CF
8/1/07
2:00 PM

The Cost of Debt*

Jules H. van Binsbergen
Fuqua School of Business
Duke University†

John R. Graham
Fuqua School of Business
Duke University‡
and NBER

Jie Yang
Fuqua School of Business
Duke University§

This version: June 2007

Abstract

We use panel data from 1980 to 2005 to estimate cost functions for corporate debt. We start with Graham's (2000) debt benefit curves and assume that for financially unconstrained firms, the benefit curve and the cost curve intersect at the actual level of debt, on average. Using this equilibrium condition, exogenous shifts of the benefit curves enable us to identify the marginal cost curve. We recover marginal cost functions that are positively sloped and provide coefficients that can be used to determine the marginal cost of debt. By integrating the area between the benefit and cost functions we estimate that the net benefit of debt equals about 4% of asset value. Our findings are consistent over time, across industries, and when accounting for fixed adjustment costs of debt. We show that both the intercept and the slope of the marginal cost curve of debt depend on firm characteristics such as asset collateral, book-to-market ratio, sales, cash flows, cash holdings, and whether the firm pays dividends. As such, our framework provides a new parsimonious environment within which we can examine implications from competing capital structure theories. Our approach also allows us to make recommendations about firm-specific optimal debt ratios and estimate the cost of being under or overlevered.

JEL classifications: G30,G32
Keywords: Capital Structure, Tax Regime Shifts

---

*We thank Ravi Bansal, Jonathan Berk, Michael Brandt, Alon Brav, Hui Chen, Cam Harvey, Han Hong, Ralph Koijen, Mike Lemmon, Rich Mathews, Bertrand Melenberg, Anamaría Pieschacón, Adriano Rampini, Michael Roberts, David Robinson, Ilya Strebulaev, George Tauchen, Toni Whited, and seminar participants at Duke University and Wharton for helpful comments.

†Durham, NC 27708. Phone: (919) 660-7636. Email: jules.vanbinsbergen@duke.edu.
‡Durham, NC 27708. Phone: (919) 660-7857. Email: john.graham@duke.edu.
§Durham, NC 27708. Phone: (919) 660-2939. Email: jie.yang@duke.edu.

1 Introduction

Hundreds of papers investigate corporate financial decisions and the factors influencing capital structure. Much theoretical work characterizes the choice between debt and equity in a trade-off context: 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 of debt include committing managers to operate efficiently (Jensen, 1984) and engaging lenders to monitor the firm (Jensen and Meckling, 1976). The costs of debt include the cost of 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 include proxy variables to measure the hypothesized effects. The empirical results are somewhat mixed but a number of empirical regularities have been documented. Large firms with tangible assets and few growth options tend to use a relatively large amount of debt (Rajan and Zingales, 2003; Frank and Goyal, 2004). Firms with high corporate tax rates also tend to have higher debt ratios and use more debt incrementally (Graham, Lemmon, and Schallheim, 1998).

One reason tax incentives receive a lot of attention in the literature (and in the classroom) is that they are relatively easy to quantify and that the gross benefits seem large (e.g., 35 cents per dollar of interest if the corporate income tax rate is 35 percent). Tax incentives are sufficiently quantifiable that it is possible to simulate the entire benefit function associated with interest tax deductibility and integrate under the curve to estimate the gross tax benefits of debt (Graham, 2000). Therefore, at least in the tax dimension, we are able to specify the firm-specific benefits of debt.

It has been much more elusive to quantify the costs of debt. Warner (1977) and Miller (1977) observe that the traditional costs of debt (e.g., direct bankruptcy costs) appear to be low relative to the tax benefits, implying that other, unobserved, or hard to quantify costs are important. Several recent papers argue that once these other debt costs are considered, the marginal costs roughly equal the marginal (tax) benefits of debt (e.g., Berk, Stanton and Zechner, 2006; Carlson and Lazrak, 2006). Notwithstanding these theoretical arguments, debt costs are generally hard to measure empirically. To date, the costs of debt have not been explicitly quantified to the same degree as have the benefits.

In this paper, we explicitly map out the debt cost function. To do this, we need to address issues related to the standard econometric difficulties associated with identifying demand and supply curves. In our case, we start with Graham's simulated marginal tax benefit curves and the observed (equilibrium) debt choices. Observing variation in the marginal benefit curve over time and in the cross section gives us an important advantage over the standard demand and supply framework where only equilibrium points are observed. Whereas in the latter framework one has to use an instrumental variable that *proxies* for shifts of the demand (supply) curve to identify the supply (demand) curve, we have the advantage of observing the *actual* shifts of the marginal benefit curve. What remains is to purge from these shifts potential correlations with cost curve shifts (econometric details are provided in Section 2) by using a set of control variables that proxy for cost effects. Then, we use the variation due to pure benefit shifts to identify the cost curve.

As just described, we use marginal benefit variation in both the cross section and in the time series to determine marginal cost curves. However, our proposed method does critically depend on the right choice of control variables. As such, omitted variables may induce a bias in our estimates. To ensure that our results are not driven by such econometric issues we repeat our analysis using as the identifying instrument the time-series of exogenous tax regime shifts between 1980 and 2005. We show that this pseudo-natural experiment leads to estimates that are highly similar to those obtained in our main specification. At the other extreme, our primary conclusions also hold when we estimate our model from 1998 to 2005. During this period there were no exogenous tax regime shifts, meaning that for this time period the time series approach is infeasible. Therefore, in this case, the identification of the cost curve is mainly based on cross-sectional marginal benefit variation. Reassuringly, the cross-sectional approach also corroborates our main results. This indicates that our results are highly robust and hold whether we identify the cost curve based on (i) cross-sectional variation of marginal benefits, (ii) time series variation of marginal benefits, or (iii) a combination of the two.

Our analysis produces cost curves that are positively sloped, and significantly different from zero, as expected. We form subsamples based on the level of financial constraint and financial distress. We assume that, on average, unconstrained and non-distressed firms make optimal capital structure choices. We estimate different curves for each industry, and the slopes of these curves vary in ways that make sense economically. We relate both the slope and the intercept of the cost curve to firm characteristics such as whether the firm's assets are collateralizable, book-to-market, sales, cash flows, cash holdings and whether the firm pays dividends. We then compare our findings to existing theories on the costs and benefits of debt. We also produce easy-to-implement algorithms to allow researchers and practitioners to explicitly map out the debt cost function by industry and by firm. This fills a big void in the current state of affairs by providing both explicit quantification of the cost of debt and firm-specific recommendations to corporations in terms of optimal capital structure.

Our results are robust to the presence of fixed adjustment costs. Recently it has been argued (e.g. Fischer, Heinkel and Zechner, 1989; Leary and Roberts, 2005; and Strebulaev, 2006) that fixed adjustment costs prevent firms from responding instantaneously to changing conditions, leading to infrequent capital structure adjustments. With adjustment costs, capital structure policy can be modeled by an (s,S) rule, where an adjustment only occurs if the 'optimal' capital structure falls outside a bandwidth with lower bound s and upper bound S. We repeat our analysis by only including those firm-year observations in which a substantial rebalancing of capital structure occurs. Our results are the same over this sample, indicating that fixed adjustment costs do not drive our main results.

Armed with simulated debt benefit functions and estimated cost functions for every company, we calculate firm-specific optimal capital structure at the intersection of the curves. We also integrate the area between the curves to estimate the net benefits of debt financing as well as the costs to deviating from the optimum. We estimate that the *net* benefit of debt financing equals, on average, 2.8-3.9% of book value in perpetuity for firms at the calculated *optimum* leverage positions, compared to a gross benefit of 9.4-9.7% of book value. The *net* benefit of debt financing equals, on average, 0.0-0.2% of book value in perpetuity for firms at the *observed* leverage positions compared to a gross benefit of 8.7% of book value. This implies deadweight losses of about 2.4-2.8% of book value in perpetuity due to costs of being away from the optimal debt ratio. Firms already at their equilibrium, on average, have gross benefits of debt equaling 12.6-13.4% of book value in perpetuity, costs of debt equaling 7.7-9.7% of book value, with net benefits of 3.8-4.9% of book value. Finally, we find that the costs to being overlevered appear to be more severe than costs to being underlevered.

The rest of the paper proceeds as follows. In Section 2, we explain the main intuition of our instrumental variables approach. In Section 3, we give an extensive data description. In Section 4, we report and discuss our results. Section 5 presents case examples of our analysis for select firms. In Section 6, we calculate the benefits and costs of debt and analyze the costs of being under or overlevered. Section 7 discusses several robustness checks. Section 8 concludes.

2 Method of Estimating Marginal Cost Curves

Using the simulation techniques of Graham (2000), we create marginal tax benefit curves of debt for a large panel of approximately 120,000 firm-years between 1980 and 2005. The marginal benefit curve measures the marginal tax benefit for each dollar of incremental

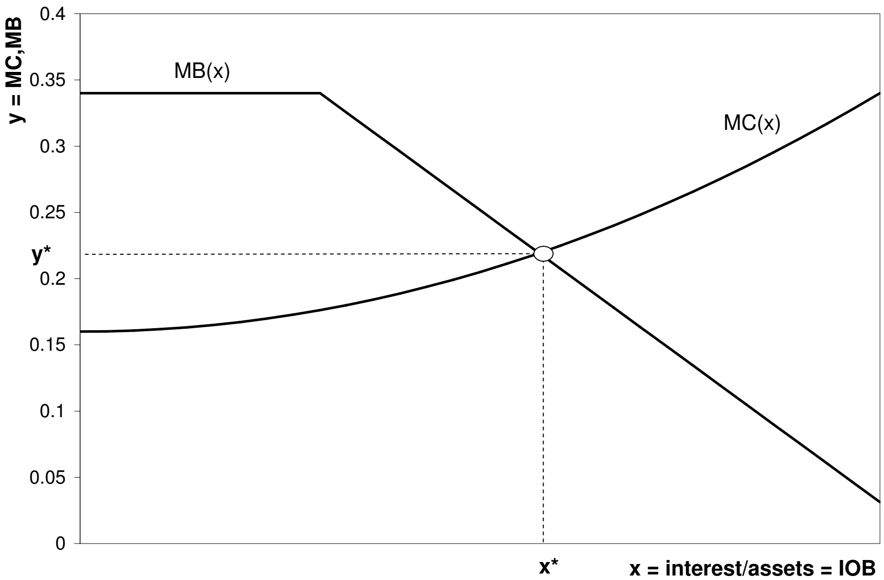

Figure 1: Capital structure equilibrium for a financially unconstrained firm. The figure shows the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, and the equilibrium level of debt, x^*, where marginal cost and marginal benefit are equated. The equilibrium marginal benefit level at x^* (which equals the cost level at x^*) is denoted by y^*.

interest deduction.[1] The shape of these benefit curves varies by firm, but they are weakly monotonic and typically horizontal for low levels of debt and become negatively sloped for higher levels of debt (see Figure 1).

We know the current level of debt for each firm in each year. Henceforth, we will refer to this current level of debt as the "equilibrium level of debt," denoted by $x^*_{i,t}$. That is, we implicitly assume that for financially unconstrained firms, on average, the marginal cost curve of debt (MC) intersects the marginal benefit curve of debt (MB) at the equilibrium level. We refer to the observed corresponding marginal benefit level as the "equilibrium benefit of debt," denoted by $y^*_{i,t}$. In equilibrium at $x_{i,t} = x^*_{i,t}$ the following equality holds:

$$y^*_{i,t} \equiv MC_{i,t}\left(x^*_{i,t}\right) = MB_{i,t}\left(x^*_{i,t}\right). \tag{1}$$

The function $f_{i,t}$, which is simulated, describes for firm i at time t the shape of the marginal benefit curve of debt:

$$MB_{i,t} = f_{i,t}\left(x_{i,t}\right), \tag{2}$$

where $x_{i,t}$ represents the level of debt, expressed as the ratio of interest over book value of assets. Note that other measures of leverage, like the ratio of debt over the market value

[1]The mechanics of the marginal benefit curve simulations are described in section 3.

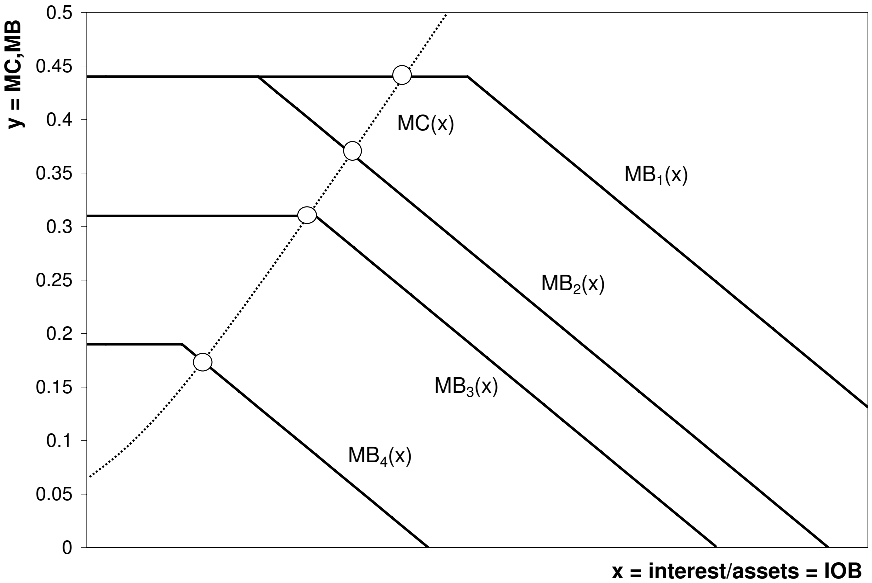

Figure 2: Identifying the cost function using shifts in the marginal benefit function. The figure shows four marginal benefit curves of debt, each intersected by the marginal cost curve of debt. The four curves can represent the marginal benefit curves of the same firm at four different points in time. The curves can alternatively represent the marginal benefit curves of four different firms at the same point in time. Empirically, we use both cross-sectional and time-series variation in the marginal benefit curve 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: $MB_1(x) \supset MB_2(x) \supset MB_3(x) \supset MB_4(x)$ translates to $A_1 \geq A_2 \geq A_3 \geq A_4$.

of assets, could alternatively be used. Figure 1 illustrates the equilibrium concept for a financially unconstrained firm.

To recover the marginal cost function of debt from the equilibrium debt levels and the equilibrium benefit levels, we need to identify 'exogenous' shifts of the marginal benefit curve. In this context, the word exogenous indicates a shift of the marginal benefit curve that is uncorrelated with a shift in the marginal cost curve. In other words, we need to identify shocks to the marginal benefit curve of debt while holding the marginal cost curve constant. The exogenous benefit shifts may result from time series shifts of the marginal benefit curve of firm i, for example after a tax regime shift. However, exogenous benefit shifts may also result from cross-sectional variation in the location of the marginal benefit curve of debt at some time t. If two otherwise similar firms have different marginal benefit curves, and hence a different equilibrium level of debt, this provides information that we exploit to estimate the marginal cost curve as illustrated in Figure 2.

To identify exogenous shocks to the marginal benefit curve, which we use as the identifying instrumental variable, we can take either of two approaches. The first approach is to find variables that proxy for, or events that cause, exogenous marginal benefit shifts.

One obvious event is the tax regime changes mentioned earlier. The shifts of the marginal benefit curve induced by such natural experiments can provide an instrument that has no or very little correlation with shifts of the marginal cost curve. The disadvantage of this time-series approach, however, is that the exogenous variation of the benefit curve is limited to the variation of the tax regime changes. In particular, this approach does not exploit the fact that there is variation of the marginal benefit curve both in the time series and in the cross section.

An alternative approach exploits the fact that, unlike the standard framework of identifying demand and supply curves where only equilibrium points are observed, we observe the entire simulated marginal benefit curve. In other words, apart from measurement errors (which we assume to be idiosyncratic), we directly observe the cross-sectional and time series variation (i.e., shifts) in the benefit curve, which we use to identify the cost function. Once we purge cost effects from this variation, we will be left with an *exogenous* benefit shifter.

To purge cost effects, we follow two steps. First, we 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:

$$A_{i,t} = \int_{0}^{\infty} f_{i,t}\left(x_{i,t}\right) dx_{i,t}. \tag{3}$$

Empirically, this area provides an accurate description of the location of the marginal benefit curve. If the marginal benefit curve shifts upward (downward), then the area under the curve will increase (decrease). Henceforth, we interpret variation in this area measure as variation (shifts) of the marginal benefit curve.[2]

Next, we purge the benefit measure $A_{i,t}$ of potential cost effects. To accomplish this, we include a set of control variables that are theorized to be correlated with the location of the debt cost curve: the log of total assets ($LTA_{i,t}$), a proxy for firms' collateralizable assets ($PPE_{i,t}$), the book-to-market ratio ($BTM_{i,t}$), whether the firm pays dividends ($DDIV_{i,t}$), cash flow ($CF_{i,t}$), and cash holdings on the balance sheet ($CASH_{i,t}$). Define C as the set of cost control variables that drive the location of the MC curve:

$$C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}. \tag{4}$$

[2]Using alternative modeling approaches to capture shifts of the marginal benefit curve, such as accounting for the y-intercept of the marginal benefit curve or including fine partitions of the area measure, lead to similar qualitative results to those we present below. For ease of exposition we focus on the area measure. Later in this section we also consider the location of the kink of the marginal benefit curve.

The purpose of our analysis is to estimate the marginal cost curve of debt, which we assume to be linear in both interest-over-book (IOB), denoted by $x_{i,t}$, and the cost control variables, C.[3] Under these assumptions, the marginal cost curve of debt is given by

$$MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}. \tag{5}$$

In Section 2.1, we explain how to estimate equation 5 using generalized method of moments (GMM) for efficiency and correct, clustered standard errors. However, since this provides relatively little intuition, we present the two-stage least squares (2SLS) equivalent of our estimation approach in Appendix A. Section 2.2 discusses alternative specifications.

2.1 Generalized Method of Moments (GMM)

Define the error function $g_{i,t}$ as

$$g_{i,t} = y^*_{i,t} - a - bx^*_{i,t} - \sum_{c \in C} \delta_c c_{i,t}. \tag{6}$$

We then estimate the coefficients, in an exactly identified system of equations, using generalized method of moments (GMM). The moments are obtained by interacting the error function above with the following instruments: a constant term, the variation of the marginal benefit curve $A_{i,t}$, and each of the control variables.

