_{i,t} = g_0$. μ is the cost markup factor, a's are the parameters on the adjustment cost of capital, b_1's are the parameters on the firm specific interest rate, and m's are parameters on the stochastic discount factor. l_0 is the parameter on $\Lambda_{i,t+1} \equiv \frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}$, the financing constraint on equity tomorrow relative to equity today, where $\lambda_{i,t}$ is the shadow value on the equity financing constraint in equation (3.5). g_0 is the parameter on $\Gamma_{i,t} \equiv \frac{\gamma_{i,t}}{1+\lambda_{i,t}}$, the financing constraint on debt today relative to equity today, where $\gamma_{i,t}$ is the shadow value on the debt financing constraint in equation (3.6). The moment conditions are defined as in equation (3.13). Instruments include lagged versions of all variables in the model. Column (i) estimates the model under the assumption that there are no financing constraints ($\Lambda_{i,t+1} \equiv 1$ and $\Gamma_{i,t} \equiv 0$). Column (ii) estimates the model under the assumption that equity financing is constrained, but debt financing is not ($\Gamma_{i,t} \equiv 0$). Column (iii) estimates the model under the assumption that debt financing is constrained, but equity financing is not ($\Lambda_{i,t+1} \equiv 1$). Column (iv) estimates the model assuming that both equity and debt financing are constrained. GMM standard errors are given in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(i)	(ii)	(iii)	(iv)
μ	1.2396 (0.0002) ***	1.2376 (0.0004) ***	1.2376 (0.0005) ***	1.2370 (0.0005) ***
a_1	0.3673 (0.0005) ***	0.3918 (0.0015) ***	0.3961 (0.0018) ***	0.3977 (0.0016) ***
a_2	0.1744 (0.0071) ***	0.3032 (0.0187) ***	0.3691 (0.0226) ***	0.3433 (0.0205) ***
a_3	-0.1723 (0.0053) ***	-0.3319 (0.0295) ***	-0.3885 (0.0360) ***	-0.3615 (0.0324) ***
b_1	0.0177 (0.0005) ***	0.0224 (0.0025) ***	0.0159 (0.0030) ***	0.0231 (0.0027) ***
b_2	-0.0065 (0.0005) ***	-0.0106 (0.0007) ***	-0.0094 (0.0007) ***	-0.0108 (0.0006) ***
m_0	0.9591 (0.0001) ***	0.9653 (0.0002) ***	0.9672 (0.0002) ***	0.9667 (0.0002) ***
m_1: MKT	-0.0217 (0.0004) ***	-0.0478 (0.0009) ***	-0.0579 (0.0008) ***	-0.0572 (0.0009) ***
m_2: SMB	0.0822 (0.0008) ***	0.0812 (0.0012) ***	0.0814 (0.0013) ***	0.0844 (0.0013) ***
m_3: HML	0.0023 (0.0005) ***	-0.0219 (0.0010) ***	-0.0298 (0.0009) ***	-0.0280 (0.0009) ***
l_0		0.9863 (0.0006) ***	***	0.6427 (0.0097) ***
g_0			0.0066 (0.0002) ***	0.3953 (0.0092) ***

