The Cost of Debt*

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Abstract

We estimate firm-specific cost of corporate debt functions for thousands of companies from 1980 to 2006. The positively sloped cost curves are identified by observing exogenous shifts of debt benefit curves. By integrating the area between the benefit and cost functions we estimate that the net benefit of debt is about 3% of asset value, in comparison to a cost of debt equal to about 7% of asset value. Our findings are consistent over time and when accounting for fixed adjustment costs of debt. The location of a given company's cost of debt function varies with characteristics such as asset tangibility, size, book-to-market, cash flows, cash holdings, and whether the firm pays dividends. We provide easy to use algorithms that allow others to construct firm-specific cost of debt curves. Our framework provides a new parsimonious environment within which to examine implications from competing capital structure theories. It also allows us to make recommendations about firm-specific optimal debt ratios and to approximate the cost of being under- or overlevered.

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1 Introduction

Hundreds of papers investigate corporate financial decisions and the factors that influence capital structure. Much theoretical work characterizes the choice between debt and equity in a trade-off context in which firms choose their optimal debt ratio by balancing the benefits and costs. Traditionally, tax savings that occur because interest is deductible have been modeled as a primary benefit of debt (Kraus and Litzenberger, 1973). Other benefits include committing managers to operate efficiently (Jensen, 1986) and engaging lenders to monitor the firm (Jensen and Meckling, 1976). The costs of debt include financial distress (Scott, 1976), personal taxes (Miller, 1977), debt overhang (Myers, 1977), and agency conflicts between managers and investors or among different groups of investors. For the most part, these theoretical predictions have been tested using reduced form regressions that attempt to explain variation in capital structure policies by studying the signs of estimated slope coefficients for factors such as firm size, tax status, asset tangibility, profitability, and growth options (Rajan and Zingales, 2003; Frank and Goyal, 2004; Graham, Lemmon, and Schallheim, 1998).

In this paper, we go beyond the reduced form regression approach and empirically estimate the entire cost function for corporate debt. This allows us to explicitly calculate the net benefit of debt, as well as identify optimal capital structure for publicly traded firms. Analogous to textbook supply/demand identification, we use variation in the benefit curve to identify the cost function. In our case, we start with Graham's (2000) simulated marginal tax benefit curves and observed (equilibrium) debt choices. Whereas in the standard framework one has to use instrumental variables that *proxy* for shifts of the demand (supply) curve to identify the supply (demand) curve, we have the advantage of observing *actual* shifts of the marginal benefit curve. Even so, to properly identify the cost of debt curve, the cost function needs to be held constant while the benefit function varies; therefore, a standard OLS approach can not discern whether variation occurs due to cost or benefit shifts and therefore can not identify cost functions. Instead, we use several different identification methods.

In our first identification strategy, we purge the data of potential shifts in the cost curve by including regressors that essentially control for the cost environment and hold the cost curve fixed. Then we use the remaining variation (which should be due to 'pure' benefit shifts) to identify the cost curve. We separately use two other identification strategies that do not require purging cost effects. 1) We examine exogenous tax regime changes that alter corporate marginal tax rates (which in turn shift the tax benefit function), and 2) we use a difference-in-difference specification based on a 1987 tax regime shift that was phased in at different times for otherwise similar firms. The three identification strategies corroborate each other in that they produce qualitatively similar estimated cost of debt functions.

The estimated cost of debt curves are positively sloped (i.e., cost increases with debt interest), as expected. Thus, the slope of the curve captures debt costs that increase directly with the amount of debt used, such as expected costs of financial distress. Our estimation procedure allows the location of the cost functions to vary (i.e., shift) with firm characteristics such as asset collateral, intangibility, size, book-to-market, cash flows, cash holdings, and dividend-paying status. Therefore, the location of the cost function captures these firm-specific features of the cost of debt. For example, the cost function shifts downward as a firm's collateral increases. In general, our approach produces an ex ante estimate of the entire net cost of debt function for a wide variety of firms.[1] This contrasts with point estimates of debt costs, for small subsets of firms, provided in previous research. We also produce easy-to-implement algorithms that allow researchers and practitioners to explicitly specify the debt cost function by firm. We emphasize that our cost estimates can be used by researchers as an alternative to the work-horse Altman's (1968) Z-score, measure of financial distress which is based on coefficients estimated in the 1960s.

Armed with simulated tax benefit functions and estimated cost of debt functions for every company in our sample, we determine optimal capital structure for any given firm at the intersection of the benefit and cost curves in Figure 1. We also integrate the area between the curves to estimate the net benefits of debt financing, and similarly estimate the cost of deviating from the optimum. Among firms operating at or near the implied optimum, the average gross tax benefits of debt equal 13.3% of book value in perpetuity, costs equal 9.5% of book value, and thus net benefits of debt are 3.9% of book value. If all the firms in the sample were to operate at the implied equilibrium level, we estimate that the cost of debt would be about 6.6% of book assets, and the *net* benefit of debt would average 2.8% of book value in perpetuity. At any given point in time, one might not expect all firms to operate at their long-run unconstrained equilibrium. For example, among firms that we label as financially constrained, our numbers imply that deadweight losses of constrained or suboptimal debt choices are 2.5% of book value. Among those we cataegorize as distressed, deadweight losses from superoptimal debt choices are 4.3% of book value. Thus, in our sample, the cost of being overlevered appears to be more severe than being underlevered.

In our main analysis, we initially set aside financially distressed companies, as well as firms that appear to be financially constrained (e.g., zero debt firms). We assume that the

[1] We estimate the 'net' cost of debt because we start with tax benefit functions, so the cost functions capture all costs as well as non-tax benefits (that show up as negative costs).