In equation 5 we assume that the control variables only cause parallel shifts of the marginal cost curve of debt and that they do not change its slope. If we also allow the slope of the cost curve to depend on the control variables, its equation is given by

$$MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}, \tag{7}$$

and the error function becomes

$$g_{i,t} = y^*_{i,t} - a - bx^*_{i,t} - \sum_{c \in C} \delta_c c_{i,t} - \sum_{c \in C} \theta_c c_{i,t} x_{i,t}. \tag{8}$$

In this setting, since we have to identify the coefficient on $x_{i,t}$ as well as the coefficients on $c_{i,t}x_{i,t}$ for each $c \in C$, we construct additional instruments by taking the product of $A_{i,t}$

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

and each of the control variables. As we argue later in the paper, separately identifying and interpreting intercept and slope effects can be challenging. We therefore also consider the case where the intercept is fixed across firms and only the slope is allowed to vary, conditional on the cost variables C. In this case the equation of the marginal cost curve is given by:

$$MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}, \tag{9}$$

and the error function is given by

$$g_{i,t} = y^*_{i,t} - a - bx^*_{i,t} - \sum_{c \in C} \theta_c c_{i,t} x_{i,t}. \tag{10}$$

2.2 Alternative Specifications

In the GMM framework above, we use the variation in the area under the marginal benefit curve, $A_{i,t}$, as our main identifying instrument. We consider four additional identification specifications, (ii) through (v). As before, the error functions are defined according to equations 6 and 10 where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value and C is the set of cost control variables. GMM moments are obtained by interacting the error function with the constant term, each of the control variables, and the following identifying instruments:

(i) the area under the marginal benefit curve, $A_{i,t}$,

(ii) corporate tax rates from the eleven tax brackets that span all tax rates and income brackets during our sample period,

(iii) the area under the marginal benefit curve, $A_{i,t}$, along with the interest expense over book value associated with the kink in the marginal benefits curve, $x^K_{i,t}$,

(iv) the area under the marginal benefit curve up to 700% of the observed interest expense over book value, $A^{700}_{i,t}$, and

(v) the corporate tax rates from eleven tax brackets across time, plus firm fixed effects.

We report estimates for all five specifications in Section 4 and show that our estimation results are similar and consistent across specifications. We discuss each of these specifications below.

2.2.1 Specification (ii): Tax regime shifts

In our main specification (i), the instrument is the area under the marginal benefits curve, $A_{i,t}$, purged from cost effects, C. Although we believe that the approach controls for the most important cost effects in the capital structure literature, there is no way to ensure that all relevant cost control variables are included. Failing to include an important cost control variable could lead to an omitted variables bias.

To rigorously address this issue, we repeat our analysis using as the identifying instrument the corporate tax regime shifts over the period 1980 to 2005. The tax regime shifts provide a natural experiment in that these shifts should mainly be correlated with the benefit function and not with the cost function.

Tax regime changes can alter both statutory corporate tax rates as well as the income level applicable to each tax bracket. To incorporate both shifts, we create eleven non-overlapping brackets that span all income/tax rate combinations during our sample period.[4] For example, in 1980 the lowest tax bracket is from $0 to $25,000, but changes to $0 to $50,000 in 1988. This results in two brackets in every year: one from $0 to $25,000 and one from $25,000 to $50,000. The tax rates for all eleven income brackets are listed in Appendix B.

Using time variation in the tax regime provides an arguably pristine way of estimating the marginal cost curve. The disadvantage is that this approach uses much less information to uncover the marginal cost curve of debt than does our primary approach, which is based on both time series and cross section variation. In particular, it does not use the cross-sectional variation in marginal benefit curves. Recall that a strong advantage of our data set is that we "observe" the *whole* marginal benefit curve of debt, and not just the equilibrium points where the marginal cost and marginal benefit curves intersect. When we only use the tax regime shifts, this advantage is not exploited. Moreover, for periods in which there are no tax regime shifts, such as 1998 to 2005, using only time series tax regimes is infeasible.

2.2.2 Specification (iii): The kink in the marginal benefit curve

Thus far, we have used the area measure, $A_{i,t}$, to summarize the variation in the marginal benefit curve of debt. If the marginal benefit curve was a simple line with a constant slope, summarizing the benefit variation would be an easy task because the y-intercept, or the x-intercept, of each function would suffice. However, not only is the functional form of the

[4] To eliminate the possibility that the results from the time series analysis are largely driven by the rate shifts in the lower tax brackets, the entire analysis is repeated using only the top three tax brackets. The results are similar to the results using all eleven brackets.

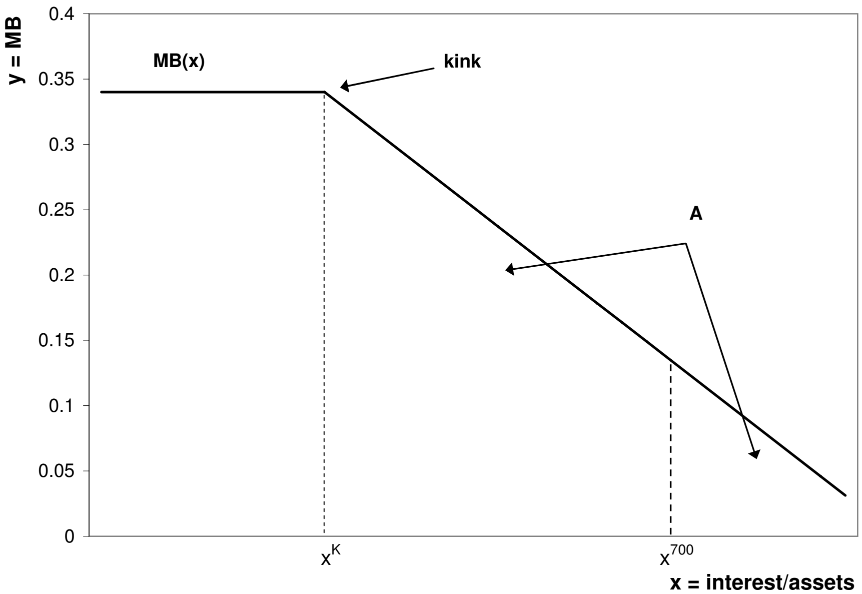

Figure 3: The kink of a marginal benefit curve is the point at which the curve begins to slope downwards. The interest expense over book assets ratio associated with the kink in the benefit curve is denoted x^K. A is the area under the entire marginal benefit curve extending out to 1000% of the observed interest expense over book assets, x^*. A^{700} is the area under the marginal benefit curve up to x^{700}, which is 700% of x^*.

benefit curves non-linear, the shape is potentially different for each firm for each year. In other words, the variation of the marginal benefit curves is caused by more than just parallel shifts. As a consequence, the challenge is to summarize this changing functional form of the benefit curve, which, in our main specification, we achieve through the area measure.

To more fully represent the various possible shapes of the marginal benefit function, in an alternative specification, in addition to the area measure, $A_{i,t}$, we include the amount of interest expense over book assets associated with the kink in the marginal benefit curve, $x^K_{i,t}$, as an instrument. We use the term 'kink' to indicate the point at which the marginal benefit curve begins to slope downward.[5] This allows us to address the possibility that two firms with different benefit curves may have the same $A_{i,t}$ due to one benefit curve pivoting around the second curve. Figure 3 illustrates the notion of a kink.

2.2.3 Specification (iv): The area under the marginal benefit curve up to 700%

In our main specification, $A_{i,t}$ is the area under the entire marginal benefit curve, which extends out to 1000% of the observed interest over assets, $x^*_{i,t}$. One could argue that the marginal benefit curve, is more precisely estimated for values closer to $x^*_{i,t}$. As such, we

[5] A marginal benefit curve may have several kinks. We use the first kink.

repeat our analysis using the area under the marginal benefit curve up to 700% of $x^*_{i,t}$, instead of 1000%, as our identifying instrument.

2.2.4 Specification (v): Tax regime shifts with fixed effects

Finally, we repeat the analysis using firm fixed effects. We focus on specification (ii) with firm fixed effects as we believe this is the cleanest test of our analysis. The tax regime shifts are arguably the cleanest instruments, and controlling for fixed effects ensures that no unmodeled firm-specific effect clouds the interpretation of the estimated marginal cost curve.

3 Data and Summary Statistics

3.1 Marginal Tax Benefit Curves

Our marginal benefit curves are derived as in Graham (2000). Each point on these benefit functions 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, 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 of the tax code, 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, for a loss firm that will soon become profitable, an extra dollar of interest today effectively shields income next year, and saves the firm $0.35 one year from today. Therefore, 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 interest deductions, the benefit function is sloped downward, reaching zero more 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. Therefore, we simulate tax benefit functions so that the tax benefit of interest deductions at any given point is conditional on the probability that the firm will be taxable.

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 income and 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., in 2005, tax losses can be carried forward 20 years into the future, so we forecast 20 years into the future when simulating the 2005 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. 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 and carryforward features of the tax code. The fourth step adds $1 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 an extra dollar 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 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 the entire process 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, 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 2005. The benefit functions in this panel vary across firms. They can also vary through time for a given firm as the tax code or a firm's circumstances change.

3.2 Corporate Financial Statement Data

We obtain corporate financial statement data from Standard & Poor's COMPUSTAT database from 1980 to 2005. Merging the tax benefit functions with COMPUSTAT based on the eight digit firm CUSIP leaves 122,832 firm-year observations.[6] For each firm, we create empirical measures of the control variables described in the previous section, which includes log of total book assets (LTA), plant, property and equipment over total book assets (PPE), book equity to market equity (BTM), an indicator for a dividend paying firm (DDIV), cash flow over total book assets (CF), and cash holdings over total book assets (CASH). We measure financial distress by Altman's (1968) Z-score (ZSCORE). Firms are conservatively defined to be non-distressed if they have Z-scores above the median. We measure financial constraint according to four definitions offered in the literature: (i) firms with no or limited long term leverage adjustments (LTDEIR), (ii) the Kaplan and Zingales (1997) index (KZ), (iii) the Cleary (1999) index (CL), and (iv) the Whited and Wu (2005) index (WW). We discuss the four measures in the next subsection and Section 7. Appendix C provides a detailed description of the construction of each variable.

We normalize equilibrium interest expense by total book assets, which hereafter we refer to as interest-over-book (IOB). Note that PPE, CF, and CASH are normalized by total book assets. For the construction of LTA, we chain total book assets to 2000 dollars to adjust for

[6]To avoid issues involving changes in firm CUSIP through time, we track firms through time using COMPUSTAT's GVKEY variable, which was created for this purpose. However, merging by firm CUSIP *within* each year is not be affected by this issue.

inflation before taking logarithms. We further remove all firms with non-positive book values, common equity, capital, and sales, or negative 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. Within our framework these firms can be considered as potentially being "out of equilibrium." Further, we remove firms that were involved in substantial M&A activity, defined as acquisitions amounting to over 15 percent of firm total assets. Finally, we remove outliers defined as firm-year observations that are in the first and 99th percentile tails for (i) the area under the marginal benefits curve (A), (ii) the observed interest-over-book (IOB) expenses (x^*), (iii) the book to market ratio (BTM), (iv) the cashflow over assets ratio (CF), (v) the cash over assets ratio (CASH), (vi) the personal tax penalty on interest (PTP) as measured in Graham (1999), (vii) the financial distress measure (ZSCORE), and (viii) the four financial constraint measures (LTDEIR, KZ, CL, and WW). [7] This results in a sample of 87,451 firm-years. Table 1 provides an overview of the sample construction. Table 2 provides summary statistics.

3.3 Financial Constraints Measures

One important assumption underlying our framework is that firms are able and willing to adjust capital structure. If firms are not able to adjust their capital structures because they are financially constrained or financially distressed (i.e., out of equilibrium) they should be excluded from our estimation procedure. Moreover, recent research on dynamic capital structure highlights that firms may not continuously adjust their leverage ratios due to non-negligible adjustment costs (Leary and Roberts, 2005; Kurshev and Strebulaev, 2006; etc.). Therefore, when a firm does not adjust capital structure it is not clear whether the firm is acting optimally, is acting passively due to adjustment costs, or is acting suboptimally due to being constrained in financial markets. Conversely, if a company makes a (substantial) capital structure adjustment, we can deduce that transactions costs were not sufficient to prevent capital structure adjustments.

To address these issues, we also perform our analysis for those firm-year observations in which a substantial capital structure adjustment takes place, i.e., those firm-year observations in which there is substantial long term debt and/or an equity issuance or repurchase (LTDEIR). In our sample the median levels of long term debt issuance and reduction among all firm-year observations are 6.8 and 3.2 percent of book value, respectively. These numbers increase to 16.0 and 9.0 percent, respectively, when we consider debt issuances and reductions

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

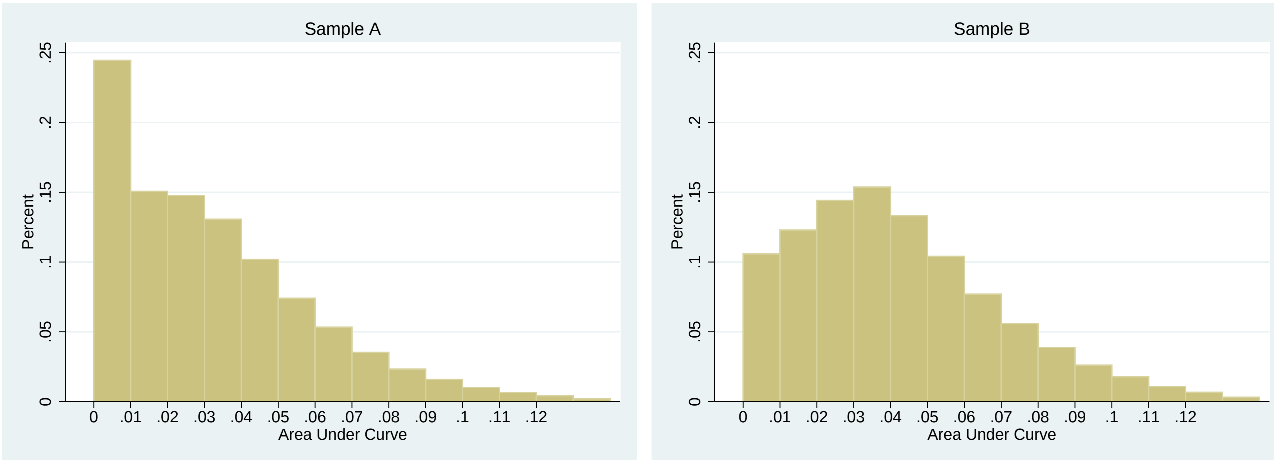

Figure 4: Histogram of the area under the curve. This figure shows the relative frequency distribution of the area under the marginal benefits curve for samples: A) all firms, B) non-distressed and unconstrained firms. Lower bins indicate firms with declining marginal benefits or constantly low marginal benefits. Higher bins indicate firms with consistently high marginal benefits.

above the 75th percentile. For equity issuances and repurchases, the medians are 0.7 and 0.9 percent, respectively, and 3.2 and 3.0 percent at the 75th percentile. We define a firm to be financially unconstrained if it has long term debt or equity adjustment (LTDEIR) above the median issuance or reduction. Even when we tighten the definition by including only firms above the 75th percentile, our main results do not change.

3.4 Data Description of the Subsamples

We perform our empirical analysis on two subsets of our primary sample. The first sample includes all firms with non-missing $A_{i,t}$, $x^*_{i,t}$, and $C_{i,t}$. The second sample is obtained using two criteria. The first criterion is based on the firms' degree of financial distress, which we measure by ZSCORE. The second criterion is based on the firms' long term debt and equity issuance and repurchases (LTDEIR). As explained earlier, the amount of LTDEIR reflects the firm's ability to adjust its capital structure and can be interpreted as a measure of financial constraint. The two samples are then given by:

A : All firms with non-missing $A_{i,t}$, $x^*_{i,t}$, and $C_{i,t}$

B : Financially non-distressed and unconstrained firms: ZSCORE above median and LTDEIR above median

The analysis of non-distressed and unconstrained firms helps to highlight those firms that can 'freely' optimize their capital structure. Because we assume in our estimation procedure that, on average, the cost curve of debt intersects the marginal benefit curve at the actual level of debt, our estimation is most accurate for those firms that have the flexibility to actively optimize over the amount of debt. If the firm is constrained, it may be (temporarily) "out of equilibrium." Figure 4 plots the histograms of the area under the marginal benefits curve for each subsample. The majority of the firms have areas under the marginal benefit curve that are less than 5 percent of book value in a single year.[8] Firms with small areas have benefit functions that are either relatively flat at low benefit levels, or that are initially high but steeply downward sloping. Firms in the 0.05 and above bin (firms with benefits of 5 percent of book value or higher in a single year, or potentially 51 percent in gross benefits or higher in perpetuity) are typically firms that have constant marginal tax rates at the highest tax rate. These are firms we would expect to load heavily on debt in equilibrium unless their marginal cost curve is especially steep. As we move from Sample A to Sample B, the distribution of the area under the marginal benefits curve shifts to the right. This indicates that the firms in Sample B tend to be more profitable and thus have higher total potential benefits to debt through interest deductions. Table 2 compares the summary statistics for these samples.

In addition to estimating by subsamples, we also estimate the marginal cost curve by industry to explore industry effects. We base our industries on the 2-digit SIC codes. Appendix D lists our industry definitions in detail.

4 Results

As described in Section 2, we estimate the marginal cost curve for five main specifications, differing in their identifying instrument(s): (i) using $A_{i,t}$, (ii) using tax regime shifts, (iii) using $A_{i,t}$ and $x^K_{i,t}$, (iv) using $A^{700}_{i,t}$, and (v) using tax regime shifts but including firm fixed effects in the regression. Tables 3 and 4 report the results for samples A and B, respectively, for all five specifications. We get similar regression results for both the slope of the marginal cost curve and the intercept on the cost curve in both samples. For sample B, the firms that are not distressed or constrained, the slope of the marginal cost curve ranges from 4.253 to 5.742 and the intercept ranges from 0.144 to 0.197. Further, the signs and magnitudes of the coefficients of the cost control variables are consistent across samples and specifications. This indicates that it does not seem to matter whether we identify the cost curve based on cross-sectional variation of the benefits, time series variation, or a combination of the two. We consider this to be a strong corroboration of our findings.