Table 3.3: Full GMM estimation of Euler equations (3.7) and (3.8). The financing constraints are parameterized as in equation (3.9) for $\Lambda_{i,t+1}$ and as in equation (3.10) for $\Gamma_{i,t}$. μ is the cost markup factor, a's are the parameters on the adjustment cost of capital, b_1's are the parameters on the firm specific interest rate, and m's are parameters on the stochastic discount factor. l's are the parameters on $\Lambda_{i,t+1} \equiv \frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}$, the financing constraint on equity tomorrow relative to equity today, where $\lambda_{i,t}$ is the shadow value on the equity financing constraint in equation (3.5). g's are the parameter on $\Gamma_{i,t} \equiv \frac{\gamma_{i,t}}{1+\lambda_{i,t}}$, the financing constraint on debt today relative to equity today, where $\gamma_{i,t}$ is the shadow value on the debt financing constraint in equation (3.6). The moment conditions are defined as in equation (3.13). Instruments include lagged versions of all variables in the model. Column (i) is the estimation of the full model. Column (ii) re-estimates the model based on significant coefficients from column (i). GMM standard errors are given in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(i)			(ii)		
μ	1.2376	(0.0003)	***	1.2376	(0.0003)	***
a_1	0.3756	(0.0010)	***	0.3771	(0.0010)	***
a_2	0.1338	(0.0129)	***	0.1530	(0.0118)	***
a_3	-0.1858	(0.0236)	***	-0.2102	(0.0207)	***
b_1	0.0203	(0.0017)	***	0.0191	(0.0017)	***
b_2	-0.0100	(0.0005)	***	-0.0097	(0.0005)	***
m_0	0.9622	(0.0002)	***	0.9625	(0.0002)	***
m_1: MKT	-0.0238	(0.0006)	***	-0.0253	(0.0006)	***
m_2: SMB	0.0732	(0.0012)	***	0.0743	(0.0012)	***
m_3: HML	-0.0008	(0.0008)		-0.0026	(0.0008)	***
l_0	2.0721	(0.0160)	***	2.0690	(0.0157)	***
l_1: LTA	-0.0548	(0.0104)	***	-0.0540	(0.0090)	***
l_2: DDIV	-0.0160	(0.0028)	***	-0.0477	(0.0026)	***
l_3: COL	-0.0309	(0.0079)	***	-0.0345	(0.0082)	***
l_4: LEV	-0.0014	(0.0095)				
l_5: INDLEV	-0.0137	(0.0090)				
l_6: CF	-0.0207	(0.0038)	***	-0.0210	(0.0033)	***
l_7: CFVOL	0.0003	(0.0027)				
l_8: CASH	0.0213	(0.0059)	***	0.0215	(0.0061)	***
l_9: LIQV	-0.5940	(0.0129)	***	-0.5915	(0.0117)	***
$l_1$0: ILLIQ	0.0011	(0.0006)	*	0.0029	(0.0009)	***
$l_1$1: ANEST	0.0002	(0.0060)				
$l_1$2: BTM	0.0004	(0.0042)				
g_0	0.0667	(0.0022)	***	0.0662	(0.0021)	***
g_1: LTA	-0.2559	(0.0208)	***	-0.2547	(0.0203)	***
g_2: DDIV	-0.0302	(0.0062)	***	-0.0295	(0.0060)	***
g_3: COL	-0.0723	(0.0059)	***	-0.0724	(0.0058)	***
g_4: LEV	0.1086	(0.0048)	***	0.0924	(0.0034)	***
g_5: INDLEV	-0.0119	(0.0033)	***	-0.0068	(0.0024)	***
g_6: CF	-0.0141	(0.0026)	***	-0.0138	(0.0025)	***
g_7: CFVOL	-0.0085	(0.0014)	***	-0.0115	(0.0014)	***
g_8: CASH	-0.0108	(0.0045)	***	-0.0099	(0.0044)	***
g_9: LIQV	-0.0288	(0.0049)	***	-0.0412	(0.0052)	***
$g_1$0: ILLIQ	-0.0002	(0.0011)				
$g_1$1: ANEST	-0.0099	(0.0029)	***	-0.0030	(0.0020)	***
$g_1$2: BTM	-0.0157	(0.0027)	***	-0.0141	(0.0027)	***

Table 3.4: Probit analysis of debt and equity issuance and reduction on the lagged financing constraint of equity, $\Lambda_{i,t}$ and the lagged financing constraint of debt, $\Gamma_{i,t}$ as in equation (3.17). Debt issuance is an indicator for active issuance of long term debt. Similarly, equity issuance, debt reduction, and equity reduction are indicators for having issued equity, reduced long term debt, and repurchased shares, respectively. Standard errors clustered by firm are given in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	Debt Issuance (0 = 20,210 obs, 1 = 22,342 obs)		
Λ (Equity)	0.7963 ***		0.7824 ***
	(0.0196)		(0.0194)
Γ (Debt)		-1.4086 ***	-1.3706 ***
		(0.0530)	(0.0504)
Constant	-1.4869 ***	0.1284 ***	-1.3960 ***
	(0.0396)	(0.0134)	(0.0395)

	Equity Issuance (0 = 8,495 obs, 1 = 34,612 obs)		
Λ (Equity)	-0.3158 ***		-0.3045 ***
	(0.0240)		(0.0242)
Γ (Debt)		0.6126 ***	0.5802 ***
		(0.0656)	(0.0651)
Constant	1.4838 ***	0.8353 ***	1.4454 ***
	(0.0519)	(0.0159)	(0.0525)

	Debt Reduction (0 = 9,889 obs, 1 = 32,721)		
Λ (Equity)	0.8758 ***		0.8521 ***
	(0.0277)		(0.0275)
Γ (Debt)		-0.7862 ***	-0.6708 ***
		(0.0652)	(0.0695)
Constant	-0.8902 ***	0.7777 ***	-0.8076 ***
	(0.0520)	(0.0168)	(0.0522)