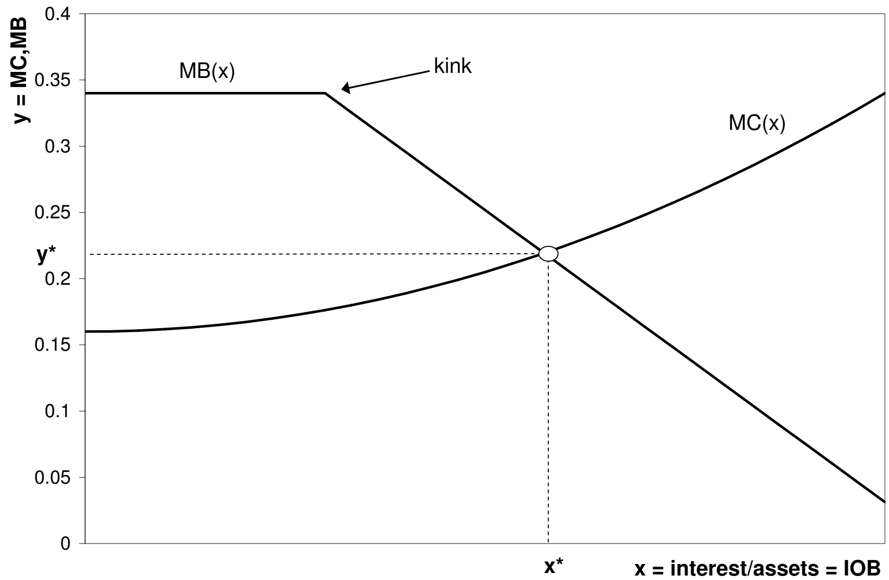

Figure 1: Capital structure equilibrium for a financially unconstrained, non-distressed firm. The figure shows the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, and the equilibrium amount of interest deductions, x^*, where marginal cost and marginal benefit are equated. The equilibrium marginal benefit (which equals the cost) is denoted by y^*. Also, note that the benefit function becomes downward sloping at the point we refer to as the 'kink.'

remaining firms make (close to) optimal debt choices, and we use these choices to back out what the costs of debt must be (or at least what the costs must be in management's perception) to justify observed debt ratios. Given that our main analysis sets aside firms that appear to be constrained and/or use no debt, our main analysis does not explicitly study the least levered firms. However, including these firms does not change our main conclusions. Related to this issue, our analysis is 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, 2007) that fixed adjustment costs prevent firms from responding instantaneously to changing conditions, leading to infrequent capital structure adjustments. To address this, we conduct our analysis on only those firm-year observations in which a substantial rebalancing of capital structure occurs, and this analysis indicates that fixed adjustment costs do not drive our main results.

Traditional debt cost studies examine small samples and focus on a subset of the ex post costs of debt. Warner (1977), for example, studies 11 bankrupt railroad companies, and estimates that ex post direct bankruptcy costs are about 5.3 percent of firm value. Weiss (1990) similarly estimates that direct bankruptcy costs are only 3.1 percent of firm value in a sample of 37 companies. Andrade and Kaplan (1998) estimate that for a sample of 31 highly levered firms, when distress occurs the cost of financial distress is no more than

10 to 20 percent of firm value. Miller (1977) and others note that once one considers the relatively low probability that financial distress will occur, the ex ante costs of debt appear to be small. One implication from these papers is that there must be other costs of debt that are sufficiently large to justify the debt choices that firms make. While these traditional papers are instructive, our analysis contributes by directly estimating ex ante all-in costs of debt, and by examining a broad cross-section of firms rather than a small ex post cost of debt sample.

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

Our approach is related to two other recent papers. Almeida and Philippon (2007) derive risk-neutral probabilities of default that capture the fact that the marginal utility of money is high in distress states. (Chen (2007) makes a similar point.) Using these probabilities, they estimate that the expected cost of distress is approximately equal to the tax benefits of debt estimated in Graham (2000), suggesting that on average observed capital structure is consistent with optimal choices. More specifically, the authors provide a point estimate of the cost of default that is about four percent of firm value for investment grade firms and seven or eight percent for speculative debt. We estimate that the all-in cost of debt is about 8.4 (11.6) percent of asset value for investment (speculative) grade firms. Therefore, our estimates are in the same ballpark but larger than Almeida and Philippon's, which makes sense because their estimates capture default costs while ours include default as well as other costs of debt such as agency costs. Overall, our analysis shows that bankruptcy costs, as estimated by Almeida and Philippon (2007), amount to approximately half of the total costs of debt, leaving about half of the costs to be explained by other factors and theories.[2]

Korteweg (2007) estimates the cost of financial distress for 269 firms from 1994 to 2004.

[2]We also benchmark the reasonableness of our numbers by showing that our estimated cost of debt for firms in the 95th percentile are very similar to the costs estimated by Andrade and Kaplan (1998) for highly levered firms.

He infers the cost of debt based on observed market debt and equity values and their implied relation in the traditional formulas that link the levered and unlevered value of the firm and that lever betas. Given that he has fewer equations than unknowns (the unknowns are the net benefit of debt and the unlevered value of the firm, plus their betas), Korteweg makes several simplifying assumptions to identify his system of equations. He assumes Normal iid errors, a specific quadratic function for the cost of debt, that the Modigliani and Miller (1958, 1963) beta levering formulas are correct, and intra-industry homogeneity (two firms in same industry with the same leverage have same same tax benefits and same costs of financial distress). Even with this different approach, Korteweg estimates an (upper bound) cost of debt of approximately five percent of firm value, not too far from our estimates. Some of the advantages of our approach are that our estimated cost of debt functions can vary by firm (even within an industry), we do not make specific distributional or functional form assumptions regarding beta formulas, we estimate the entire cost of debt function, and our end-product produces coefficient estimates that can be used by anyone to easily specify the cost of debt for any firm.