[8] Note that this reflects the potential gross tax benefit of debt. The actual gross benefit is measured at the observed debt levels which is on average 0.9% of book value for a single year, which corresponds to 9.1% of book value in perpetuity.

4.1 Marginal Cost Curves with Fixed Intercept

The estimated coefficients in equation 9 for all firms except those in utilities, finance, and public administration for samples A and B are reported in the left panel of Table 3 and Table 4, respectively.[9] All control variables are standardized (i.e., have mean zero and standard deviation of one within sample A) so that the coefficients have a one standard deviation interpretation. These estimates allow the slope of the marginal cost curve to depend on the control variables, but assume that the intercept is the same for all firms. (We allow for intercept variation in the next section.) The slope of the marginal cost curve determines the convexity of the total cost curve and measures the increase in marginal cost that results from a one-unit increase in the interest-over-book ratio. When the intercept of the marginal cost curve is fixed, a larger slope on the marginal cost curve implies higher marginal cost for all values of leverage. Note that the estimates for samples A and B are very similar, apart from a small difference in the intercept. Henceforth, we will focus on the results in sample B, purely for expositional reasons.

Within our framework, the capital structure decision follows from a tradeoff between the tax benefits of debt and the costs of debt. It is important to stress that, in our framework, the marginal benefit curve only measures the tax benefits of debt. As a consequence, the other benefits of debt, such as committing managers to operate efficiently (Jensen, 1984) and engaging lenders to monitor the firm (Jensen and Meckling, 1976), are included in our framework 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), personal taxes (Miller, 1977), debt overhang (Myers, 1977), agency conflicts between managers and investors or between different groups of investors, and any other cost that firms consider in their optimal debt choice.

We interpret the cost coefficients embedded in the cost of debt functions, and compare the implications from these coefficients to the capital structure regularities documented in the literature. For example, it has been documented that large firms with tangible assets and few growth options tend to use relatively large amounts of debt (Frank and Goyal, 2004). As we will show, the effects of individual cost variables on the cost of debt function are consistent with debt usage implications in the existing capital structure literature, which we find reassuring. There are a great many unanswered questions in the capital structure literature in terms of interpreting individual coefficients, and by no means do we believe that our procedure solves all these questions. Rather, our procedure quantifies just how large the

[9] Firms in utilities, finance, and public administration tend to be heavily regulated. Excluding these industries is common practice in capital structure analysis.

Control Variable	Cost of Debt	Leverage
LTA	+	+/-
PPE	−	+
BTM	−	+
DDIV	+	−
CF	+	−
CASH	+	−

Table A: The influence of each of the control variables on (i) the cost of debt following from Tables 3 and 4, and (ii) the leverage of the firm, as documented in the literature.

influence of individual variables must be on the cost of debt to explain observed capital structure choices. Table A summarizes the effect of the control variables on the cost of debt function, and summarizes the standard capital structure result (as presented in Frank and Goyal (2004) among others).

The average firm has a cost curve of debt with an estimated slope of 5.126. That is, when we set all the control variables to their mean values (of zero since they are standardized), the estimated slope of the marginal cost curve of debt equals 5.126. In other words, on average, increasing the interest-over-book value (IOB) by one percent increases the marginal cost of debt by 5.126 percent of book value. For example, suppose that the IOB changes from 0.02 to 0.03, then the marginal cost of taking on an additional dollar of debt has increased by 5.126 cents per dollar. The firm will find it optimal to increase interest-over-book until the marginal cost of an additional dollar of debt equals the marginal benefit of debt, which, if interest is fully deductible equals around 35 cents per dollar.

The 0.491 coefficient on LTA indicates that large firms face a higher cost of debt. All else equal, a firm that has a LTA value one standard deviation higher than the average faces a slope of 5.617 as opposed to 5.126. This result is somewhat surprising because it implies that large firms face hgher costs of debt, but is consistent with recent research that indicates that large firms use less debt (Faulkender and Petersen, 2004; Kurshev and Strebulaev, 2006). Other research (as summarized in Frank and Goyal, 2004) documents a positive relation between size and debt usage. In Table 5 we see that there is no significant relationship between firm size and the benefits of debt. That is, controlling for PPE, BTM, DDIV, CF, and CASH, large firms are just as likely to have large IOBs as small IOBs. Therefore, the net effect of size on the use of debt depends on whether the cost or benefit effect dominates.[10]

[10] For recent work on the relation between size and capital structure, see Kurshev and Strebulaev (2006). They argue that fixed costs of external financing lead to infrequent restructuring and create a wedge between small and large firms. Small firms choose higher leverage at the moment of refinancing to compensate for

The differing firm size implications documented in various capital structure papers imply that the influences of size on the costs versus benefits of debt dominate in different settings and samples. Figure 5 illustrates how a one standard deviation increase of the LTA (high LTA) and a one standard deviation decrease of the LTA (low LTA) pivot the marginal cost curve.

For PPE, the coefficient equals -0.471 (note that PPE is normalized by the book value of assets), so high PPE firms have a larger cost of debt. All else equal, a firm that has a PPE value one standard deviation higher than the average faces a slope of 4.655 as opposed to 5.126. This is consistent with the common finding that high PPE leads to increased use of debt (see Table A).

Firms with growth opportunities (i.e., a low book-to-market (BTM)) on average face a higher cost of debt (coefficient of -0.291). 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.

Dividend paying firms (DDIV) face a higher cost of debt, as indicated by the 0.899 coefficient on Table 4. All else equal, committing to pay dividends reduces the availability of cash flows to service debt, given the extreme stickiness of dividend payments (e.g., Brav et al., 2005), thereby increasing debt costs. This result and interpretation are consistent with the negative relation between dividend-paying status and debt ratios documented in Frank and Goyal (2004) and elsewhere (see Table A).[11]

Debt choices by firms with large cash holdings (CASH) and cash flows (CF) imply that these firms face a higher cost of debt, with coefficient estimates of 1.560 and 1.835, respectively. Firms with large cash holdings may be firms that know they have high costs of debt and so in equilibrium hold large amounts of cash to avoid external financing. Similarly, profitable (high CF) firms may have no need for debt as they are able to fund their projects internally. Both results are consistent with the pecking order theory of using internal financing before external financing.

Finally, it is important to note that we measure the cost of debt as perceived by the firm

less frequent rebalancing.

[11] There is also a pecking-order interpretation of the positive relation between dividend-paying status and the cost of debt. For companies that are on the margin between issuing either debt or equity (like Sample B, by construction), those that pay dividends may have lower information asymmetry costs and therefore use relatively more equity (and less debt). Therefore, the positive coefficient on dividends might indicate that, relative to equity, debt is less attractive in dividend-paying firms.

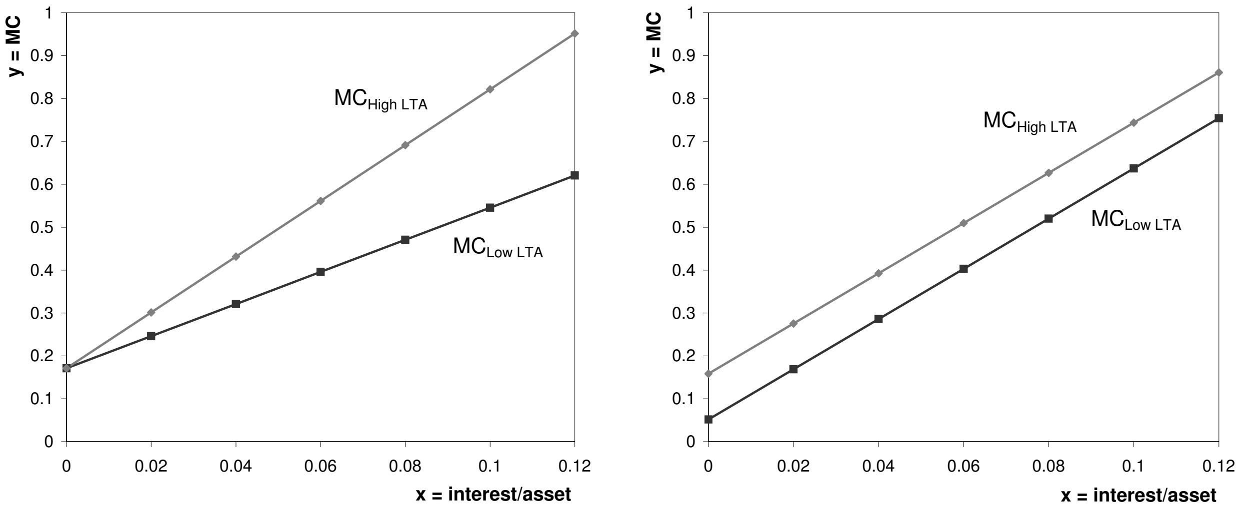

Figure 5: Comparing marginal cost curves for high and low asset size (LTA) firms. a) The left panel shows the effect of a one standard deviation increase (decrease) in LTA on a marginal cost curve with a fixed intercept and varying slope. b) The right panel shows the effect of a one standard deviation increase (decrease) in LTA on a marginal cost curve with a fixed slope and varying intercept.

and therefore reflected in its chosen debt policy. This cost of debt could, but does not have to, coincide with the cost of debt perceived by debt markets.

4.2 Marginal Costs with Fixed Slope

In the previous section, we assumed that only the slope of the marginal cost curve depends on the control variables, but that these variables do not influence the intercept. Alternatively, we can assume that the slope of the marginal cost curve is fixed across firms but that the intercept is conditional on the control variables. The results are presented in the last four columns of Table 3 and Table 4, with qualitative results identical to the ones described in the previous section. That is, small, non-dividend paying firms with high collateralizable assets, few growth options, and low cash and cashflow make debt choices consistent with them facing a lower cost of debt. Note that in this case the interpretation of the coefficients of the control variables is different than before. Whereas previously a one standard deviation increase of a control variable pivot the cost curve around its y-intercept, now a one standard deviation leads to a parallel shift of the whole curve. Figure 5 illustrates how a one standard deviation increase (decrease) of the LTA implies a parallel upward (downward) shift of the marginal cost curve.

4.3 Marginal Costs with Varying Slopes and Intercepts

In the previous two sections, we assumed that either the intercept or the slope of the cost curve is the same for all firms. In this section, we explore the possibility that both the slope and the intercept vary with the control variables. In equation 7 we include the control variables and the interaction terms between the interest-over-book (IOB) and the control variables. Econometrically this is challenging because the information contained in our instruments may not be sufficient to separately identify the slope and intercept effects. Indeed our estimation results indicate that when we include the interaction terms, the statistical significance of our results decreases, specifically when we move from Sample A to Sample B and the sample size drops by almost two-thirds.

In addition, in this case, slope and intercept effects may offset each other. Only when the coefficient signs of a given control variable is the same for both the slope (interaction term) and the intercept is the resulting effect of that control variable on the marginal cost curve monotone. When the slope and intercept coefficients have opposite signs, the effect is ambiguous, leading to a higher cost curve in one region and potentially a lower cost curve in another (e.g., higher intercept but flatter slope). This is not surprising and can be understood in the following way. When we fix the intercept, as in section 4.1, variation in the control variables implies pivoting the marginal cost curve around the intercept point. When we fix the slope across all firms and only allow the intercept to vary with the control variables, as in section 4.2, changes in the control variables lead to parallel shifts of the cost curve. However if we let both the intercept and the slope vary, the procedure can pivot around some center point of the curve, making interpretation of the cost of debt more challenging.

4.4 Marginal Costs By Industry

The resulting coefficients from estimating equation 9 by industry are given in Table 6. These estimates allow the slope of the marginal cost curve to vary with the control variables while keeping the intercept fixed within an industry. The estimated coefficients are based on industries categorized by two-digit Standard Industry Classification (SIC) codes. The industry classification is documented in Appendix C. We find steep, positive, and highly significant slopes for the full sample as well as in each industry. The slope is particularly steep for utilities and flat for finance, insurance and real estate firms. At the same time, the intercept is particularly low for utilities and high for finance, insurance, and real estate.

4.5 Interpreting Recent Capital Structure Theories

In this section, we address recent research that explores the effect on the cost of debt function. In each of these cases, these theories suggest the inclusion of a control variable in our specification that either (i) has low data quality, (ii) has many missing values and hence would lead to a small sample size, or (iii) is redundant in the cross section or time series. Thus, they are not included in the main analysis discussed earlier. However, these examples illustrate that our framework can be used to analyze implications from various capital structure theories. After the tax benefits of debt have been accurately modeled, the estimated coefficients on the control variables in the cost curve can be used to assess the importance of various factors that affect capital structure decisions.

4.5.1 Personal tax penalty

Graham (1999) argues 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 over capital gains tax, they will demand a premium for holding debt, which is reflected in the cost of debt, deterring firms from using debt, all else equal. The paper shows that when empirically modeling debt ratios, a specification that adjusts for personal tax penalty statistically dominates specifications that do not. Following Graham's (1999) method of measuring personal tax penalty (PTP), we include this measure in our analysis as one of the cost control variables.

Table 7 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 high personal tax penalty do indeed face higher marginal costs of debt (0.936 for fixed intercept and varying slope and 0.036 for fixed slope and varying intercept). This is consistent with Graham's (1999) findings. However, the PTP measure is sensitive to outliers, so we exclude it from the main specification.

4.5.2 Wages

Recent work by Berk, Stanton and Zechner (2006) suggests that ex post the true costs of bankruptcy are born by the employees of the firm. As a consequence, the firm needs to compensate employees ex ante if it makes riskier capital structure decisions. If a firm wants to take on additional debt, part of the cost of debt will therefore be the higher wages that employees require as compensation for bankruptcy risk. The authors argue that employees self-select, implying that risk-averse employees will find employment with firms that take on low leverage. As a consequence, increasing leverage is more costly for firms with risk averse employees. The theory suggests that we should include wages per employee as a control variable in our analysis. We use log of labor expenses divided by number of employees (LWAGE) as our COMPUSTAT proxy for wages.

Table 7 shows the estimation results when log wages per employee (LWAGE) is included as a control variable. We find that although there is a positive coefficient (0.225) in the fixed intercept specification, the result is not statistically significant. In the fixed slope, varying intercept specification, the coefficient (-0.006) is neither statistically nor economically significant. This lack of statistical significance may be due to the large drop in the sample size due to the lack of wage data in COMPUSTAT (from 27,555 to 2,330).

4.5.3 Macroeconomic Influences

Chen (2006) and Almeida and Philippon (2006) propose that bankruptcies are concentrated in bad times, i.e., periods when consumers' 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 significant role in the time variation of the cost of debt from the viewpoint of financial markets. As noted before, the cost of debt as perceived by the firm could, but does not have to, coincide with the costs perceived by the markets.

Table 7 gives the results for the analysis when we include the Moody's Baa-Aaa spread (CS) as a control variable. When the spread is high, indicative of bad times with high volatility, we expect the cost of debt to be high. Thus, we expect a positive sign on our credit spread variable. We see that this is indeed true and the coefficient is significant.[12]

4.5.4 Asymmetric information

Finally, Myers' (1984) pecking order theory of capital structure suggests that it is costlier for firms with higher information asymmetry to issue equity over debt. Thus firms with higher information asymmetry should face a lower marginal cost of debt when deciding on external financing. On the other hand, these firms face higher costs of debt when deciding between internal financing and external debt despite tax benefits of debt, suggesting firms with high information asymmetry face higher cost of debt. Including a control variable that proxies for information asymmetry will allow us to estimate in our framework the effects of information asymmetry on the cost of debt. One quick proxy for information asymmetry

[12]Note that this analysis is infeasible when including year dummies.

is to use a dummy variable for whether the firm has a S&P credit rating (DCR).[13] Firms that have credit ratings have presumably less information asymmetry than firms that do not. Again Table 7 reports the coefficients for DCR. We see that firms with low information asymmetry have lower marginal costs of debt.

5 Using the Marginal Cost and Marginal Benefit Functions to Infer Optimal Capital Structure

Using the fixed intercept, varying slope results from Table 4, the marginal cost function as a function of the interest-over-book value (x) for any particular firm i at time t can be determined by:

$$\begin{aligned} MC(IOB) &= \alpha + \beta * IOB \\ \alpha &= 0.171 \\ \beta &= 5.126 + 0.491LTA - 0.471PPE - 0.291BTM + 0.899DDIV + 1.560CF + 1.835CASH \end{aligned} \tag{11}$$

and, when using the fixed slope, varying intercept results the curve is given by:

$$\begin{aligned} MC(IOB) &= \alpha + \beta * IOB \\ \alpha &= 0.105 + 0.019LTA - 0.018PPE - 0.020BTM + 0.039DDIV + 0.089CF + 0.058CASH \\ \beta &= 5.854 \end{aligned} \tag{12}$$

where each of the control variables is standardized based on Sample A to have a mean of zero and a standard deviation of one.[14] The mean and standard deviation for each of the control variables for Sample A is reported below:

	LTA	PPE	BTM	DDIV	CF	CASH
Mean	5.156	0.329	0.782	0.419	0.087	0.133
Std. Dev.	2.368	0.255	0.638	0.493	0.147	0.180

Note that these statistics differ slightly from Table 2 since we exclude firms in utilities, finance, and public administration in the estimated coefficients shown in equations 11 and 12.

[13]Ideally, we should use actual S&P ratings to test not only for information asymmetry, but also quality of firm, but we are limited in sample size from either lack of data on COMPUSTAT or low number of firms with S&P ratings.

[14]The control variables are not re-standardized by sample to prevent selection bias when analyzing across samples.