	Equity Reduction (0 = 26,627 obs, 1 = 15,766)		
Λ (Equity)	-0.0075		-0.0555 ***
	(0.0193)		(0.0191)
Γ (Debt)		-1.2898 ***	-1.3025 ***
		(0.0525)	(0.0522)
Constant	-0.3121	-0.2847 ***	-0.1757 ***
	(0.0392)	(0.0126)	(0.0392)

Table 3.5: One-way sorts on the three financial constraint measures into three (LOW, MED, HIGH) bins. The first three columns sort on the overall financing constraint, $FC_{i,t}$. The middle three columns sort on the equity constraint today relative to the equity constraint tomorrow, $\Lambda^{-1}_{i,t+1}$. The last three columns sort on the debt to equity constraint, $\Gamma_{i,t}$. SPCR is the S&P credit rating on long term debt grouped into ten categories where {1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C, 10=D}, SPSR is the S&P equity ranking grouped into nine categories where {1=A+, 2=A, 3=A-, 4=B+, 5=B, 6=B-, 7=C, 8=D, 9=LIQ}, HASACR is an indicator for having at least a credit rating of "A", HASASR is an indicator for having at least an equity ranking of "A", TA is total book assets, MKEQT is the market capitalization, LTD is long term debt, I/A is the ratio of capital expenditure to total assets, RD & AD is the sum of research & development and advertising expenses for the firm, DDIV is an indicator for dividend paying firm, DISS is the amount of long term debt issued, DRED is the amount of long term debt reduced, EISS is the amount of equity issued, and ERED is the amount of equity repurchased. The means of the variables for each sorting bin are presented.

	Sort on $FC_{i,t} \equiv \frac{\Gamma}{\Lambda_{i,t+1}}$			Sort on $\Lambda^{-1}_{i,t+1}$			Sort on Γ		
	LOW	MED	HIGH	LOW	MED	HIGH	LOW	MED	HIGH
SPCR	3.730	5.151	5.640	4.461	3.845	3.694	3.748	5.113	5.574
SPSR	4.022	5.179	5.955	5.039	4.630	4.841	4.022	5.135	6.001
HASACR	0.421	0.021	0.012	0.214	0.397	0.489	0.415	0.022	0.008
HASASR	0.337	0.091	0.007	0.146	0.221	0.177	0.338	0.091	0.008
TA	6543.768	466.621	90.607	3952.537	2470.819	676.087	6571.680	415.922	113.390
MKEQT	7582.525	525.947	160.480	1384.092	486.633	50.579	7588.014	521.525	159.416
LTD	1280.749	135.410	19.160	1021.688	376.164	37.339	1293.227	108.071	34.016
I / A	0.080	0.073	0.056	0.067	0.075	0.066	0.080	0.072	0.056
RD & AD	232.386	15.484	7.996	121.735	92.194	41.864	232.347	15.572	7.947
DDIV	0.716	0.371	0.136	0.447	0.462	0.314	0.718	0.367	0.138
DISS	429.118	64.208	9.965	344.651	145.471	13.248	432.823	53.287	17.262
DRED	378.277	57.342	8.359	296.732	130.088	17.214	381.612	47.581	14.857
EISS	60.041	14.310	10.013	32.798	27.539	24.001	60.329	14.715	9.331
ERED	140.735	8.384	1.207	59.210	67.613	23.440	140.957	7.754	1.646

Table 3.6: Two way sorts on $\Lambda^{-1}_{i,t+1}$ and $\Gamma_{i,t}$ into three bins (LOW, MED, HIGH) each. Panel A sorts first on $\Lambda^{-1}_{i,t+1}$ and second on $\Gamma_{i,t}$. Panel B sorts first on $\Gamma_{i,t}$ and then on $\Lambda^{-1}_{i,t+1}$. $\Lambda^{-1}_{i,t+1}$ is the inverse of the intertemporal equity financing constraint, i.e., the relative constraint between equity today and equity tomorrow. $\Gamma_{i,t}$ is the contemporaneous debt to equity constraint, e.g., the relative constraint between debt today and equity today. Across each panel, the first block of results presents the mean of the investment to assets ratio (I/A), the second block presents the mean of $\Lambda^{-1}_{i,t+1}$, the third block presents the mean of $\Gamma_{i,t}$, and the last block presents the mean of the overall financing constraint, $FC_{i,t}$.