The rest of the paper proceeds as follows. In Section 2, we explain the main intuition and econometric issues underlying our instrumental variables approach. In Section 3, we describe the data and our sample selection process. In Section 4, we report and discuss our results. Section 5 presents the cost of debt functions and examines how they can be implemented in case studies. 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 panel of approximately 124,000 firm-years between 1980 and 2006. The marginal benefit curves measure the marginal tax benefit for each dollar of incremental interest deduction (simulation details are described in Section 3).

We observe the current level of debt for each firm in each year. Henceforth, we refer to this observed level of debt as the "equilibrium amount of interest" or the "equilibrium level of debt," denoted by $x^*_{i,t}$. That is, we implicitly assume that for financially unconstrained, non-distressed firms, the marginal cost curve of debt (MC) intersects the marginal benefit curve of debt (MB) at the equilibrium level. We refer to the 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:

$$y_{i,t}^{*} \equiv MC_{i,t}\left(x_{i,t}^{*}\right) = MB_{i,t}\left(x_{i,t}^{*}\right). \qquad (1)$$

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

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

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 of assets, can alternatively be used without changing our main results. Figure 1 illustrates the equilibrium concept for a financially unconstrained, non-distressed firm.

Note that we cannot use standard ordinary least squares estimation techniques. Based on equilibrium $x_{i,t}^{*}, y_{i,t}^{*}$ choices, OLS is unable to determine whether variation is due to shifts in the cost or benefit curves, and hence is unable to identify either curve accurately. Only by using instrumental variables are we able to isolate benefit shifts and therefore identify the cost curve (see Appendix A for intuition).

To implement the instrumental variables approach, 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 (described in Section 2.3). Alternatively, exogenous benefit shifts may also reflect cross-sectional variation in the location of the marginal benefit curve of debt at some time t (described in this section). See Figure 2 for an illustration.

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 error (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 are left with a pure benefit shifter. Note that one advantage of this approach is that it can be implemented on data for which there is no exogenous tax regime or other time series event.

To implement this approach, we first compute for each firm in each year the total potential tax benefit of debt, $A_{i,t}$, which is equal to the area under the marginal tax benefit curve:

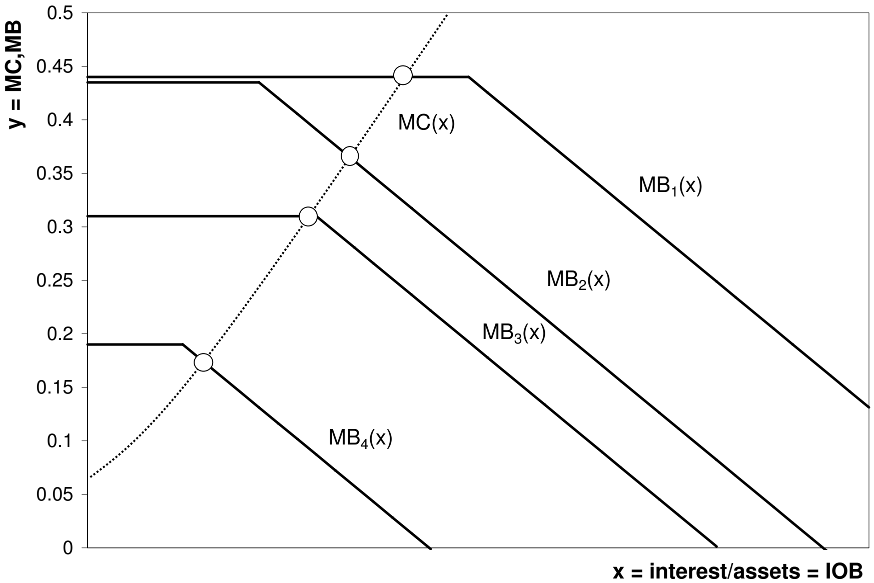

Figure 2: Identifying the cost function using shifts in the marginal benefit function. The figure shows four marginal benefit curves of debt, each intersected by the marginal cost curve of debt. The four marginal benefit curves can represent the same firm at four different points in time. The marginal benefit curves can alternatively represent four different firms at the same point in time. Empirically, we use both cross-sectional and time-series variation in marginal benefit curves to identify the marginal cost function of debt. Notice that the area under the marginal benefit curve, A, is a good proxy for the location of the curve: $MB_1(x) \supseteq MB_2(x) \supseteq MB_3(x) \supseteq MB_4(x)$ implies that $A_1 \geq A_2 \geq A_3 \geq A_4$.

$$A_{i,t} = \int_0^\infty f_{i,t}\left(x_{i,t}\right) dx_{i,t}. \tag{3}$$

Since the area under the curve measures the total potential tax benefits, $A_{i,t}$ provides a natural description for the location of the marginal benefit curve and accommodates non-linearities in benefits (see Appendix A for a detailed discussion). If the marginal benefit curve shifts upward (downward), then the area under the curve increases (decreases) in tandem. Henceforth, we interpret variation in this area measure as variation (shifts) of the marginal benefit curve.[3]

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

[3]Using alternative approaches to capture shifts of the marginal benefit curve, such as the location of the kink in the marginal benefit curve or partitions of the area measure, lead to similar results (see Section 7). For ease of exposition we focus on the area measure.

firm pays dividends ($DDIV_{i,t}$). These variables are standard measures of debt costs in the literature (Frank and Goyal, 2004). Define C as the set of cost control variables that drive the location of the MC curve:

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

We assume that the marginal cost of debt function is linear in both interest-over-book (IOB), denoted by $x_{i,t}$, and the cost control variables, C.[4] 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 describe the intuition behind the identification strategy in the context of 2SLS. In the end, we use generalized method of moments (GMM) to estimate equation 5, as described in Section 2.2. Section 2.3 discusses alternative specifications.