5.1 Case Studies of Optimal Debt Usage

Once the cost and benefit functions have been estimated, they can be used to draw inference on optimal capital structure. We illustrate with four specific cases. The following four firms are chosen based on name recognition and span of industries: i) A.C. Moore, in the retail industry, ii) Coca Cola, in the wholesale industry, iii) Verizon, in the telecommunications industry, and iv) Southwest Gas, in the utilities industry. Note that although we did not include Southwest Gas in the estimation of the cost curve since it is an utility firm, we can compute a cost curve for it. Figure 6 displays the marginal benefit and marginal cost curves for these four firms. The marginal cost curve is derived using equation 11.[15] We see that each of these firms is indeed close to its 'equilibrium', i.e., the marginal cost curve and the marginal benefit curves intersect close to the actual amount of debt the firm employs. (Verizon is somewhat underlevered in 2005.)

Figure 7 follows the observed and equilibrium IOB of the four firms from 2001 to 2005. We see that A.C. Moore was overlevered in 2001, but by 2005 its observed and equilibrium amounts of leverage have converged. This appears to be the case for Southwest Gas as well.[16] The observed and equilibrium IOB for Coca Cola have been consistently close during this period. Verizon, on the other hand, was in equilibrium in 2001, but by 2005, appears to be underlevered, also depicted in Figure 6.

Table 9 compares the decile rankings of specific financial ratios for the four firms from 2001 to 2005. All four firms differ substantially in terms of decile ranking for financial measures.

A.C. Moore is the smallest of the four firms in terms of both book value and market capitalization with medium collateralizability, high growth opportunities, no dividend payments, high cash holdings, and relatively high cashflows and sales. The firm's high growth potential, large cash holdings, and high cash flows indicate that it should be conservative in its debt usage. Indeed we see that the firm decreased its interest (over book asset) expenses from 2001 to 2004, moving its actual leverage closer to our model recommendation. However, by 2005, A.C. Moore's book to market ratio more than doubled. Together with its lack of dividend obligations, this should make the firm more favorable towards debt, which is consistent with its observed increase of debt usage.

Coca Cola, being a large, established company, has relatively stable financials over the 2001 to 2005 period. With moderate plants, property and equipment (collateral), low

[15]The qualitative results are similar when we fix the slope and let the intercept vary with the control variables.

[16]The 2002 equilibrium IOB for Southwest Gas is missing due to missing marginal benefit curve data.

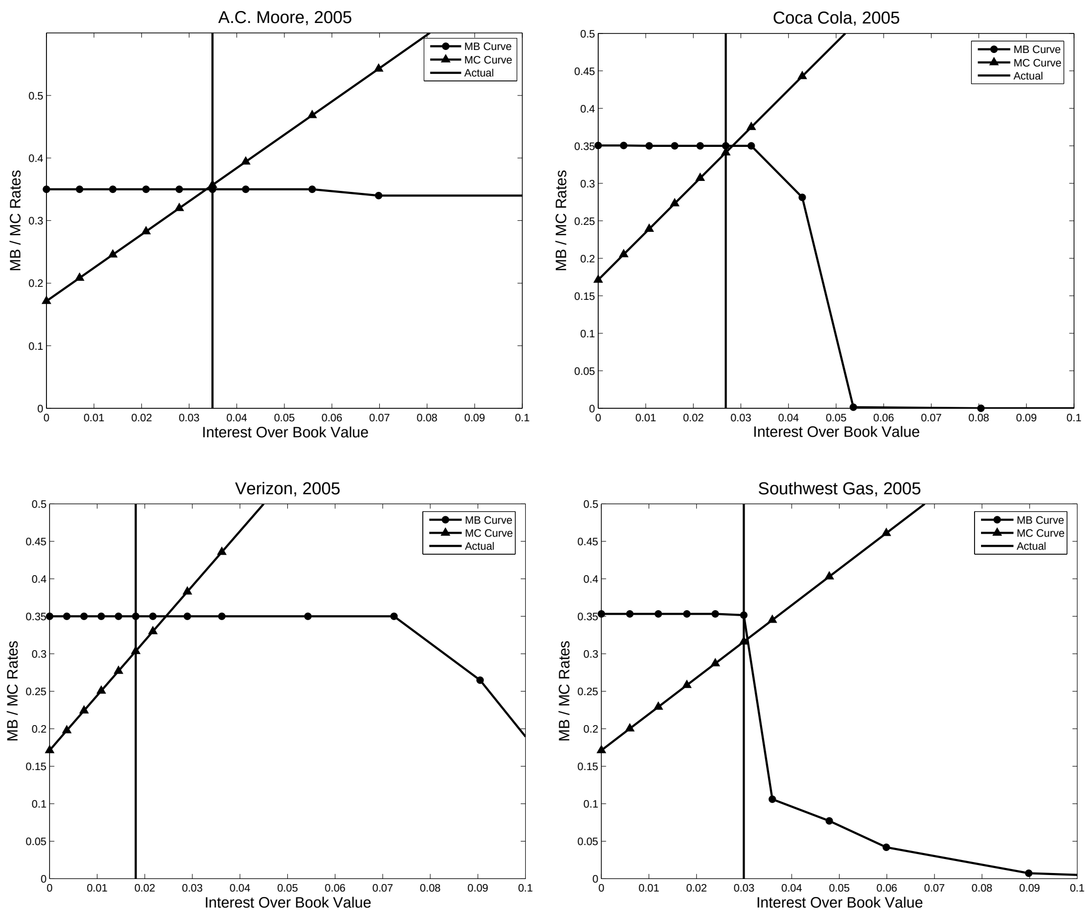

Figure 6: Marginal benefit and marginal cost curves for i) A.C. Moore, ii) Coca Cola, iii) Verizon, and iv) Southwest Gas. The vertical line reflects the actual debt in terms of interest of book value observed empirically.

dividend payments, low cash holdings and moderate cash flows and sales, we expect Coca Cola to maintain moderate debt usage overall. Alternatively, based on its increasing book to market ratio, we expect the company to take on more leverage in the latter years of this period. As the financials indicate, our equilibrium IOBs are relatively stable from 2001 to 2005 with a dip in 2003 and then increasing from 2003 to 2005. The firm's actual IOB, which starts slightly higher than our model prediction in 2001, decreases until it converges to its 'equilibrium'.

Verizon, however, diverges from the capital structure implied by the estimated marginal cost curve over this period. Being a large and established company, Verizon has stable financials with large amounts of plant, property, and equipment, low cash holdings and sales, and moderate cashflows. The increase in Verizon's book to market ratio appears to be offset by the increase in dividend payments resulting in a relatively constant implied optimal

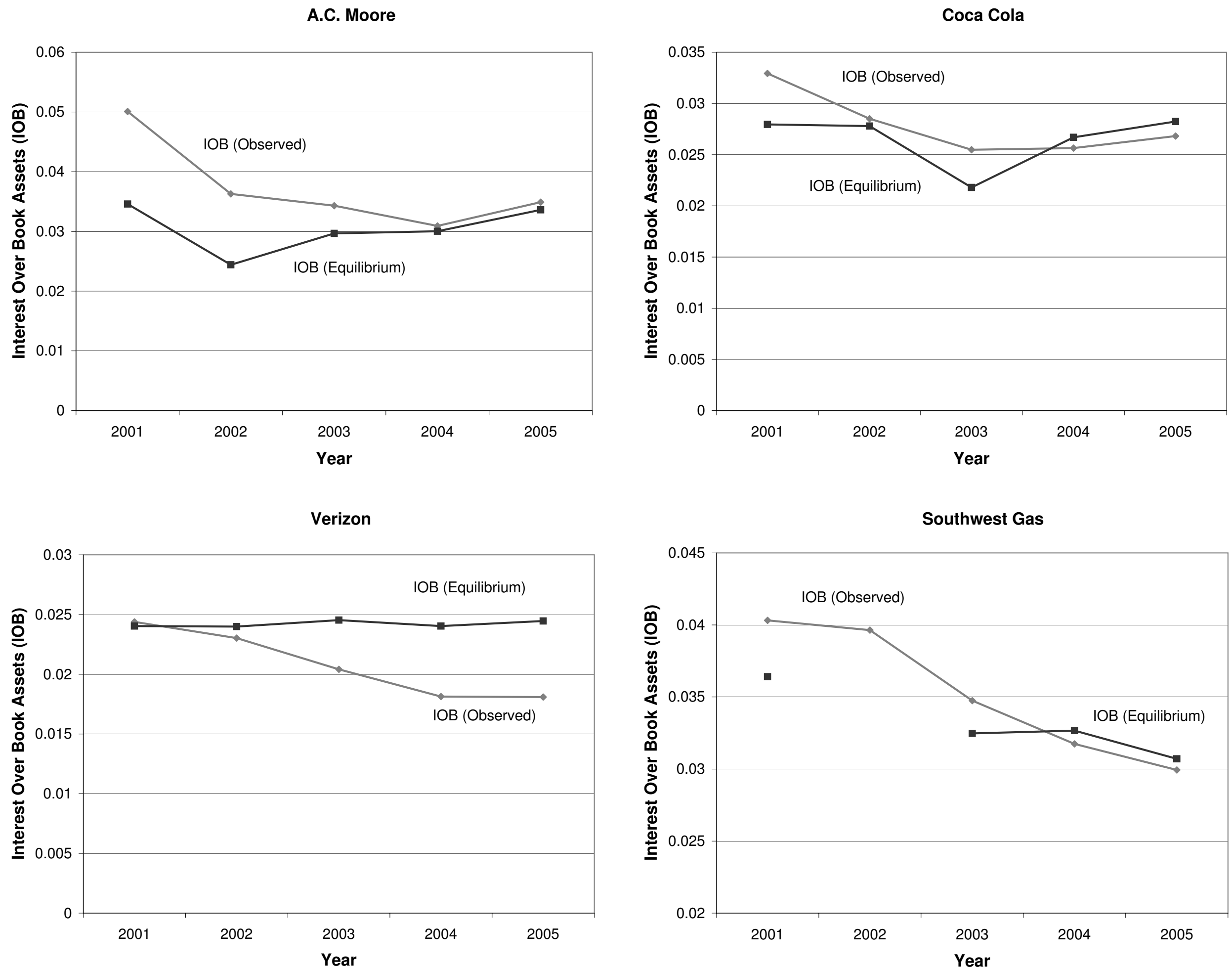

Figure 7: Observed (actual) and equilibrium (based on equation 11) interest over book value from 2001 to 2005 for i) A.C. Moore, ii) Coca Cola, iii) Verizon, and iv) Southwest Gas.

debt ratio. However, in reality, Verizon decreased its interest expenses relative to its book value over the 2001 to 2005 period, becoming underlevered.

Finally, Southwest Gas, a natural gas company, is a medium sized company with high collaterizability, high book-to-market ratio, relatively high dividend obligations, low cash, and moderate cashflows and sales. Being a utility company, Southwest Gas is not included in the estimation of the cost curve coefficients. Therefore, in principle, it is unclear how well our model represents this firm's capital structure behavior. However, it is reassuring to see the observed leverage of Southwest Gas converging to our prescribed equilibrium. In fact, from 2004 to 2005, both the actual and recommended interest expenses move not only in the same direction, but parallel.

These cases illustrate that our analysis can be used not only to interpret capital structure theories, but also to provide a benchmark against which companies can compare their capital structure decisions. Our analysis identifies the intersection of each firm's marginal benefit and marginal cost curves, where the costs are inferred from the debt choices made by firms with similar characteristics, as reflected in the estimated marginal cost curve.

6 Quantifying the Costs and Benefits of Debt

As seen in Section 5, using both the marginal benefit and marginal cost functions, we can compute the 'optimal' or 'equilibrium' IOB for a firm as the value for the interest over book value where the two curves intersect. This allows us to infer whether a firm is over or underlevered. We quantify over and underleverage as follows.

First, for each firm, we normalize the current interest-over-book value (IOB) to one. In other words, a firm is at 100% of its observed IOB. The 'equilibrium' level of IOB, described above, is then normalized by the observed level, i.e., 'equilibrium' capital structure is expressed as a proportion of the observed. For example, a firm that has an equilibrium factor of 0.8 should, according to our model, should optimally have 80% of its actual IOB. That is the firm should reduce leverage until the equilibrium to observed proportion equals to 1.0. Suppose the normalized equilibrium level of debt equals e, then the percentages of underleverage and overleverage are given by:

$$\text{Underleverage} = 1 - 1/e \text{ when } e > 1, and \tag{13}$$

$$\text{Overleverage} = 1/e - 1 \text{ when } e < 1. \tag{14}$$

Proceeding with our example of a firm with an equilibrium factor of 0.8, this implies this firm is overleveraged by 25%. We can also say this firm is 25% "out of equilibrium." Equipped with these definitions, we can use our benefit and cost functions to quantify the gross and net benefits of debt and the costs of being "out of equilibrium." Note that we use the statement in a relative sense: we refer to the firms as overlevered (underlevered) if the observed debt usage is too high (low) "relative to the optimum implied by the coefficients of our empirical model."

6.1 Gross and Net Benefits of Debt

The observed (equilibrium) gross benefits of debt, GBD_o (GBD_e), is the area under the marginal benefits 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 difference between the gross benefit of debt and the cost of debt.

Tables 10 and 11 report the unconditional and conditional summary statistics for the gross benefit, cost, and net benefit of debt for all firms in our sample for which we have marginal benefit and cost curves. Note that this includes constrained and distressed firms that we excluded in our estimation of equations 11 and 12. Values are reported for firms both at the observed level of interest-over-book values (IOB) as well as at the equilibrium implied by equations 11 and 12. Note that all values are are reported as percentages of book value in perpetuity.[17] We see that although the average gross benefits of debt are similar for observed debt levels and equilibrium debt levels, the costs of debt are lower at the equilibrium levels. This results in a higher net benefit of debt for firms at the equilibrium implied by our analysis, relative to their observed levels. On average, the net benefit of debt at the implied equilibrium is 2.8% of book value in perpetuity, and 0.0% of book value in perpetuity at observed debt levels. This result is consistent for both over and underlevered firms. The difference between the equilibrium and observed net benefits increases as firms move further out of equilibrium and is on average 5.76% of firm value for firms that are further than 80% or more from the equilibrium. This result is not driven by the distressed and constrained firms in the sample. Figures 8a and 8b show histograms of the gross benefit of debt and cost of debt percentiles. Figure 8c shows the observed gross benefit of debt and observed net benefit of debt over our sample period of 1980 to 2005. The annual one year treasury bill rate is included for reference. Figure 8d compares the observed net benefit of debt against the equilibrium net benefit of debt.

6.2 Cost of Being Underlevered or Overlevered

Our analysis allows us to answer the question: how costly is it for firms to be out of equilibrium? The cost of being 'overlevered' can provide insights on the potential cost of financial distress, while the cost of being 'underlevered' can shed light on the cost of financial constraints or managerial conservation. Figure 8e shows the observed and equilibrium net benefits of debt for over and underlevered firms. We can see that the net benefits of debt plummet for firms more than 80% overlevered, while the net benefits of debt stay positive for underlevered firms.

Figure 9 illustrates how we estimate the cost of being overlevered. The cost of being overlevered, DW_o, is the loss due to additional costs from having interest over book value

[17] For example, a gross benefit of 5% means 5% of book value in perpetuity.

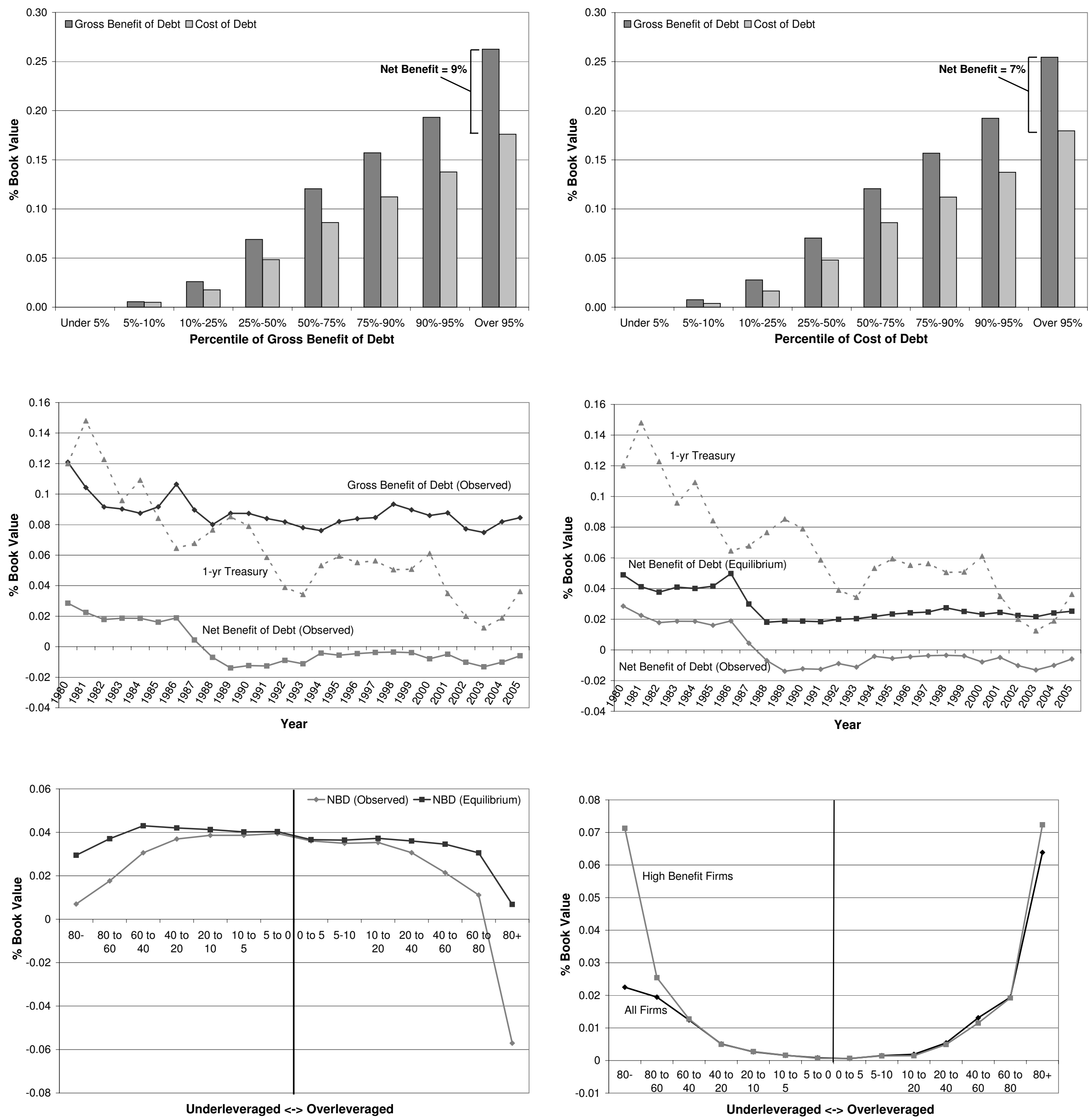

Figure 8: a) Histogram based on observed gross benefit of debt percentiles with paired cost of debt observations, b) histogram based on observed cost of debt percentiles with paired gross benefit of debt observations, c) observed gross benefit of debt and observed net benefit of debt over sample period 1980 to 2005, d) observed net benefit of debt and equilibrium net benefit of debt, e) observed and equilibrium net benefit of debt for under and overlevered firms, f) Cost of being out of equilibrium for under and overlevered firms.