	Panel A: Down: $\Gamma_{i,t}$, Across: $\Lambda^{-1}_{i,t+1}$, Correlation: 0.0813							
	I/A				$\Lambda^{-1}_{i,t+1}$			
	LOW	MED	HIGH	MEAN	LOW	MED	HIGH	MEAN
LOW	0.068	0.085	0.087	0.08	0.392	0.511	0.765	0.556
MED	0.071	0.079	0.064	0.071	0.389	0.516	0.782	0.562
HIGH	0.063	0.06	0.047	0.057	0.377	0.518	0.774	0.556
MEAN	0.067	0.075	0.066		0.386	0.515	0.774	
	Γ				$FC_{i,t}$			
	LOW	MED	HIGH	MEAN	LOW	MED	HIGH	MEAN
LOW	-0.239	-0.25	-0.139	-0.209	-0.094	-0.127	-0.104	-0.108
MED	0.059	0.027	0.104	0.064	0.023	0.014	0.083	0.04
HIGH	0.319	0.263	0.29	0.291	0.119	0.136	0.224	0.16
MEAN	0.047	0.014	0.085		0.016	0.008	0.068	

	Panel B: Down: $\Lambda^{-1}_{i,t+1}$, Across: $\Gamma_{i,t}$, Correlation: 0.0813							
	I/A				$\Lambda^{-1}_{i,t+1}$			
	LOW	MED	HIGH	MEAN	LOW	MED	HIGH	MEAN
LOW	0.067	0.071	0.063	0.067	0.388	0.397	0.376	0.387
MED	0.083	0.077	0.058	0.073	0.49	0.533	0.532	0.518
HIGH	0.09	0.068	0.048	0.069	0.713	0.797	0.796	0.769
MEAN	0.08	0.072	0.056		0.53	0.576	0.568	
	Γ				$FC_{i,t}$			
	LOW	MED	HIGH	MEAN	LOW	MED	HIGH	MEAN
LOW	-0.227	0.065	0.317	0.052	-0.088	0.026	0.118	0.018
MED	-0.228	0.062	0.289	0.041	-0.112	0.033	0.154	0.025
HIGH	-0.187	0.071	0.275	0.053	-0.132	0.057	0.219	0.048
MEAN	-0.214	0.066	0.294		-0.111	0.039	0.164	

Conclusion

The central theme of the chapters above focuses on the topic of capital structure.

Chapter 1 starts by studying the cost of debt. We propose an identification strategy using the marginal tax benefit of debt that allows us to identify and estimate the marginal cost of debt by conditioning on firm characteristics. The resulting estimation gives us a straightforward formula for calculating the marginal cost of debt for any firm at any time.

Chapter 2 takes a broader scope and uses the marginal cost of debt curves and the marginal benefit curves of debt to define the optimal capital structure as the intersection of the two curves. This allows us to quantify the gross benefit of debt, cost of debt, and net benefit of debt at both the optimal level of leverage and the level observed in reality. We can then measure how much having optimal leverage adds to firm value and how costly it is to deviate from that optimum.

Chapter 3 takes another step out and asks how the capital structure decision relates to the capital investment decision through studying financing constraints. By introducing a structural model of investment with two separate financing restrictions, one for external equity and one for non-secured debt, I allow observed capital structure choices of firms to give insight on the perceived values of access to equity or debt financing. Between equity and debt, the limiting constraint is the one that restricts debt, suggesting that firms care about preserving debt capacity. This result underscores the importance of studying and understanding the cost of debt.

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Biography

Jie Yang was born on July 20, 1981 in Beijing, China. She moved to New York, USA in 1986 and attended primary and secondary schooling there until 1995. Subsequently, she moved to Virginia where she attended the Thomas Jefferson High School for Science and Technology, during which she interned at the Food and Drug Administration before graduating in 1999 with the Governor's seal of honor.

She went on to pursue an undergraduate degree at the Massachusetts Institute of Technology in Cambridge, MA. During this period, she interned at The Nature Conservancy and the United States Office of Personnel Management during the summers and provided research assistance during the academic years. She graduated in 2003 with a Bachelor of Science in Economics.

In 2004, she entered a doctoral program in Business Administration, majoring in finance, at the Fuqua School of Business at Duke University in Durham, NC. She was awarded the American Finance Association student travel grant in 2008 and visited Georgetown University in 2009, where she received a tenure-track offer at the McDonough School of Business. She plans to continue at Georgetown University upon completion of her doctoral degree.