2.1 2SLS Estimation

To provide intuition, we discuss how 2SLS could be used to estimate cost of debt functions. First one would purge $A_{i,t}$ of possible cost effects, by performing the following regression:

$$A_{i,t} = \beta_0 + \sum_{c \in C} \beta_c c_{i,t} + \varepsilon_{i,t}. \tag{6}$$

By construction, the error term $\varepsilon_{i,t}$ of this regression is orthogonal to the regressors (i.e., the cost 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. This variation can be used to identify the marginal cost curve of debt. It is important to note that when purging the cost effects, we may not have controlled for all possible cost variables. As in any model specification, this could possibly lead to omitted variable bias. (To ensure that our results are not driven by such econometric issues, we separately perform our analysis using alternative specifications, discussed in Section 2.3, and find very similar results.)

This error term, $\varepsilon_{i,t}$, which captures pure benefit shifts, is the main identifying instrument

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

used in 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:

$$x^*_{i,t} = \beta_0 + \beta_\varepsilon \varepsilon_{i,t} + \sum_{c \in C} \beta_c c_{i,t} + \eta_{i,t}, \tag{7}$$

where $\eta_{i,t}$ is the error term of the first-stage regression.[5] In the second stage, the 2SLS approach would regress $y^*_{i,t}$ on a constant, the fitted values of the first stage regression, $\hat{x}^*_{i,t}$, and the control variables in C to obtain the slope and the intercept of the marginal cost curve.

$$y^*_{i,t} = a + b\hat{x}^*_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}, \tag{8}$$

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 above, it controls for shifts in the location of the marginal cost curve. Second, it allows each control variable to affect the functional form of the marginal cost curve. As described in the next section, rather than use 2SLS, we equivalently estimate an exactly identified GMM system with double-clustered standard errors (Thompson (2006) and Petersen (2007)).

2.2 Generalized Method of Moments (GMM)

To estimate equation 5,

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

via generalized method of moments (GMM), we define the corresponding error function, $g_{i,t}$, as

$$g_{i,t} = y^*_{i,t} - a - bx^*_{i,t} - \sum_{c \in C} \delta_c c_{i,t}. \tag{9}$$

We estimate the coefficients, in an exactly identified system of equations. 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. Alternatively, we 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

[5] Given the presence of the control variables in the first stage, $\varepsilon_{i,t}$ could be replaced in equation 7 by $A_{i,t}$.

is given by:

$$MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}, \tag{10}$$

and the corresponding error function is given by

$$g_{i,t} = y^*_{i,t} - a - bx^*_{i,t} - \sum_{c \in C} \theta_c c_{i,t} x_{i,t}. \tag{11}$$

2.3 Alternative Specifications

We also consider two additional identification strategies. As before, the error functions are defined according to equations 9 and 11. 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, $A_{i,t}$ (as discussed above),

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

(iii) a dummy for December fiscal year-end firms, a dummy for the implementation of the Tax Reform Act of 1986, and the difference in difference dummy that is the product of the two.

Specification (ii) uses as the identifying instrument corporate tax regime shifts over the period 1980 to 2006. The tax regime shifts provide a natural experiment in that these shifts should be directly correlated with the benefit function but not with variables that affect the location of the cost function.

Tax regime changes can alter statutory corporate tax rates as well as the income level applicable to each tax bracket. To incorporate both potential changes, we create eleven non-overlapping brackets that span all income/tax rate combinations during our sample period.[6] For example, in 1980 the lowest tax bracket is from \$0 to \$25,000, but changes to \$0 to \$50,000 in 1988. We account for this by including two brackets in every year: one from \$0 to \$25,000 and one from \$25,001 to \$50,000. The tax rates for all eleven income brackets used in specification (ii) are listed in Appendix B.

[6] To eliminate the possibility that the results from the time series analysis are 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 based on all eleven brackets.

The Tax Reform Act of 1986 offers a unique feature that aids identification. Firms with fiscal year-ends in June 1987 had all 12 months of income subject to tax rates at the old 46 percent tax rate that year (see Maydew 1997). Income for July 1987 upper bracket fiscal year-end firms was subject to a blended tax rate that was $\frac{1}{12}$ of the new 34 percent statutory tax rate and $\frac{11}{12}$ of the old 46 percent tax rate.[7] Firms with fiscal year ending in August are exposed to $\frac{2}{12}$ of the new tax rate and $\frac{10}{12}$ of the previous tax rate for each income bracket, and so on. Firms with December fiscal year end face half of the old tax regime and half of the new tax regime (i.e., an upper bracket maximum tax rate of $\frac{1}{2}(0.46)+\frac{1}{2}(0.34)=0.40$). By June 1988, all firms had switched over to the new regime that had a maximum 34 percent tax rate.

This unique phase-in of the tax regime aids identification strategy (ii). It also permits a difference-in-difference identification strategy (iii) in which we compare December 1987 fiscal year end firms that were taxed at 40 percent to June 1987 firms that were taxed at 46 percent. The statistical advantage of this phase-in is that firms that are essentially similar in every way but fiscal year-end were affected differentially by the exogenous change in corporate tax rates, allowing identification tied just to the tax regime changes. To implement specification (iii) we limit the sample to only June and December fiscal year-end firms. We use as the identifying instruments the variation in a December fiscal year-end dummy, a dummy for the implementation of the TRA of 1986, and the difference in difference dummy that is the product of the two. While arguably pristine, the disadvantage is that this approach uses much less information to uncover the marginal cost curve of debt than does our primary approach, which not only relies on time series variation but on cross sectional variation as well. 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 2006, using only the time series of tax rate changes or the difference in difference approach is infeasible.

[7] The accounting data for a July 1987 fiscal year-end firm covers 11 months prior to and including June 1987 and one month post June 1987.