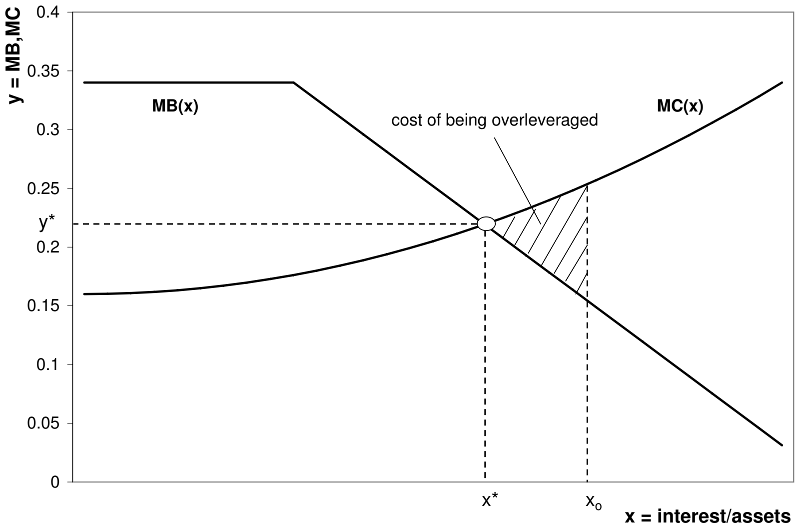

Figure 9: The costs of being overleveraged. The figure shows the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, and the equilibrium level of debt, x^*, where marginal cost and marginal benefit are equated. The marginal benefit level at x^* (which equals the cost level at x^*) is denoted by y^*. The actual level of debt, denoted by x_o, exceeds the equilibrium level of debt x^*. The shaded area indicates the deadweight loss of being over-leveraged.

(IOB) above the equilibrium. This is because overlevered firms pay higher costs relative to the benefits received. At the other extreme, the cost of being underlevered, DW$_u$, is the deadweight loss from lower benefits due to having IOB below the equilibrium; the deadweight loss comes from leaving money on the table in the form of unused benefits relative to cost of debt. The cost of being out of equilibrium, DW$_t$, combines DW$_o$ and DW$_u$ into one measure.

Tables 10 and 11 also report the costs of being "out of equilibrium," the values of the deadweight losses mentioned above. Table 10 show that on average the cost of being out of equilibrium is 2.4-2.8% of book value in perpetuity. However, we see that the costs for overleveraged firms (on average, 3.6-4.3% of book value in perpetuity) are much higher than those for underleveraged firms (on average, 1.1-1.3% of book value in perpetuity). This suggests that it is much more costly for firms to be overleveraged than underleveraged. Figure 8f graphs the cost of deviating from the equilibrium implied by the marginal cost curves in equation 11. We can see the asymmetry between underleveraging and overleveraging on average for all firms with the cost of being overlevered much higher than the cost of being underlevered. However, if we focus solely on firms with high benefits, defined as firms with gross benefits in the top quartile, the asymmetry disappears. This is intuitive as the more potential gross benefits to debt a firm has, the more it costs the firm to underlever. However, since this applies only to firms with high benefits, it does not eliminate the result that it is more costly to have too much debt relative to too little debt.

Table 11, panel A shows that, sensibly, costs of being out of equilibrium increase as firms move further away from the equilibrium. At the extreme, for firms that are more than 80% away from the equilibrium, the cost of being overlevered is, on average, 6.4% of book value in perpetuity compared to the firms on the opposite end with the cost of being underlevered equalling 2.2% of book value in perpetuity. Furthermore, we see that a vast majority of overlevered firm are more than 80% away from the equilibrium. This suggests that deadweight costs of being out of equilibrium have a heavy impact. Again this asymmetry in the costs of being out of equilibrium is not driven by distressed firms or constrained firms. Table 11, panel B looks at firms with equilibrium within a certain percentage of their actual (observed). Again we identify an asymmetry in the costs of being away from the equilibrium.

Finally, Table 12 asks the hypothetical question: what are the costs of being under or overlevered if a firm currently in equilibrium actually had only 20% of what it should? 40%? and so on? We see that even here, the asymmetry still persists. This gives insight as to why firms might be conservative in their debt usage (Graham, 2000). If a firm is incorrect in the analysis of its optimal capital structure, it is less costly to err on the side of having too little debt than too much debt.

7 Robustness checks

7.1 Alternative financial constraint measures

As discussed previously, our estimation procedure depends on the assumption that, on average, firms optimize their capital structure decisions. In this section we explore how excluding firms based on a variety of financial constraint or financial distress measures affects our results. Previously, we used long-term debt issuance or reduction as a measure of financial constraint. As additional robustness checks, we also identify unconstrained firms based on (i) the financial constraints measure derived by Kaplan and Zingales (1997) as estimated by Lamont, Polk, and Saá-Requejo (2001), hereafter referred to as KZ, (ii) the Cleary (1999) index, hereafter called CL, and (iii) the Whited and Wu (2005) index, hereafter called WW. 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 median).

Kaplan and Zingales (1997) categorize the 49 low dividend paying firms of Fazzari, Hubbard, and Petersen (1988) into five degrees of financial constraint and estimate an ordered logit model to obtain the probability of a firm falling into any one of the five financial constraint categories, with financial slack being the lowest state and financial constraint the highest state. Lamont, Polk, and Saá-Requejo (2001) report the coefficients for the KZ index that uses only variables available on COMPUSTAT. We use these coefficients to construct our KZ index. Following the approach of Kaplan and Zingales (1997), Cleary (1999) calculates a more 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 Cleary's (1999) sample period of 1987 to 1994 to obtain the coefficients for our CL index. Finally, in a recent paper, Whited and Wu (2005) argue that the KZ measure is inconsistent with the intuitive behavior of financially constrained firms. They 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. A fully unconstrained firm is a fast growing firm in a slow growing industry.

The formula for the KZ index is given by

$$KZ_{i,t} = -1.002CF_{i,t} + 3.139LTD_{i,t} - 39.367TDIV_{i,t} - 1.314CASH_{i,t} + 0.282Q_{i,t}, \tag{15}$$

the CL index is given by

$$\begin{aligned} CL_{i,t} = \; & 0.176CUR_{i,t-1} - 0.0003FC_{i,t-1} + 0.008SL_{i,t-1} - 2.802NI_{i,t-1} \\ & +0.018SG_{i,t-1} + 4.372DEBT_{i,t-1}, \end{aligned} \tag{16}$$

and the WW index is given by

$$\begin{aligned} WW_{i,t} = \; & -0.091CF_{i,t} - 0.062DDIV_{i,t} + 0.021LTD_{i,t} - 0.044LTA_{i,t} \\ & +0.102ISG_{i,t} - 0.035SG_{i,t}, \end{aligned} \tag{17}$$

where CF is cash flows, LTD is long-term debt, TDIV is total dividends over assets, Q is Tobin's Q, DDIV is an indicator for a dividend paying firm, ISG is industry sales growth, SG is the firm's sales growth, CUR is the firm's current ratio, FC is the fixed charge coverage, NI is the firms net income margin, DEBT is the firm's debt ratio, and SL is the ratio of slack over net fixed assets.

Thus, in addition to our Sample A and Sample B, defined in Section 3, we also perform our analysis using the following samples:

C : KZ below median and ZSCORE above median

D : CL below median and ZSCORE above median

E : WW below median and ZSCORE above median

F : LTDEIR above 3rd quartile and ZSCORE above median

The estimation results are presented in Table 13.

8 Conclusion

We use panel data from 1980 to 2005 to estimate cost curves for corporate debt. We simulate debt tax benefit curves and assume that for financially unconstrained firms, the benefit curve intersects the cost curve at the actual level of debt, on average. Using this equilibrium condition, exogenous shifts to the benefit curves enable us to identify the marginal cost function. We recover marginal cost curves that are steeply positively sloped. Both the slope and the intercept of these curves depend on firm characteristics such as collateral, sales, book-to-market, cash flows, cash holdings, and whether the firm pays dividends. We perform a multitude of robustness checks and find that our findings are robust across estimation specifications using any combination of cross-sectional or time series instruments. Our results are also robust when accounting for fixed adjustment costs of debt. As such, our framework provides a new parsimonious environment to estimate and evaluate competing capital structure theories. We also provide firm specific recommendations of optimal debt policy against which firms' actual debt choices can be benchmarked.

References

Almeida, H., and T. Philippon, "The Risk-Adjusted Cost of Financial Distress", *Journal of Finance, forthcoming.*

Altman, E., 1968, Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy, *Journal of Finance*, 23, 4, 589-609.

Berk, J., Stanton, R., and J. Zechner, 2006, Human Capital, Bankruptcy and Capital Structure, *working paper* UC Berkeley.

Brav, A., Graham, J., Harvey, C., and Michaely, R., 2005, Payout Policy in the 21st Century, *Journal of Financial Economics*, 77, 483-527.

Carlson, M., and A. Lazrak, 2006, Leverage Choice and Credit Spread Dynamics when Managers Risk Shift, *working paper*, Sauder School of Business, UBC.

Chen, H., 2006, Macroeconomic Conditions and the Puzzles of Credit Spreads and Capital Structure, *working paper*, University of Chicago GSB.

Chevalier, J.A., 1995, Capital Structure and Product Market Competition: Empirical Evidence from the Supermarket Industry, *American Economic Review*, 84, 3, 415-435.

Cleary, S., 1999, The Relationship between Firm Investment and Financial Status, *Journal of Finance*, 54, 2, 673-692.

Erickson, T., and T.M. Whited, 2006, On the accuracy of different measures of Q *Financial Management*, 35, 5-33.

Fazzari, S.M., R.G. Hubbard, B.C. Petersen, 1988, Financing constraints and coporate investment, *Brookings Papers on Economic Activity*, 1988, 1, 141-206.

Fischer, E., Heinkel, R. and J. Zechner, 1989, Optimal Dynamic Capital Structure Choice: Theory and Tests, *Journal of Finance*, 44, 19-40.

Frank, M.Z., and V.K. Goyal, 2004, Capital structure decisions: which factors are reliably important?

Graham, J.R., 1999, Do personal taxes affect corporate financing decisions? *Journal of Public Economics*, 73, 147-185.

Graham, J.R., 2000, How big are the tax benefits of debt? *Journal of Finance*, 55, 1901-1941.

Graham, J.R., Lemmon, M. and J. Schallheim, 1998, Debt, Leases, Taxes, and the Endogeneity of Corporate Tax Status, *Journal of Finance* 53, 131-161.

Graham, J.R., and C. Smith, 1999, Tax Incentives to Hedge, *Journal of Finance* 54, 2241-2262.

Jensen, M.C., and W.H. Meckling, 1976, Theory of the firm: Managerial behaviour, agency costs and ownership structure, *Journal of Financial Economics*, 3, 305-360.

Kraus, A., and R. Litzenberg, 1973, A State-Preference Model of Optimal Financial Leverage, *Journal of Finance*, September, 911-922.

Kurshev, A. and I.A. Strebulaev, 2006, Firm Size and Capital Structure, *working paper* Stanford GSB.

Lamont, O., C. Polk, and J. Saá-Requejo, 2001, Financial constraints and stock returns, *Review of Financial Studies* 14, 529-554.

Leary, M., and M. Roberts, 2005, Do Firms Rebalance their Capital Structures?, Journal of Finance, 2575-2619.

MacKie-Mason, J., 1990, Do taxes affect corporate financing decisions?, *Journal of Finance*, 45, 1471-1493.

Miller, M.H., 1977, Debt and Taxes, *Journal of Finance*, 32, 2, 261-275.

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

Polk, C., R. Cohen, and T. Vuolteenaho, 2003, The value spread, *Journal of Finance*, 58, 609-641.

Roberts, M., R. Michaely, 2006, Dividend Smoothing, Agency Costs, and Information Asymmetry: Lessons from the Dividend Policies of Private Firms, *working paper*, Wharton, UPenn.

Scott, J.H. 1976, A theory of optimal capital structure, *Bell Journal of Economics*, 7, 33-54.

Strebulaev, I.A. and B. Yang, 2006, The Mystery of Zero-Leverage Firms, *working paper* Stanford GSB.

Strebulaev, I.A., 2006, Do Tests of Capital Structure Theory Mean What They Say?, forthcoming, *Journal of Finance*.

Warner, J.B., 1977, Bankruptcy Costs: Some Evidence, *Journal of Finance*, 32(2), 337-347.

Whited, T., and G. Wu, 2005, Financial constraints risk, *Review of Financial Studies*, 19, 531-559.

Appendix A: Two-Stage Least Squares (2SLS)

As explained in Section 2.1, we estimate our coefficients by GMM for efficiency and correct, firm-clustered standard errors. However, to better explain the underlying intuition of our estimation, we now present the two-stage least squares equivalent of equations 5 and 6.

First, to purge $A_{i,t}$ of possible cost effects, the 2SLS approach would perform the following regression:

$$A_{i,t} = \beta_0 + \sum_{c \in C} \beta_c c_{i,t} + \varepsilon_{i,t}. \tag{18}$$

By construction, the error term $\varepsilon_{i,t}$ of this regression is orthogonal to the regressors (i.e., the control variables). To the extent that the regressors span the information set that describes the location of the marginal *cost* curve of debt, the error term $\varepsilon_{i,t}$ can be interpreted as the exogenous variation of the marginal *benefit* curve of debt that is not correlated with shifts of the MC curve. We use this variation as the instrumental variable to identify the marginal cost curve of debt. It is important to note that this variation of the marginal benefit curve includes the tax regime shifts described earlier, and also includes other marginal benefit shifters both in the time series and in the cross-section. That is the exogenous variation (both time series and cross-sectional) in the benefit curve is large and not limited to tax regime shifts. The disadvantage is that when purging the cost effects, we may not have controlled for all possible cost variables. As in all model specifications, this could possibly lead to an omitted variable bias. To ensure that our results are not driven by such econometric issues, we also perform our analysis using the tax regime shifts as the instrument. We show that this leads to highly similar results.

This error term, $\varepsilon_{i,t}$, which captures purged benefit shifts, is then main identifying instrument used by the 2SLS approach. The first stage of the 2SLS analysis involves projecting firms' equilibrium debt levels $x^*_{i,t}$ onto a constant, $\varepsilon_{i,t}$, and the control variables in C:

$$x^*_{i,t} = \beta_0 + \beta_\varepsilon \varepsilon_{i,t} + \sum_{c \in C} \beta_c c_{i,t} + \eta_{i,t}, \tag{19}$$

where $\eta_{i,t}$ is the error term of the first-stage regression.[18] The fitted values of this regression, denoted by $\hat{x}^*_{i,t}$, represents the variation in the equilibrium debt level due to exogenous shifts of the marginal benefit curve, while holding the marginal cost curve fixed. In the second stage, the 2SLS approach would regress $y^*_{i,t}$ on a constant, $\hat{x}^*_{i,t}$, and the control variables in C to obtain the slope and the intercept of the marginal cost curve.

$$y^*_{i,t} = a + b\hat{x}^*_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}, \tag{20}$$

where $\xi_{i,t}$ is the error term of the second-stage regression, which is uncorrelated with $\hat{x}_{i,t}$ by construction. Including the control variables in both stages of the analysis serves two purposes. First, as mentioned in the previous paragraph, it allows us to control for shifts in the location of the marginal cost curve. Second, it allows us to separately examine the contribution of each control variable to the estimated functional form of the marginal cost curve. Note, however, that the standard errors from the second stage regression would not be correct since they would represent the standard errors of $\hat{x}_{i,t}$ instead of $x_{i,t}$. Therefore, rather than use 2SLS, we estimate using GMM to obtain correct, firm-clustered standard errors.

[18]Given the presence of the control variables in the first stage, $\varepsilon_{i,t}$ can be replaced in equation 19 by $A_{i,t}$. We have presented equation 18 merely to convey the intuition that $\varepsilon_{i,t}$ captures the exogenous variation of the marginal benefit curve, as this residual is by construction orthogonal to the cost control variables.

Appendix B

Corporate tax rates over the period 1980 to 2005. Both the corporate tax rates as well as their corresponding income tax brackets change during this period. To resolve this issue, eleven non-overlapping income tax brackets are created for all years.