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, as incremental interest deductions are added, all taxable income would be shielded by interest deductions, and incremental deductions would be worthless. Therefore, ignoring the complexities of the tax code, a static tax benefit function would be a step function that has an initial value of 0.35 and eventually drops to 0.0.

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

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

More specifically, we calculate one point on a tax benefit function for one firm in one year as follows. (Recall that each point on the function represents the expected corporate marginal tax rate (MTR) for that level of income and interest deduction.) The first step for a given firm-year involves calculating the historic mean and variance of the change in taxable income for each firm. Using this historical information, the second step forecasts future income many years into the future to allow for full effects of the tax carryforward feature of the tax code (e.g., 2005 current tax law specified that tax losses could 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, carryforward, and other dynamic features of the tax code. The fourth step adds $10,000 (the smallest increment observable in Compustat data) to current year income and recalculates the present value tax liability along each path. The incremental tax liability calculated in the fourth step, minus that calculated in the third step, is the present value tax liability from earning extra income today; in other words, the economic MTR. A separate marginal tax rate is calculated along each of the forecasted income paths to capture the different tax situations a firm might experience in different future scenarios. The idea is to mimic the different planning scenarios that a manager might consider. The final step averages across the MTRs from the 50 different scenarios to calculate the expected economic marginal tax rate for a given firm-year.

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

These steps are replicated for each firm for each year, to produce a panel of firm-year tax benefit functions for each year from 1980 to 2006. 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 2006. Merging the tax benefit functions with COMPUSTAT based on eight digit firm CUSIP creates 124,189 firm-year observations.[8] We normalize equilibrium interest expense by total book assets, which hereafter we refer to as interest-over-book (IOB). Note that COL, INTANG, 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 inflation before taking logarithms. We further remove any firms with non-positive book asset value, 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. Next, we delete observations that were involved in substantial M&A activity, defined as acquisitions amounting to over 15 percent of total assets. Third, we remove outliers defined as firm-year observations that are in the first and 99th percentile tails for (i) area under the marginal benefits curve (A), (ii) the observed interest-over-book (IOB), (iii) the book to market ratio (BTM), and (iv) the cashflow over assets ratio (CF).[9] Finally we remove all firms in the financial and insurance, utilities, and public administration industries as they tend to be heavily regulated. This results in a sample of 91,343 firm-years, of which 79,552 have non-missing data for IOB and all control variables. Table 1 provides an overview of the sample construction.

For each firm, we create empirical measures of the control variables described in the previous section: collateralizable assets over total book assets (COL) which includes plants, properties, and equipments and inventories, intangible assets over total book assets (INTANG), log of total book assets (LTA), book equity to market equity (BTM), cash flow over total book assets (CF), cash holdings over total book assets (CASH), and an indicator for a dividend paying firm (DDIV). 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

[8]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 affected by this issue.

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

the median. We measure financial constraint according to firms with no or limited long term leverage adjustments (LTDEIR).[10] This approach allows us to address fixed transaction cost issues as discussed below. Appendix C provides a detailed description of the construction of each control variable.

3.3 Data Samples, Financial Constraint, and Financial Distress

We perform our empirical analysis on two primary samples:

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

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

There are two reasons that we focus our attention on Sample B. First, our empirical approach assumes that observed debt ratios represent equilibrium choices. Compared to constrained or distressed firms, the observations in Sample B are relatively likely to represent unconstrained, long-term capital structure equilibria. Of course, one could argue that the constrained and distressed firms in Sample A also make optimal choices, possibly in response to steeper cost functions. In this way of thinking, comparing the results across the samples will highlight the differing costs facing distressed or constrained firms.

The second reason that we focus on Sample B is to attenuate the effect of observations that might be severely affected by fixed adjustment costs. Recent research highlights that firms might not continuously adjust their leverage ratios due to non-negligible adjustment costs (Leary and Roberts, 2005; Kurshev and Strebulaev, 2006; etc.), which can lead to data that reflect passive, or no change, observations. Sample B avoids this issue by only including firm-year observations in which there is substantial long term debt and/or equity issuance or repurchase (LTDEIR), observations for which fixed transactions did not constrain the firm into inaction. Sample B includes firms that are financially unconstrained, defined as having LTDEIR above the median issuance or reduction. Even if we tighten the definition and include only firms above the 75th percentile, the main results do not change.[11] Overall, relative to Sample A, Sample B is relatively free of the effects of financial constraints, financial

[10] We also look at two other definitions for financial constraint offered in the literature: (i) the Cleary (1999) index (CL) and (ii) the Whited and Wu (2005) index (WW). These are discussed in Section 7.

[11] In our sample the median levels of long term debt issuance and reduction among all firm-year observations are 6.9 and 3.3 percent of book value, respectively. These numbers increase to 16.4 and 9.3 percent, respectively, when we consider debt issuances and reductions above the 75th percentile. For equity issuances and repurchases, the medians are 0.7 and 1.0 percent of book value, respectively, and 3.5 and 3.2 percent at the 75th percentile.

distress, and fixed adjustment costs. Table 2 compares the summary statistics for these samples.

4 Results

As described in Section 2, we estimate the marginal cost curve for three main specifications: (i) panel identification, (ii) time series tax regime identification, and (iii) difference in difference identification. They differ in their identifying instrument(s): (i) using $A_{i,t}$, (ii) using corporate tax rates from eleven tax brackets across time, and (iii) a dummy for December fiscal year-end firms, a dummy for the implementation of the Tax Reform Act of 1986, and a difference in difference dummy that is the product of the two. We repeat specifications (i)-(iii) with firm fixed effects as specifications (iv)-(vi), respectively.[12] Tables 3 and 4 report the estimation results for samples B and A, respectively, for all six specifications. 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.