Year	Income Tax Bracket in Thousands $$										
	0 to 25	25 to 50	50 to 75	75 to 100	100 to 335	335 to 1000	1000 to 1405	1405 to 10000	10000 to 15000	15000 to 18333	18333+
1980	0.170	0.200	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1981	0.170	0.200	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1982	0.160	0.190	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1983	0.150	0.180	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1984	0.150	0.180	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1985	0.150	0.180	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1986	0.150	0.180	0.300	0.400	0.460	0.460	0.510	0.460	0.460	0.460	0.460
1987	0.150	0.165	0.275	0.370	0.425	0.400	0.425	0.400	0.400	0.400	0.400
1988	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.340	0.340	0.340
1989	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.340	0.340	0.340
1990	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.340	0.340	0.340
1991	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.340	0.340	0.340
1992	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.340	0.340	0.340
1993	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
1994	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
1995	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
1996	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
1997	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
1998	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
1999	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
2000	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
2001	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
2002	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
2003	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
2004	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350
2005	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350

Appendix C

Detailed description on the construction of the control variables used in the analysis and variables included in the summary statistics reported in Table 2. Numbers in parentheses indicate the corresponding COMPUSTAT annual industrial data items.

$$\text{LTA} = \log\left(\text{Total Assets (6)}\right)$$

$$\text{PPE} = \frac{\text{Net Plants, Property, and Equipment (8)}}{\text{Total Book Assets (6)}}$$

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

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

$$\text{CF} = \frac{\text{EBIT (18) + Depreciation (14)}}{\text{Total Book Assets (6)}}$$

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

$$\text{HHI} = \frac{H - \frac{1}{N}}{1 - \frac{1}{N}} \quad \text{where} \quad H = \sum_{i}^{N} s_i^2 \quad \text{and} \quad s_i = \text{market share of firm } i$$

$$\text{LWAGE} = \log\left(\text{WAGE}\right) = \log\left(\frac{\text{Labor and Related Expenses (42)}}{\text{Number of Employees (29)}}\right)$$

$$\text{CS} = \text{Moody's Baa Rate} - \text{Moody's Aaa Rate} \quad (\mathit{Source}: \mathit{Economagic})$$

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

$$\text{TLC} = \frac{\text{Net Carryloss Forward (52)}}{\text{Net Sales (12)}}$$

$$\text{PTP} = \tau_p - (1 - \tau_c)\tau_e \quad \text{for } \tau_c = \text{observed marginal tax rate} \quad \text{and } \tau_e = [d + (1 - d)g\alpha]\tau_p$$

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.

Appendix D

Firms are classified by their two-digit SIC codes into industries. The following table describes the industries and the corresponding two-digit SIC codes we use in our analysis.

Agriculture, Forestry, and Fishing	01-09
Mining	10-14
Construction	15-17
Manufacturing	20-39
Transportation	40-47
Communication	48
Utilities	49
Wholesale Trade	50-51
Retail Trade	52-59
Finance, Insurance, and Real Estate	60-67
Services	70-89
Public Administration	91-99

Table 1: Sample construction. y^* is the 'equilibrium' marginal benefit level, x^* is the observed or 'equilibrium' interest payments over book value (IOB), A is the area under the marginal benefit curve, and C is the set of control (cost) variables. $C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}$. ZSCORE is a measure of financial distress. LTDEIR is the long term debt and/or equity issuance or repurchase used to measure for financial constraint. KZ, CL, and WW are financial constraint measures as defined by Kaplan and Zingales (1997), Cleary (1999), and Whited and Wu (2005) indices respectively.

Sample		No. Obs
All firm-year obs. with marginal benefit (MB) curves and COMPUSTAT data in 1980-2005		122,832
Non-M&A firm-years with positive book value, common equity, capital, and sales		108,730
Sample without outliers		99,774
Sample with non-missing $(y^*_{i,t}, x^*_{i,t}, A_{i,t}, C_{i,t})$ variables:	Sample A	87,451
Sample of financially unconstrained and non-distressed firm-years: LTDEIR above median and ZSCORE above median	Sample B	28,360
For robustness checks:		
Sample of financially unconstrained and non-distressed firm-years: KZ below median and ZSCORE above median	Sample C	22,539
Sample of financially unconstrained and non-distressed firms-years: CL below median and ZSCORE above median	Sample D	20,014
Sample of financially unconstrained and non-distressed firms-years: WW below median and ZSCORE above median	Sample E	20,178
Sample of financially unconstrained and non-distressed firms-years: LTDEIR above third quartile and ZSCORE above median	Sample F	14,896

Table 2: Summary statistics for the samples used in the analysis. LTA is log of total assets expressed in 2000 dollars, PPE is property, plant, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firms, CF is net cashflow over total book values, and CASH is cash holdings over total book values. HCR is the historical credit rankings based on the S&P long term domestic issuer credit ratings. ZSCORE is a measure of financial distress. KZ, CL, and WW are financial constraint measures as defined by the Kaplan and Zingales (1997), Cleary (1999), and Whited and Wu (2005) indices, respectively. TLC is total tax loss carryforwards normalized by total sales. PTP is the personal tax penalty on interest as measured in Graham (1999). WAGE is total labor compensation normalized by total employees. HHI is the normalized Herfindahl-Hirschman index for industry concentration based on the 3-digit SIC.

Sample A: All Firms					
	No. Obs	Mean	Std. Dev	Min	Max
Area Under Curve	87451	0.032	0.027	0.000	0.137
Interest Over Book Value	87451	0.031	0.024	0.000	0.133
LTA	87451	5.101	2.243	-1.872	13.759
PPE	87451	0.322	0.247	0.000	1.000
BTM	87451	0.780	0.640	0.034	4.677
DDIV	87451	0.403	0.491	0	1
CF	87451	0.086	0.150	-0.826	0.397
CASH	87451	0.140	0.183	-0.027	1.000
HCR	15868	4.067	1.304	1	10
ZSCORE	80252	1.523	2.066	-13.700	5.596
KZ	57688	1.912	87.065	-627.915	13842.770
CL	71017	-10.548	422.176	-74645.580	5936.831
WW	68638	-0.221	0.370	-21.715	50.016
TLC	63317	2.783	103.606	0.000	15571.430
PTP	75440	0.246	0.091	-0.194	0.456
WAGE	9862	52.498	383.926	0.000	20357.510
HHI	87101	0.188	0.153	0.000	1.000
Sample B: Financially Unconstrained and Non-distressed LTDEIR above median and ZSCORE above median					
	No. Obs	Mean	Std. Dev	Min	Max
Area Under Curve	28360	0.042	0.027	0.000	0.137
Interest Over Book Value	28360	0.029	0.022	0.000	0.132
LTA	28360	5.274	1.876	0.096	12.173
PPE	28360	0.281	0.174	0.000	0.953
BTM	28360	0.696	0.552	0.035	4.670
DDIV	28360	0.469	0.499	0	1
CF	28360	0.160	0.081	-0.568	0.397
CASH	28360	0.129	0.153	-0.002	0.985
HCR	4647	3.812	1.246	1	10
ZSCORE	28360	2.800	0.752	1.802	5.596
KZ	21381	-0.099	1.662	-207.099	17.033
CL	24109	-5.334	60.014	-7212.505	21.760
WW	25071	-0.238	0.223	-20.285	14.331
TLC	23211	0.023	0.357	0.000	50.598
PTP	25128	0.255	0.087	-0.186	0.456
WAGE	2485	37.764	195.796	0.003	9392.839
HHI	28231	0.198	0.153	0.000	0.993

Table 3: Marginal cost of debt using all firms in Sample A except those in utilities, finance, and public administration. We present GMM estimates of the coefficients in equations 5 and 9. The error functions are defined according to equations 6 and 10 where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB) and C is the set of cost control variables. GMM moments are obtained by interacting the error function with the following instruments: the constant term, each of the control variables, and an additional identifying instrument. We consider five different specifications for this additional instrument, denoted by (i)-(v): (i) the area under the marginal benefit curve $A_{i,t}$, (ii) the corporate tax rates from eleven tax brackets across time, (iii) the IOB associated with the 'kink' of the marginal benefit curve, $x^K_{i,t}$ in addition to $A_{i,t}$, (iv) the area under the marginal benefit curve up to 700% of the observed IOB, $A^{700}_{i,t}$ and (v) the corporate tax rates from eleven tax brackets across time with firm fixed effects. The set of control variables is $C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}$, where LTA is log of total assets expressed in 2000 dollars, PPE is plant, property, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firms, CF is net cashflow over total book values, and CASH is cash holdings over total book values. The control variables are standardized to have mean zero and standard deviation one based on Sample A (and are not re-standardized across samples). Robust, firm-clustered GMM standard errors are reported in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(9) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$					(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$				
	(i)	(ii)	(iii)	(iv)	(v)	(i)	(ii)	(iii)	(iv)	(v)
Constant	0.012 *	0.090 ***	0.059 ***	0.047 ***	0.100 ***	-0.001	0.045 ***	0.028 ***	0.038 ***	0.024 ***
	(0.006)	(0.008)	(0.005)	(0.005)	(0.006)	(0.006)	(0.008)	(0.006)	(0.005)	(0.008)
IOB	9.120 ***	6.557 ***	7.414 ***	7.816 ***	6.028 ***	8.412 ***	6.855 ***	7.495 ***	7.178 ***	7.544 ***
	(0.206)	(0.267)	(0.177)	(0.170)	(0.193)	(0.191)	(0.258)	(0.172)	(0.152)	(0.237)
LTA*IOB	0.672 ***	0.361 ***	0.639 ***	0.630 ***	1.034 ***					
	(0.083)	(0.067)	(0.069)	(0.071)	(0.077)					
PPE*IOB	-0.793 ***	-0.740 ***	-0.701 ***	-0.678 ***	-0.088 *					
	(0.065)	(0.051)	(0.055)	(0.056)	(0.047)					
BTM*IOB	-0.350 ***	-0.289 ***	-0.266 ***	-0.269 ***	-0.385 ***					
	(0.041)	(0.031)	(0.036)	(0.036)	(0.020)					
DDIV*IOB	1.636 ***	2.024 ***	1.513 ***	1.464 ***	1.476 ***					
	(0.080)	(0.068)	(0.068)	(0.068)	(0.037)					
CF*IOB	2.245 ***	3.042 ***	2.136 ***	1.970 ***	2.303 ***					
	(0.075)	(0.064)	(0.064)	(0.069)	(0.030)					
CASH*IOB	2.741 ***	2.633 ***	2.006 ***	2.190 ***	2.118 ***					
	(0.163)	(0.155)	(0.131)	(0.141)	(0.076)					
LTA						0.017 ***	0.018 ***	0.016 ***	0.016 ***	0.040 ***
						(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
PPE						-0.024 ***	-0.022 ***	-0.023 ***	-0.022 ***	-0.015 ***
						(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
BTM						-0.011 ***	-0.008 ***	-0.010 ***	-0.010 ***	-0.013 ***
						(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
DDIV						0.071 ***	0.066 ***	0.068 ***	0.066 ***	0.051 ***
						(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
CF						0.094 ***	0.092 ***	0.092 ***	0.091 ***	0.081 ***
						(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
CASH						0.082 ***	0.069 ***	0.073 ***	0.071 ***	0.059 ***
						(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
No. Obs.	75794	68188	75794	75794	68188	75794	68188	75794	75794	68188
Fixed Effects?	N	N	N	N	Y	N	N	N	N	Y

Table 4: Marginal cost of debt using all firms in Sample B except those in utilities, finance, and public administration. We present GMM estimates of the coefficients in equations 5 and 9. The error functions are defined according to equations 6 and 10 where $y^*_{i,t}$ is the observed marginal benefit/cost level, $x^*_{i,t}$ is the observed interest expenses over book value (IOB) and C is the set of cost control variables. GMM moments are obtained by interacting the error function with the following instruments: the constant term, each of the control variables, and an additional identifying instrument. We consider five different specifications for this additional instrument, denoted by (i)-(v): (i) the area under the marginal benefit curve $A_{i,t}$, (ii) the corporate tax rates from eleven tax brackets across time, (iii) the IOB associated with the 'kink' of the marginal benefit curve, $x^K_{i,t}$ in addition to $A_{i,t}$, (iv) the area under the marginal benefit curve up to 700% of the observed IOB, $A^{700}_{i,t}$ and (v) the corporate tax rates from eleven tax brackets across time with firm fixed effects. The set of control variables is $C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}$, where LTA is log of total assets expressed in 2000 dollars, PPE is plant, property, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firms, CF is net cashflow over total book values, and CASH is cash holdings over total book values. The control variables are standardized to have mean zero and standard deviation one based on Sample A (and are not re-standardized across samples). Robust, firm-clustered GMM standard errors are reported in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(9) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$					(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$				
	(i)	(ii)	(iii)	(iv)	(v)	(i)	(ii)	(iii)	(iv)	(v)
Constant	0.171 ***	0.144 ***	0.194 ***	0.197 ***	0.164 ***	0.105 ***	0.054 ***	0.118 ***	0.131 ***	0.046 ***
	(0.005)	(0.010)	(0.005)	(0.004)	(0.008)	(0.007)	(0.012)	(0.006)	(0.006)	(0.011)
IOB	5.126 ***	5.742 ***	4.317 ***	4.253 ***	4.637 ***	5.854 ***	7.387 ***	5.451 ***	5.015 ***	7.501 ***
	(0.190)	(0.343)	(0.167)	(0.154)	(0.260)	(0.181)	(0.349)	(0.171)	(0.149)	(0.329)
LTA*IOB	0.491 ***	0.723 ***	0.409 ***	0.412 ***	1.845 ***					
	(0.082)	(0.102)	(0.072)	(0.070)	(0.146)					
PPE*IOB	-0.471 ***	-0.795 ***	-0.378 ***	-0.380 ***	-0.082					
	(0.084)	(0.104)	(0.073)	(0.070)	(0.095)					
BTM*IOB	-0.291 ***	-0.312 ***	-0.259 ***	-0.214 ***	-0.308 ***					
	(0.046)	(0.050)	(0.041)	(0.040)	(0.034)					
DDIV*IOB	0.899 ***	1.220 ***	0.864 ***	0.828 ***	1.140 ***					
	(0.066)	(0.075)	(0.058)	(0.055)	(0.051)					
CF*IOB	1.560 ***	3.380 ***	1.411 ***	1.316 ***	3.289 ***					
	(0.136)	(0.146)	(0.123)	(0.121)	(0.078)					
CASH*IOB	1.835 ***	3.738 ***	1.473 ***	1.417 ***	2.258 ***					
	(0.138)	(0.229)	(0.121)	(0.118)	(0.115)					
LTA						0.019 ***	0.023 ***	0.018 ***	0.017 ***	0.058 ***
						(0.002)	(0.003)	(0.002)	(0.002)	(0.005)
PPE						-0.018 ***	-0.022 ***	-0.017 ***	-0.016 ***	-0.004
						(0.003)	(0.004)	(0.003)	(0.003)	(0.004)
BTM						-0.020 ***	-0.024 ***	-0.018 ***	-0.017 ***	-0.021 ***
						(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
DDIV						0.039 ***	0.044 ***	0.038 ***	0.037 ***	0.039 ***
						(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
CF						0.089 ***	0.093 ***	0.087 ***	0.086 ***	0.097 ***
						(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
CASH						0.058 ***	0.072 ***	0.055 ***	0.051 ***	0.056 ***
						(0.003)	(0.004)	(0.003)	(0.002)	(0.003)
No. Obs.	27555	25411	27555	27555	25411	27555	25411	27555	27555	25411
Fixed Effects?	N	N	N	N	Y	N	N	N	N	Y

Table 5: Regressing area and observed leverage (debt over assets) under the marginal benefits curve on the set of cost control variables. The set of control variables, C, includes $\{LTA, PPE, BTM, DDIV, CF, CASH\}$ where LTA is log of total assets expressed in 2000 dollars, PPE is plant, property, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firms, CF is net cashflow over total book values, and CASH is cash holdings over total book values. Standard errors are reported in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	Sample A	Sample B	Sample A	Sample B
	$A_{i,t} = \alpha + \sum_{c \in C} \beta_c c_{i,t} + \nu_{i,t}$		$Lev_{i,t} = \alpha + \sum_{c \in C} \beta_c c_{i,t} + \nu_{i,t}$	
LTA	-0.0012 ***	-0.0003	0.0355 ***	0.0094 ***
	(0.0002)	(0.0003)	(0.0021)	(0.0019)
PPE	-0.0012 ***	-0.0005	0.0308 ***	0.0155 ***
	(0.0002)	(0.0003)	(0.0019)	(0.0019)
BTM	-0.0017 ***	-0.0004	0.0020 *	0.0042 ***
	(0.0001)	(0.0002)	(0.0011)	(0.0014)
DDIV	0.0033 ***	0.0024 ***	-0.0309 ***	-0.0124 ***
	(0.0002)	(0.0003)	(0.0016)	(0.0017)
CF	0.0100 ***	0.0095 ***	-0.0235 ***	-0.0259 ***
	(0.0002)	(0.0003)	(0.0012)	(0.0015)
CASH	-0.0029 ***	-0.0051 ***	-0.0732 ***	-0.0655 ***
	(0.0002)	(0.0003)	(0.0013)	(0.0015)
Constant	0.0321 ***	0.0423 ***	0.2418 ***	0.1994 ***
	(0.0002)	(0.0003)	(0.0015)	(0.0016)
No. Obs	87451	28360	87188	28329
R^2	0.2037	0.1623	0.2310	0.2718