As described in more detail below, estimated coefficients for the slope of the marginal cost curve for Sample B (see second row of Table 3) are generally flatter than the slopes estimated on Sample A, likely reflecting the higher costs faced by constrained or distressed firms. The signs on the coefficients of the cost control variables are consistent across samples and specifications. It is worthy to note that, compared to specification (i), the slope is slightly larger in the time series approach but the intercept is smaller. So relatively speaking, the MC curve pivots upward in specification (ii). Similarly, the slope of the estimated MC curve in the difference in difference approach is larger than in either specifications (i) or (ii), but the intercept is also smaller than either specification. Thus, it is hard to say unambiguously that any one estimated MC curve dominates the others based on slopes alone. Furthermore, compared to specification (i), the standard errors in the tax regime approach are large. This is expected given that much capital structure variation is cross-sectional (Lemmon, Roberts, Zender, forthcoming JF), and is lost in the tax regime approach. Although, specification (iii) represents a fairly clean experiment, the difference in difference approach highlights only June and December fiscal year-end firms and the Tax Reform Act of 1986 and thus leads to the least precise estimates. Nonetheless, the similarity across these three approaches implies that errors, if any, are not too large. Finally, we note that including firm fixed effects affects specifications (iv) and (vi) more than (v) and increases standard errors in all cases, as expected.

[12] Since specifications (i) and (iii) rely on cross-sectional instruments, we would expect adding firm fixed effects to have more impact on these specifications than on specification (ii).

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

Table A: The influence of each of the control variables on the cost of debt (as estimated in Tables 3 and 4), and on the corporate debt ratios (as documented in the capital structure literature). COL is asset collateralizability, LTA is firm size in terms of book assets, BTM is the book to market ratio, INTANG is asset intangibility, CF is cashflow, CASH is the firm's cash holdings, and DDIV is an indicator for dividend paying firms.

Within our framework, the capital structure decision follows from a tradeoff between the costs and benefits of debt. It is important to highlight that our marginal benefit curves only measure the tax benefits of debt. As a consequence, the other benefits of debt, such as committing managers to operate efficiently (Jensen, 1986) and engaging lenders to monitor the firm (Jensen and Meckling, 1976), are included 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), debt overhang (Myers, 1977), agency conflicts between managers and investors, and any other cost that firms consider in their optimal debt choice.

Next, 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 expositional reasons we henceforth focus on the analysis of sample B for specification (i), the panel identification approach. Table A summarizes the effect of the control variables on the cost of debt function, and compares these coefficients to standard capital structure results (as presented in Frank and Goyal (2004) and elsewhere). As we highlight below when we discuss the effect of each control variable, 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 corroborates the implications from our analysis. There are a great many unanswered questions in the capital structure literature in terms of interpreting individual coefficients, and by no means does our procedure solve all these puzzles and unanswered questions. Rather, our procedure quantifies just how large the influence of individual variables on the cost of debt must be to explain observed capital structure choices.

4.1 Marginal Cost Curves with Fixed Intercept

In this section, the slope of the marginal cost curve varies across firms conditional on the control variables but the intercept is the same for all firms. (We allow intercept variation in the next section.) The slope of the marginal cost curve measures the increase in marginal cost that results from a one-unit increase in the interest-over-book ratio and determines the degree of convexity of the total cost curve. With a fixed intercept, a larger slope implies higher marginal cost for all levels of leverage.

Based on identification strategy (i), the typical firm has a cost curve of debt with an estimated slope of 5.447. That is, when all control variables are set to their mean values (of zero since they are standardized), the estimated slope of the marginal cost curve of debt equals 5.447. Suppose that IOB changes from 0.02 to 0.03, then the marginal cost of taking on additional debt would increase by 5.447 cents per dollar of interest.

The -0.691 coefficient on COL (recall that COL is normalized by the book value of assets and includes hard assets and inventories) implies that high collateral firms have a lower cost of debt. (And, all else equal, a lower cost of debt should lead to higher debt usage, which is consistent with the positive relation between COL and debt ratios found in the standard capital structure literature, as shown in Table A.) All else equal, a firm that has COL one standard deviation larger than the average faces a marginal cost slope of 4.756 as opposed to 5.447. Figure 3 illustrates how a one standard deviation increase in COL (high COL) and a one standard deviation decrease in COL (low COL) pivot the marginal cost curve.

The 0.556 coefficient on LTA indicates that large firms face a higher cost of debt. Holding all else constant, a firm that has LTA one standard deviation higher than the average faces a slope of 6.003 as opposed to 5.447. On one hand, this might initially seem surprising because it can be interpreted to imply that large firms face high costs of debt – but not surprising in that our result is consistent with recent research that indicates that large firms use less debt (Faulkender and Petersen, 2006; Kurshev and Strebulaev, 2006).[13] In contrast, other research (as summarized in Frank and Goyal, 2004) documents a positive relation between size and debt usage. The differing firm size implications documented in various capital structure papers implies that the influence of size on the costs versus benefits of debt varies in different settings and samples. In our sample, size increases the marginal cost of debt.

Firms with growth opportunities (i.e., a low book-to-market (BTM)) on average face a higher cost of debt (coefficient of -0.274). This is consistent with the common finding that

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

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.

For brevity, we do not discuss the signs on the following coefficients in more detail though we note that they have implications that are similar to other capital structure research (see Table A). The -0.487 coefficient on INTANG suggest that firms with more intangible assets face lower costs of debt, consistent with intangibles supporting debt claims in ways similar to physical assets. The 1.540 and 1.544 coefficients on CF and CASH respectively imply that firms with high cash flow and large cash holdings behave as though they face high costs of debt, consistent with implications from the pecking order theory. Finally, the 0.871 coefficient on DDIV indicates that dividend paying firms face higher costs of debt, perhaps because dividends are rarely omitted (Brav et al, 2005), leaving fewer funds to cover interest obligations.