Table 6: Marginal cost of debt by industry. GMM estimation of the coefficients in equation 9 (see below) by industry. The error function is defined in equation 10 where $y^*_{i,t}$ is the 'equilibrium' marginal benefit/cost level, $x^*_{i,t}$ is the observed or 'equilibrium' interest expenses over book value (IOB) and C is the set of cost control variables. GMM moments are obtained by interacting the error function with the following instruments: the constant term, the variation of the marginal benefit curve $A_{i,t}$, and each of the control variables. The set of control variables is $C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}$, where LTA is log of total assets expressed in 2000 dollars, PPE is plant, property, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firm, and CF is net cashflow over total book values, CASH is cash holdings over total book values. The control variables are standardized to have mean zero and standard deviation one for each industry. Robust, firm-clustered GMM standard errors are reported in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

$$(9)\ MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$$

	Constant	IOB	LTA *IOB	PPE *IOB	BTM *IOB	DDIV *IOB	CF *IOB	CASH *IOB	No. Obs
Sample A: All Firms									
All Industries	0.029 ***	8.639 ***	0.651 ***	-0.585 ***	-0.358 ***	1.637 ***	2.047 ***	2.437 ***	87451
	(0.005)	(0.177)	(0.080)	(0.059)	(0.039)	(0.071)	(0.066)	(0.140)	
All Industries Except Utilities, Finance, & Public Admin.	0.012 *	9.120 ***	0.672 ***	-0.793 ***	-0.350 ***	1.636 ***	2.245 ***	2.741 ***	75794
	(0.006)	(0.206)	(0.083)	(0.065)	(0.041)	(0.080)	(0.075)	(0.163)	
Mining & Construction	-0.009	8.339 ***	0.465	0.089	-0.484 ***	1.433 ***	2.170 ***	2.090 ***	6838
	(0.014)	(0.531)	(0.351)	(0.185)	(0.148)	(0.294)	(0.216)	(0.569)	
Utilities	-0.134 ***	14.559 ***	-0.147	-0.047	-0.345	2.049 ***	1.335 ***	1.902 ***	4216
	(0.047)	(1.407)	(0.225)	(0.263)	(0.222)	(0.280)	(0.221)	(0.386)	
Manufacturing	0.017 *	11.122 ***	0.427 ***	-0.031	-0.343 ***	1.889 ***	3.238 ***	4.488 ***	42747
	(0.009)	(0.365)	(0.113)	(0.092)	(0.057)	(0.106)	(0.105)	(0.277)	
Wholesale & Retail Trade	-0.078 ***	8.671 ***	0.844 ***	-0.854 ***	-0.499 ***	1.167 ***	1.074 ***	0.452 **	10164
	(0.027)	(0.568)	(0.184)	(0.153)	(0.091)	(0.161)	(0.153)	(0.188)	
Transportation, Warehousing, & Communication	-0.054	9.226 ***	0.470	-0.552 **	-0.264	1.906 ***	2.243 ***	0.834 *	4125
	(0.038)	(0.934)	(0.313)	(0.278)	(0.168)	(0.347)	(0.320)	(0.502)	
Finance, Insurance, & Real Estate	0.185 ***	4.038 ***	0.421 *	-0.367 ***	-0.230 ***	0.877 ***	0.941 ***	0.744 ***	6771
	(0.009)	(0.253)	(0.218)	(0.091)	(0.074)	(0.117)	(0.101)	(0.171)	
Services & Leisure	-0.074 ***	10.680 ***	1.211 ***	-1.324 ***	-0.306 ***	0.783 ***	1.909 ***	4.055 ***	11551
	(0.018)	(0.579)	(0.205)	(0.168)	(0.106)	(0.168)	(0.155)	(0.393)	
Sample B: Financially Unconstrained and Non-distressed: LTDEIR above median and ZSCORE above median									
All Industries	0.171 ***	5.169 ***	0.552 ***	-0.478 ***	-0.282 ***	0.917 ***	1.461 ***	1.812 ***	28360
	(0.005)	(0.185)	(0.085)	(0.088)	(0.045)	(0.066)	(0.127)	(0.132)	
All Industries Except Utilities, Finance, & Public Admin.	0.171 ***	5.126 ***	0.491 ***	-0.471 ***	-0.291 ***	0.899 ***	1.560 ***	1.835 ***	27555
	(0.005)	(0.190)	(0.082)	(0.084)	(0.046)	(0.066)	(0.136)	(0.138)	
Mining & Construction	0.146 ***	6.557 ***	0.439	0.989	-0.763 **	0.735	1.376 **	1.531 ***	654
	(0.024)	(1.193)	(0.668)	(0.723)	(0.351)	(0.467)	(0.619)	(0.522)	
Utilities	-0.012	13.309 ***	0.393	0.533	-0.443	0.873	0.509	1.983 **	187
	(0.133)	(4.194)	(1.026)	(0.834)	(0.611)	(0.730)	(0.428)	(0.790)	
Manufacturing	0.176 ***	6.760 ***	0.340 ***	0.208 **	-0.367 ***	0.908 ***	1.822 ***	3.447 ***	17312
	(0.007)	(0.282)	(0.101)	(0.089)	(0.059)	(0.079)	(0.158)	(0.213)	
Wholesale & Retail Trade	0.010	7.085 ***	0.732 ***	-0.613 ***	-0.675 ***	0.832 ***	0.375	0.331 *	5334
	(0.030)	(0.653)	(0.194)	(0.165)	(0.127)	(0.147)	(0.251)	(0.174)	
Transportation, Warehousing, & Communication	0.168 ***	3.826 ***	1.026 **	-0.888 **	-0.223	0.399	1.680 ***	0.240	775
	(0.028)	(0.740)	(0.496)	(0.368)	(0.180)	(0.379)	(0.383)	(0.398)	
Finance, Insurance, & Real Estate	0.245 ***	3.497 ***	0.968 *	-0.592 *	0.281	0.745 **	0.565 **	1.007 ***	516
	(0.018)	(0.794)	(0.495)	(0.325)	(0.237)	(0.331)	(0.286)	(0.280)	
Services & Leisure	0.148 ***	5.434 ***	0.916 ***	-0.405 **	-0.198	0.235	1.436 ***	2.457 ***	3397
	(0.017)	(0.587)	(0.214)	(0.204)	(0.142)	(0.144)	(0.332)	(0.307)	

Table 7: Alternative control specifications. GMM estimation of the coefficients in equations 5 and 9 for all firms in Sample B except those in utilities, finance, and publid administration. The error functions are defined according to equations 6 and 10 where $y^*_{i,t}$ is the 'equilibrium' marginal benefit/cost level, $x^*_{i,t}$ is the observed or 'equilibrium' interest expenses over book value (IOB) and C is the set of cost control variables. GMM moments are obtained by interacting the error function with the following instruments: the constant term, the variation of the marginal benefit curve $A_{i,t}$, and each of the control variables. The set of control variables is $C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}$, and one of each alternative control specification: $\{PTP, LWAGE, CS, DCR\}$. LTA is log of total assets expressed in 2000 dollars, PPE is plant, property, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firms, CF is net cashflow over total book values, and CASH is cash holdings over total book values. PTP is the personal tax penalty as measured in Graham (1999), LWAGE is the log of wages per employee, CS is the spread between Moody's Baa rate and Aaa rate, and DCR is a dummy for whether the firm has an S&P credit rating. The control variables are standardized to have mean zero and standard deviation one based on Sample A (and are not re-standardized across samples). Robust, firm-clustered GMM standard errors are reported in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(9) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$			
	PTP	LWAGE	CS	DCR
Constant	0.206 ***	0.188 ***	0.196 ***	0.174 ***
	(0.005)	(0.021)	(0.005)	(0.005)
IOB	3.731 ***	3.994 ***	4.181 ***	5.006 ***
	(0.187)	(0.576)	(0.189)	(0.186)
LTA*IOB	0.746 ***	0.848 ***	0.605 ***	0.866 ***
	(0.073)	(0.216)	(0.072)	(0.087)
PPE*IOB	-0.425 ***	-0.577 **	-0.453 ***	-0.472 ***
	(0.073)	(0.230)	(0.072)	(0.083)
BTM*IOB	-0.392 ***	0.016	-0.434 ***	-0.338 ***
	(0.043)	(0.189)	(0.041)	(0.046)
DDIV*IOB	0.839 ***	1.176 ***	0.648 ***	0.843 ***
	(0.058)	(0.218)	(0.061)	(0.065)
CF*IOB	1.386 ***	1.541 ***	1.471 ***	1.503 ***
	(0.129)	(0.392)	(0.121)	(0.135)
CASH*IOB	1.492 ***	0.096	1.613 ***	1.804 ***
	(0.122)	(0.412)	(0.122)	(0.136)
PTP*IOB	0.936 ***			
	(0.045)			
LWAGE*IOB		0.225		
		(0.205)		
CS*IOB			0.670 ***	
			(0.044)	
DCR*IOB				-0.581 ***
				(0.057)
No. Obs	24445	2330	27555	27555

	(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$			
	PTP	LWAGE	CS	DCR
Constant	0.157 ***	0.135 ***	0.135 ***	0.105 ***
	(0.006)	(0.024)	(0.007)	(0.006)
IOB	4.163 ***	4.369 ***	4.895 ***	5.789 ***
	(0.177)	(0.519)	(0.196)	(0.177)
LTA	0.025 ***	0.021 ***	0.021 ***	0.036 ***
	(0.002)	(0.007)	(0.002)	(0.003)
PPE	-0.016 ***	-0.016 **	-0.018 ***	-0.018 ***
	(0.002)	(0.007)	(0.003)	(0.003)
BTM	-0.020 ***	-0.009	-0.022 ***	-0.022 ***
	(0.002)	(0.009)	(0.002)	(0.002)
DDIV	0.039 ***	0.051 ***	0.032 ***	0.038 ***
	(0.002)	(0.007)	(0.002)	(0.002)
CF	0.077 ***	0.078 ***	0.085 ***	0.086 ***
	(0.003)	(0.013)	(0.003)	(0.003)
CASH	0.044 ***	0.024 **	0.050 ***	0.056 ***
	(0.002)	(0.010)	(0.003)	(0.003)
PTP	0.036 ***			
	(0.001)			
LWAGE		-0.006		
		(0.004)		
CS			0.020 ***	
			(0.002)	
DCR				-0.024 ***
				(0.002)
No. Obs.	24445	2330	27555	27555

Table 8: Marginal benefit and marginal cost functions of debt for the average (representative) firm in Sample A and Sample B. The marginal cost curve is calculated using equation 11. 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.

	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	0.000	0.297	0.171	0.000	0.352	0.171
20% of Obs.	0.006	0.291	0.203	0.006	0.348	0.220
40% of Obs.	0.013	0.286	0.235	0.012	0.345	0.268
60% of Obs.	0.019	0.280	0.268	0.018	0.341	0.317
80% of Obs.	0.025	0.273	0.300	0.024	0.336	0.366
100% of Obs.	0.031	0.266	0.332	0.030	0.331	0.415
120% of Obs.	0.038	0.257	0.364	0.035	0.324	0.463
160% of Obs.	0.050	0.241	0.429	0.047	0.310	0.561
200% of Obs.	0.063	0.223	0.493	0.059	0.294	0.658
300% of Obs.	0.094	0.185	0.654	0.089	0.251	0.902
400% of Obs.	0.126	0.153	0.815	0.118	0.211	1.146
500% of Obs.	0.157	0.128	0.976	0.148	0.177	1.389
600% of Obs.	0.189	0.110	1.137	0.177	0.152	1.633
700% of Obs.	0.220	0.096	1.298	0.207	0.132	1.876
800% of Obs.	0.251	0.085	1.459	0.236	0.116	2.120
900% of Obs.	0.283	0.076	1.620	0.266	0.104	2.364
1000% of Obs.	0.314	0.070	1.782	0.295	0.094	2.607

Table 9: Key financial characteristics of the four firms studied in our case analysis. TA is the total assets expressed in thousands of 2000 dollars, MCAP represents the market capitalization expressed in thousands of 2000 dollars, BTM is the book equity to market equity ratio, PPE stands for plants, property, and equipment over total book assets, DIVIDENDS is the total dividend payout in thousands of dollars over total book assets, SALES is firm sales over total book assets, CASH is cash holdings over total book assets, CF is income over total book value and D/E is the debt to equity ratio.

	A.C. Moore		Coca Cola		Verizon		Southwest Gas	
	Decile	Value	Decile	Value	Decile	Value	Decile	Value
2001								
TA ($thousand)	4	120	10	23067	10	166101	8	2304
MCAP ($thousand)	5	213	10	7957	10	125082	7	698
PPE	5	0.202	6	0.262	8	0.436	10	0.770
BTM	3	0.336	3	0.340	2	0.253	7	0.782
DIVIDENDS	1	0	7	0.003	9	0.024	8	0.011
CASH	6	0.087	3	0.012	3	0.017	3	0.014
CF	9	0.172	5	0.086	9	0.170	6	0.107
SALES	10	2.685	4	0.662	3	0.393	4	0.589
D/E	3	0.015	9	0.437	7	0.267	9	0.361
2002								
TA ($thousand)	4	188	10	23335	10	160322	8	2276
MCAP ($thousand)	6	217	10	9336	10	101237	7	740
PPE	4	0.142	6	0.262	8	0.445	10	0.832
BTM	5	0.634	2	0.339	2	0.308	6	0.771
DIVIDENDS	1	0	7	0.003	9	0.025	8	0.011
CASH	9	0.313	1	0.003	3	0.021	2	0.008
CF	8	0.150	5	0.098	9	0.173	6	0.116
SALES	9	2.000	5	0.693	3	0.404	4	0.555
D/E	2	0.003	10	0.461	7	0.267	10	0.485
2003								
TA ($thousand)	4	217	10	24057	10	155360	8	2441
MCAP ($thousand)	5	345	10	9294	10	90501	7	709
PPE	5	0.206	6	0.264	8	0.454	10	0.834
BTM	5	0.453	5	0.440	4	0.346	8	0.832
DIVIDENDS	1	0	7	0.003	9	0.026	8	0.011
CASH	8	0.189	1	0.003	3	0.017	2	0.007
CF	8	0.149	6	0.101	8	0.164	6	0.104
SALES	9	1.872	5	0.674	3	0.408	4	0.472
D/E	1	0.000	9	0.411	7	0.237	10	0.468
2004								
TA ($thousand)	5	277	10	24026	10	151300	8	2679
MCAP ($thousand)	6	512	10	8839	10	102301	6	815
PPE	6	0.274	6	0.262	8	0.447	10	0.795
BTM	4	0.332	7	0.555	4	0.335	9	0.789
DIVIDENDS	1	0	7	0.003	9	0.026	8	0.010
CASH	8	0.217	1	0.006	3	0.027	1	0.005
CF	6	0.116	5	0.095	8	0.168	5	0.107
SALES	9	1.636	5	0.689	3	0.430	4	0.503
D/E	4	0.088	9	0.399	7	0.215	9	0.430
2005								
TA ($thousand)	4	276	10	22359	10	148250	8	2847
MCAP ($thousand)	4	253	9	7961	10	73461	6	888
PPE	6	0.282	6	0.259	8	0.448	10	0.771
BTM	8	0.691	7	0.625	6	0.476	8	0.746
DIVIDENDS	1	0	6	0.004	9	0.027	7	0.010
CASH	8	0.201	1	0.004	3	0.019	2	0.009
CF	4	0.087	5	0.100	8	0.170	5	0.098
SALES	9	1.725	5	0.738	3	0.447	4	0.531
D/E	4	0.077	9	0.361	6	0.190	9	0.410

Table 10: Summary statistics for benefits and costs of debt. Measures are based on the marginal cost curves estimated from equations 9 and 5 for sample B for all industries except utilities, finance, and public adminstration. The observed gross benefits of debt, GBD_o, is the area under the marginal benefits curve up to the observed level of interest over book value (IOB). The observed cost of debt, CD_o is the area under the marginal cost curve up to the observed level of IOB. The observed net benefits of debt, NBD_o, is the area under the marginal benefits curve minus the area under the marginal cost curve up to the observed IOB. Equilibrium is defined as the intersection of the marginal benefit and cost curves. The equilibrium gross benefits of debt, GBD_e, is the area under the marginal benefits curve up to the equilibrium level of IOB. The equilibrium cost of debt, CD_e is the area under the marginal cost curve up to the equilibrium level of IOB. The equilibrium net benefits of debt, NBD_e, is the area under the marginal benefits curve minus the area under the marginal cost curve up to the equilibrium IOB. The cost of being overleveraged, DW_o, is the deadweight loss from additional costs due to having IOB above the equilibrium. The cost of being underleveraged, DW_u, is the deadweight loss from lower benefits due to having IOB below the equilibrium. The cost of being out of equilibrium, DW_t, combines DW_o and DW_u into one measure.

Analysis Based on (9) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$										
	N	Mean	Std. Dev.	1%	10%	25%	Median	75%	90%	99%
Observed gross benefits of debt (GBD_o)	87451	0.0874	0.0780	0.0000	0.0032	0.0243	0.0717	0.1285	0.1922	0.3380
Observed costs of debt (CD_o)	87451	0.0877	0.0882	0.0000	0.0106	0.0294	0.0648	0.1154	0.1904	0.4190
Observed net benefits of debt (NBD_o)	87451	-0.0003	0.0620	-0.2444	-0.0644	-0.0104	0.0153	0.0315	0.0459	0.0806
Equilibrium gross benefits of debt (GBD_e)	87451	0.0944	0.0786	0.0000	0.0000	0.0137	0.0972	0.1421	0.1873	0.3036
Equilibrium costs of debt (CD_e)	87451	0.0666	0.0536	0.0000	0.0000	0.0102	0.0698	0.1012	0.1319	0.2047
Equilibrium net gross benefits of debt (NBD_e)	87451	0.0278	0.0300	0.0000	0.0000	0.0021	0.0264	0.0407	0.0561	0.1039
Cost of being out of equilibrium (DW_t)	87451	0.0280	0.0545	0.0000	0.0003	0.0023	0.0100	0.0276	0.0750	0.2638
Cost of overleveraging (DW_o)	45897	0.0433	0.0682	0.0000	0.0004	0.0036	0.0181	0.0548	0.1156	0.3188
Cost of underleveraging (DW_u)	41554	0.0112	0.0239	0.0000	0.0002	0.0016	0.0064	0.0146	0.0245	0.0653
Analysis Based on (5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$										
	N	Mean	Std. Dev.	1%	10%	25%	Median	75%	90%	99%
Observed gross benefits of debt (GBD_o)	87451	0.0874	0.0780	0.0000	0.0032	0.0243	0.0717	0.1285	0.1922	0.3380
Observed costs of debt (CD_o)	87451	0.0724	0.0865	-0.0351	0.0023	0.0177	0.0500	0.0971	0.1703	0.4085
Observed net benefits of debt (NBD_o)	87451	0.0150	0.0595	-0.2214	-0.0323	0.0004	0.0189	0.0435	0.0686	0.1244
Equilibrium gross benefits of debt (GBD_e)	87451	0.0970	0.0732	0.0000	0.0000	0.0253	0.0982	0.1527	0.1934	0.2636
Equilibrium costs of debt (CD_e)	86839	0.0588	0.0493	-0.0447	0.0000	0.0101	0.0657	0.1001	0.1186	0.1524
Equilibrium net gross benefits of debt (NBD_e)	86839	0.0388	0.0357	0.0000	0.0000	0.0100	0.0318	0.0584	0.0855	0.1490
Cost of being out of equilibrium (DW_t)	86839	0.0237	0.0474	0.0000	0.0002	0.0018	0.0082	0.0245	0.0581	0.2383
Cost of overleveraging (DW_o)	41469	0.0356	0.0640	0.0000	0.0003	0.0020	0.0109	0.0399	0.1009	0.3118
Cost of underleveraging (DW_u)	45370	0.0128	0.0174	0.0000	0.0002	0.0016	0.0067	0.0174	0.0329	0.0773

Table 11: Conditional summary statistics for benefit and cost measures based on the marginal cost curves estimated from equations 9 and 5 for sample B for all industries except utilities, finance, and public adminstration. Panel A groups observations based on how far a firm-year observation actually observed is from the equilibrium for i) all observations, ii) overleveraged firm-years, and iii) underleveraged firm-years. Panel B groups observations based on how far the equilibrium IOB of a firm-year observation is from the observed actual IOB. The cutoffs follow those of the marginal benefit curves. The observed gross benefits of debt, GBD_o, is the area under the marginal benefits curve up to the observed level of interest over book value (IOB). The observed cost of debt, CD_o is the area under the marginal cost curve up to the observed level of IOB. The observed net benefits of debt, NBD_o, is the area under the marginal benefits curve minus the area under the marginal cost curve up to the observed IOB. Equilibrium is defined as the intersection of the marginal benefit and cost curves. The equilibrium gross benefits of debt, GBD_e, is the area under the marginal benefits curve up to the equilibrium level of IOB. The equilibrium cost of debt, CD_e is the area under the marginal cost curve up to the equilibrium level of IOB. The equilibrium net benefits of debt, NBD_e, is the area under the marginal benefits curve minus the area under the marginal cost curve up to the equilibrium IOB. The cost of being overleveraged, DW_o, is the deadweight loss from additional costs due to having IOB above the equilibrium. The cost of being underleveraged, DW_u, is the deadweight loss from lower benefits due to having IOB below the equilibrium. The cost of being out of equilibrium, DW_t, combines DW_o and DW_u into one measure.