4.2 Marginal Costs with Fixed Slope

In the previous section, we allowed the slope of the marginal cost curve to depend on the control variables but did not allow these variables to 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 for the six specifications are presented in the last six columns of Table 3 and Table 4 for samples B and A, with qualitative results identical to the ones described in the previous section. That is, small, non-dividend paying firms with 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 somewhat different than before. Whereas previously a one standard deviation increase of a control variable pivoted the cost curve around its y-intercept, now a one standard deviation leads to a parallel shift of the whole curve. Figure 3 illustrates how a one standard deviation increase (decrease) of COL leads to a parallel upward (downward) shift of the marginal cost curve.

5 Implementing Cost and Optimal Capital Structure

Using the estimated coefficients from the fixed intercept, varying slope specification in Table 3 (left panel), the marginal cost of debt for any particular firm i at time t can be determined

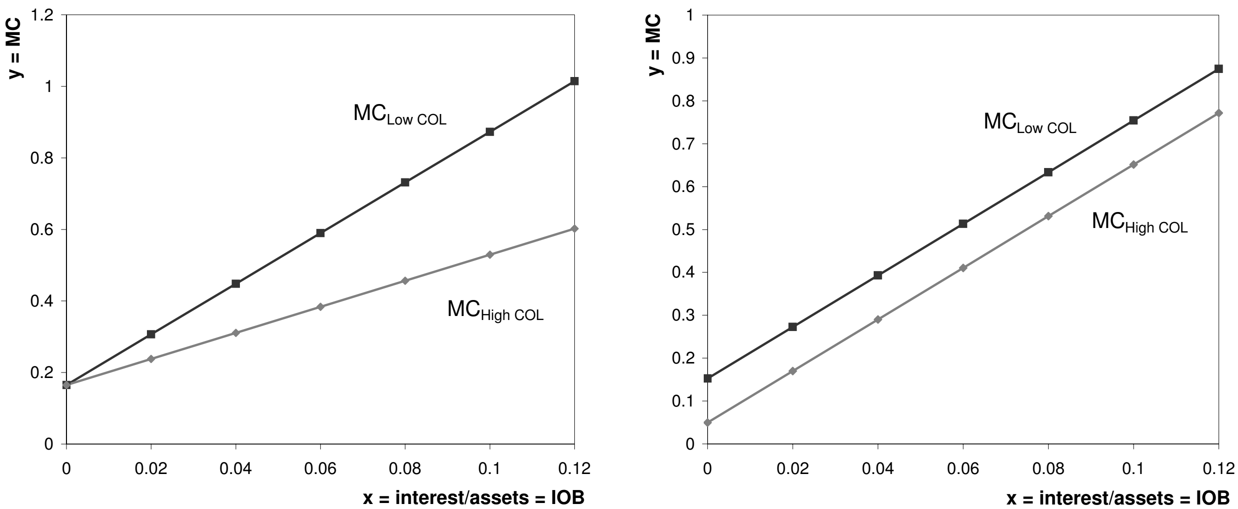

Figure 3: Comparing marginal cost curves for firms with high and low asset collateral (COL). The left panel shows the effect of a one standard deviation increase (decrease) in COL on a marginal cost curve with a fixed intercept and varying slope. The right panel shows the effect of a one standard deviation increase (decrease) in COL on a marginal cost curve with a fixed slope and varying intercept.

by:

$$\begin{aligned} &MC(IOB) = \alpha + \beta * IOB \\ &\alpha \quad = 0.165 \\ &\beta \quad = 5.447 - 0.691 \text{ COL} - 0.487 \text{ INTANG} + 0.556 \text{ LTA} - 0.274 \text{ BTM} + 1.540 \text{ CF} \\ &\qquad + 1.544 \text{ CASH} + 0.871 \text{ DDIV} \end{aligned} \tag{12}$$

and, when using the fixed slope, varying intercept coefficients in Table 3 (right panel), the curve is given by:

$$\begin{aligned} &MC(IOB) = \alpha + \beta * IOB \\ &\alpha \quad = 0.105 - 0.021 \text{ COL} - 0.011 \text{ INTANG} + 0.018 \text{ LTA} - 0.020 \text{ BTM} + 0.088 \text{ CF} \\ &\qquad + 0.051 \text{ CASH} + 0.038 \text{ DDIV} \\ &\beta \quad = 6.016 \end{aligned} \tag{13}$$

where each of the control variables is standardized (demeaned and divided by the standard deviation) based on Sample A to have a mean of zero and a standard deviation of one. The mean and standard deviation for each of the control variables for Sample A are reported below:

	COL	INTANG	LTA	BTM	CF	CASH	DDIV
Mean	0.493	0.061	5.007	0.764	0.090	0.143	0.382
Std. Dev.	0.232	0.119	2.160	0.638	0.155	0.182	0.486

The equations above provide linear approximations for firm-specific MC curves of debt that are functions of the firm's interest payments at any time t. They can be used to estimate the marginal cost of debt for a firm at any particular IOB. Thus, these equations allow us to compare marginal costs across firms or any subset of firms, and, when combined with the marginal benefit curves of debt, make statements about optimal capital structure.

Moreover, our estimated marginal cost curves include not only bankruptcy costs, but all costs that are relevant to a firm's capital structure decision. Therefore equations 12 and 13 can be used in future capital structure research to control for debt costs. For example, countless studies use Altman's (1968) coefficients from the 1960s applied to recent data to estimate the expected costs of distress. Alternatively, researchers can use our coefficients from equations 12 and 13 to estimate (or control for) the cost of debt.