Panel A: Grouping by percentage of observed IOB relative to equilibrium IOB																
	Analysis Based on (9) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$								Analysis Based on (5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$							
	N	GBD_o	CD_o	NBD_o	GBD_e	CD_e	NBD_e	DW_t	N	GBD_o	CD_o	NBD_o	GBD_e	CD_e	NBD_e	DW_t
	All Observations															
<5% of equilibrium	3903	0.1342	0.0963	0.0379	0.1354	0.0967	0.0387	0.0007	4126	0.1259	0.0770	0.0490	0.1264	0.0773	0.0491	0.0001
5%-10% from eq.	3687	0.1281	0.0911	0.0370	0.1310	0.0924	0.0386	0.0015	4108	0.1236	0.0743	0.0494	0.1251	0.0753	0.0498	0.0004
10%-20% from eq.	7641	0.1293	0.0920	0.0373	0.1358	0.0962	0.0396	0.0023	8309	0.1222	0.0742	0.0479	0.1272	0.0777	0.0495	0.0016
20%-40% from eq.	14165	0.1183	0.0834	0.0349	0.1376	0.0975	0.0401	0.0052	16063	0.1113	0.0663	0.0450	0.1291	0.0787	0.0504	0.0054
40%-60% from eq.	13027	0.0968	0.0686	0.0282	0.1367	0.0959	0.0408	0.0126	14687	0.0904	0.0544	0.0360	0.1259	0.0762	0.0497	0.0137
60%-80% from eq.	10641	0.0687	0.0526	0.0162	0.1208	0.0852	0.0356	0.0194	12120	0.0621	0.0407	0.0214	0.1091	0.0648	0.0443	0.0228
>80% from eq.	34387	0.0580	0.1053	-0.0473	0.0346	0.0243	0.0103	0.0576	27426	0.0632	0.0996	-0.0365	0.0416	0.0242	0.0174	0.0539
	Overleveraged Observations															
	N	GBD_o	CD_o	NBD_o	GBD_e	CD_e	NBD_e	DW_o	N	GBD_o	CD_o	NBD_o	GBD_e	CD_e	NBD_e	DW_o
<5% of equilibrium	1734	0.1329	0.0969	0.0360	0.1304	0.0937	0.0366	0.0006	1868	0.1245	0.0776	0.0469	0.1216	0.0746	0.0470	0.0001
5%-10% from eq.	1611	0.1331	0.0982	0.0349	0.1256	0.0891	0.0364	0.0015	1801	0.1305	0.0818	0.0487	0.1220	0.0729	0.0491	0.0004
10%-20% from eq.	3117	0.1443	0.1090	0.0353	0.1274	0.0902	0.0372	0.0019	3352	0.1386	0.0914	0.0472	0.1221	0.0732	0.0489	0.0017
20%-40% from eq.	4490	0.1581	0.1275	0.0306	0.1260	0.0900	0.0360	0.0054	5302	0.1414	0.1015	0.0399	0.1122	0.0673	0.0449	0.0050
40%-60% from eq.	3426	0.1656	0.1441	0.0214	0.1178	0.0832	0.0346	0.0131	4038	0.1497	0.1201	0.0296	0.1058	0.0628	0.0430	0.0133
60%-80% from eq.	2363	0.1778	0.1667	0.0111	0.1113	0.0807	0.0305	0.0194	2919	0.1477	0.1300	0.0176	0.0931	0.0551	0.0381	0.0204
>80% from eq.	29156	0.0659	0.1229	-0.0570	0.0241	0.0173	0.0068	0.0639	22189	0.0749	0.1222	-0.0473	0.0305	0.0177	0.0127	0.0600
	Underleveraged Observations															
	N	GBD_o	CD_o	NBD_o	GBD_e	CD_e	NBD_e	DW_u	N	GBD_o	CD_o	NBD_o	GBD_e	CD_e	NBD_e	DW_u
<5% of equilibrium	2169	0.1352	0.0958	0.0395	0.1394	0.0991	0.0403	0.0008	2258	0.1272	0.0765	0.0507	0.1304	0.0796	0.0509	0.0002
5%-10% from eq.	2076	0.1243	0.0856	0.0386	0.1352	0.0950	0.0402	0.0016	2307	0.1183	0.0684	0.0499	0.1276	0.0772	0.0504	0.0005
10%-20% from eq.	4524	0.1189	0.0803	0.0386	0.1416	0.1004	0.0413	0.0026	4957	0.1111	0.0626	0.0484	0.1306	0.0807	0.0499	0.0015
20%-40% from eq.	9675	0.0998	0.0629	0.0369	0.1429	0.1009	0.0420	0.0051	10761	0.0965	0.0490	0.0476	0.1374	0.0843	0.0531	0.0056
40%-60% from eq.	9601	0.0722	0.0416	0.0306	0.1434	0.1004	0.0430	0.0124	10649	0.0679	0.0295	0.0384	0.1336	0.0813	0.0522	0.0138
60%-80% from eq.	8278	0.0376	0.0200	0.0176	0.1235	0.0865	0.0371	0.0195	9201	0.0350	0.0123	0.0226	0.1142	0.0679	0.0463	0.0236
>80% from eq.	5231	0.0139	0.0069	0.0070	0.0930	0.0635	0.0295	0.0225	5237	0.0133	0.0040	0.0093	0.0888	0.0516	0.0372	0.0279

Panel B: Grouping by percentage of equilibrium IOB relative to observed IOB																
	Analysis Based on (9) $MC_{i,t} = a + bx_{i,t} + \sum\limits_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$								Analysis Based on (5) $MC_{i,t} = a + bx_{i,t} + \sum\limits_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$							
	Overleveraged Observations															
	N	GBD$_o$	CD$_o$	NBD$_o$	GBD$_e$	CD$_e$	NBD$_e$	DW$_o$	N	GBD$_o$	CD$_o$	NBD$_o$	GBD$_e$	CD$_e$	NBD$_e$	DW$_o$
Within 5% of observed	1308	0.1454	0.1078	0.0376	0.1433	0.1041	0.0392	0.0015	1619	0.1351	0.0867	0.0484	0.1319	0.0833	0.0485	0.0001
80%-95% of obs.	4807	0.1574	0.1215	0.0359	0.1415	0.1012	0.0403	0.0043	5461	0.1483	0.1014	0.0469	0.1310	0.0821	0.0489	0.0020
60%-80% of obs.	5688	0.1754	0.1512	0.0242	0.1294	0.0934	0.0360	0.0119	6695	0.1556	0.1226	0.0330	0.1141	0.0698	0.0443	0.0113
40%-60% of obs.	4194	0.1738	0.1772	-0.0034	0.1000	0.0713	0.0287	0.0321	5419	0.1385	0.1385	-0.0001	0.0788	0.0468	0.0319	0.0320
20%-40% of obs.	2884	0.1308	0.1696	-0.0388	0.0568	0.0390	0.0178	0.0566	4103	0.0916	0.1349	-0.0433	0.0365	0.0214	0.0150	0.0584
Less than 20% of obs.	16640	0.0267	0.0884	-0.0618	0.0018	0.0014	0.0004	0.0622	9259	0.0274	0.0874	-0.0600	0.0027	0.0018	0.0009	0.0609
	Underleveraged Observations															
	N	GBD$_o$	CD$_o$	NBD$_o$	GBD$_e$	CD$_e$	NBD$_e$	DW$_u$	N	GBD$_o$	CD$_o$	NBD$_o$	GBD$_e$	CD$_e$	NBD$_e$	DW$_u$
Within 5% of observed	1589	0.1448	0.1053	0.0395	0.1495	0.1086	0.0409	0.0014	1621	0.1361	0.0849	0.0511	0.1393	0.0881	0.0512	0.0001
105%-120% of obs.	3992	0.1302	0.0911	0.0390	0.1466	0.1055	0.0411	0.0021	4448	0.1232	0.0737	0.0496	0.1375	0.0871	0.0504	0.0008
120%-160% of obs.	8279	0.1102	0.0734	0.0368	0.1512	0.1092	0.0420	0.0052	9078	0.1049	0.0578	0.0471	0.1428	0.0913	0.0515	0.0044
160%-200% of obs.	5232	0.0860	0.0539	0.0321	0.1520	0.1098	0.0422	0.0101	5678	0.0811	0.0404	0.0408	0.1424	0.0911	0.0512	0.0105
200%-300% of obs.	6329	0.0635	0.0377	0.0258	0.1490	0.1067	0.0423	0.0165	6852	0.0579	0.0242	0.0337	0.1351	0.0833	0.0518	0.0181
300%-400% of obs.	2762	0.0437	0.0250	0.0187	0.1455	0.1045	0.0409	0.0222	3061	0.0374	0.0135	0.0239	0.1257	0.0767	0.0490	0.0251
400%-500% of obs.	1716	0.0283	0.0155	0.0128	0.1207	0.0859	0.0347	0.0219	1726	0.0254	0.0082	0.0173	0.1110	0.0661	0.0448	0.0276
500%-600% of obs.	1503	0.0167	0.0091	0.0076	0.0863	0.0611	0.0252	0.0176	1249	0.0186	0.0046	0.0141	0.1012	0.0551	0.0461	0.0321
600%-700% of obs.	921	0.0179	0.0098	0.0082	0.1078	0.0754	0.0324	0.0242	915	0.0133	0.0019	0.0114	0.0856	0.0406	0.0450	0.0336
700%-800% of obs.	691	0.0165	0.0091	0.0075	0.1098	0.0783	0.0315	0.0240	760	0.0112	0.0021	0.0091	0.0825	0.0418	0.0407	0.0316
800%-900% of obs.	599	0.0127	0.0067	0.0060	0.1047	0.0739	0.0309	0.0249	659	0.0103	0.0005	0.0098	0.0867	0.0387	0.0480	0.0382
More than 900% of obs.	435	0.0125	0.0068	0.0056	0.1024	0.0785	0.0238	0.0182	568	0.0088	0.0029	0.0059	0.0821	0.0509	0.0312	0.0253

Table 12: Conditional summary statistics of benefit and cost of debt for firms in equilibrium. Measures are based on the marginal cost curves estimated from equations 9 and 5 for sample B for all industries except utilities, finance, and public adminstration. 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 overleveraged, DW_o, is the deadweight loss from additional costs due to having IOB above the equilibrium. The cost of being underleveraged, DW_u, is the deadweight loss from lower benefits due to having IOB below the equilibrium. The cost of being out of equilibrium, DW_t, combines DW_o and DW_u into one measure.

Analysis Based on (9) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$							
	N	GBD	CD	NBD	DW_t	DW_o	DW_u
20% of equilibrium	3876	0.0271	0.0139	0.0132	0.0254		0.0254
40% of equilibrium	3876	0.0541	0.0305	0.0236	0.0150		0.0150
60% of equilibrium	3876	0.0810	0.0498	0.0313	0.0074		0.0074
80% of equilibrium	3876	0.1078	0.0718	0.0361	0.0026		0.0026
at equilibrium	3876	0.1344	0.0965	0.0379	0.0008	0.0007	0.0009
120% of equilibrium	3876	0.1593	0.1240	0.0353	0.0033	0.0033	
160% of equilibrium	3876	0.2036	0.1871	0.0165	0.0222	0.0222	
200% of equilibrium	3876	0.2426	0.2611	-0.0185	0.0572	0.0572	
300% of equilibrium	3876	0.3178	0.4936	-0.1758	0.2145	0.2145	
400% of equilibrium	3876	0.3667	0.7941	-0.4274	0.4661	0.4661	
500% of equilibrium	3876	0.3983	1.1627	-0.7644	0.8031	0.8031	
Analysis Based on (5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$							
	N	GBD	CD	NBD	DW_t	DW_o	DW_u
20% of equilibrium	4144	0.0255	0.0083	0.0172	0.0319		0.0319
40% of equilibrium	4144	0.0508	0.0201	0.0307	0.0184		0.0184
60% of equilibrium	4144	0.0760	0.0354	0.0405	0.0085		0.0085
80% of equilibrium	4144	0.1009	0.0542	0.0467	0.0024		0.0024
at equilibrium	4144	0.1255	0.0766	0.0489	0.0001	0.0001	0.0002
120% of equilibrium	4144	0.1485	0.1024	0.0461	0.0030	0.0030	
160% of equilibrium	4144	0.1894	0.1646	0.0248	0.0243	0.0243	
200% of equilibrium	4144	0.2249	0.2408	-0.0159	0.0650	0.0650	
300% of equilibrium	4144	0.2912	0.4926	-0.2013	0.2508	0.2508	
400% of equilibrium	4144	0.3326	0.8320	-0.4994	0.5493	0.5493	
500% of equilibrium	4144	0.3589	1.2591	-0.9003	0.9508	0.9508	

Table 13: Analysis on alternative definitions of being financially unconstrained (C) KZ index below median, (D) CL index below median, (E) WW index below median, and (F) LTDEIR in the top quartile. GMM estimation of the coefficients in equations 5 and 9 for all industries except utilities, finance, and public adminstration. The error functions are defined according to equations 6 and 10 where $y^*_{i,t}$ is the 'equilibrium' marginal benefit/cost level, $x^*_{i,t}$ is the observed or 'equilibrium' interest expenses over book value (IOB) and C is the set of cost control variables. GMM moments are obtained by interacting the error function with the following instruments: the constant term, the variation of the marginal benefit curve $A_{i,t}$, and each of the control variables. The set of control variables is $C \equiv \{LTA, PPE, BTM, DDIV, CF, CASH\}$, where LTA is log of total assets expressed in 2000 dollars, PPE is plant, property, and equipment over total book values, BTM is book equity to market equity, DDIV is an indicator for dividend paying firms, CF is net cashflow over total book values, and CASH is cash holdings over total book values. The control variables are standardized to have mean zero and standard deviation one based on Sample A (and are not re-standardized across samples). Robust, firm-clustered GMM standard errors are reported in the parentheses. Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***.

	(9) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$				(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \delta_c c_{i,t} + \xi_{i,t}$			
	Sample C	Sample D	Sample E	Sample F	Sample C	Sample D	Sample E	Sample F
Constant	0.251 ***	0.215 ***	0.238 ***	0.172 ***	0.203 ***	0.172 ***	0.161 ***	0.096 ***
	(0.004)	(0.005)	(0.005)	(0.007)	(0.005)	(0.005)	(0.007)	(0.008)
IOB	3.752 ***	4.507 ***	3.038 ***	5.008 ***	4.613 ***	4.872 ***	4.811 ***	5.808 ***
	(0.188)	(0.227)	(0.213)	(0.227)	(0.160)	(0.192)	(0.196)	(0.220)
LTA*IOB	0.150 *	0.302 ***	0.349 ***	0.494 ***				
	(0.089)	(0.107)	(0.105)	(0.095)				
PPE*IOB	0.350 ***	-0.373 ***	-0.189 *	-0.494 ***				
	(0.133)	(0.125)	(0.099)	(0.091)				
BTM*IOB	0.304 ***	0.063	0.148 **	-0.340 ***				
	(0.075)	(0.085)	(0.072)	(0.056)				
DDIV*IOB	0.724 ***	1.121 ***	0.966 ***	0.763 ***				
	(0.088)	(0.098)	(0.068)	(0.073)				
CF*IOB	1.341 ***	1.433 ***	1.707 ***	1.361 ***				
	(0.150)	(0.188)	(0.204)	(0.152)				
CASH*IOB	0.998 ***	1.071 ***	0.984 ***	1.937 ***				
	(0.133)	(0.194)	(0.176)	(0.159)				
LTA					0.007 ***	0.011 ***	0.006 **	0.020 ***
					(0.002)	(0.002)	(0.002)	(0.003)
PPE					0.011 ***	-0.012 ***	-0.008 ***	-0.022 ***
					(0.003)	(0.003)	(0.003)	(0.004)
BTM					0.004	-0.005 **	-0.007 ***	-0.023 ***
					(0.002)	(0.002)	(0.003)	(0.003)
DDIV					0.026 ***	0.036 ***	0.035 ***	0.035 ***
					(0.002)	(0.002)	(0.002)	(0.002)
CF					0.063 ***	0.074 ***	0.077 ***	0.086 ***
					(0.003)	(0.004)	(0.004)	(0.004)
CASH					0.034 ***	0.032 ***	0.038 ***	0.059 ***
					(0.002)	(0.003)	(0.003)	(0.003)
No. Obs.	21811	19437	19713	14476	21811	19437	19713	14476