5.1 The Representative Firm

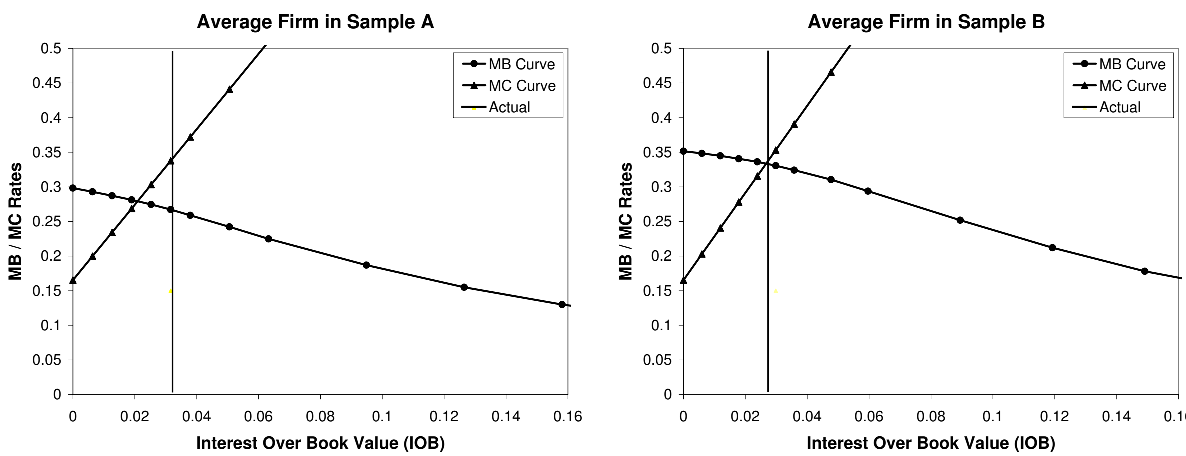

Figure 4: The average (representative) firm in Samples A and B. The marginal benefit curves are based on the average marginal tax benefit and interest over book values for each representative sample. The marginal cost curves are obtained using equation 12 and sample means of the standardized cost control variables.

In Table 5 and Figure 4 we show the marginal benefit and cost curves for the average (representative) firm in samples A and B across 1980 to 2006. The marginal cost curves are derived using equation 12 above, which is based on coefficients estimated in the left panel of Table 3. For Sample A, we set the control variables equal to their average value of 0 to arrive at the cost curve of debt for the average firm. For Sample B, we calculate the average standardized values for each control variable and apply to equation 12. To obtain the average marginal benefit curve, we compute the average marginal tax rate and interest over book value at 0%, 20%, 40%, ..., 1000% of the observed IOB.

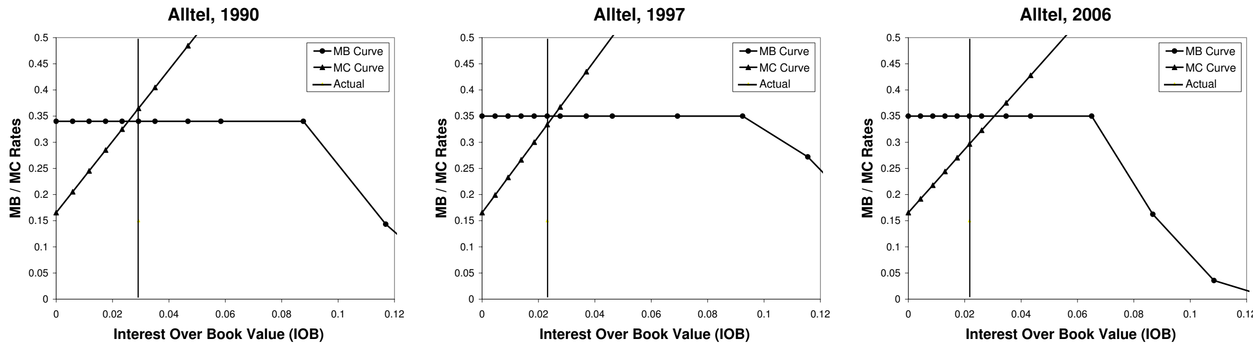

Figure 5: Marginal benefit and marginal cost curves for Alltel. The vertical line reflects the actual debt usage.

Figure 4 indicates that, on average, firms in Sample B are in equilibrium, as is assumed in the sample construction. Sample A also includes financially constrained and distressed firms. Relative to Sample B, the average marginal benefit curve in Sample A is shifted downward, and the representative firm is overlevered. The MB and MC curves presented in Table 5 can be used by researchers to calibrate models of aggregate capital structure behavior.

5.2 Case Studies of Optimal Debt Usage

Once the cost and benefit functions have been estimated, they can be used to draw inference on firm-specific optimal capital structure. We illustrate four case studies. The following companies are chosen for expositional purposes: i) Alltel, ii) Black & Decker, iii) Mine Safety Appliances, and iv) U.S. Playing Cards. The marginal cost curves are derived using equation 12. The qualitative results are similar if we instead use equation 13.

5.2.1 Alltel

The first panel of Table 6 displays the decile rankings of financial ratios for Alltel in 1990, 1997, and 2006. Alltel is a large telecommunications company that consistently pays dividends and has relatively high intangible assets. From 1997 to 2006, Alltel's collateral to assets ratio and growth opportunities both decrease. The drop in collateral increases marginal cost, while fewer growth opportunities decrease the marginal cost of debt, with the net effect being a slightly flatter marginal cost of debt curve (the firm specific slope of the marginal cost curve decreases from 7.287 in 1997 to 6.054 in 2006). Alltel's model-implied optimal capital structure increases slightly from 0.025 to 0.030 by 2006.

Figure 5 displays the marginal benefit and marginal cost curves for Alltel in 1990, 1997, and 2006. We see that in 1990 and 1997, Alltel chooses an actual IOB that is close to the

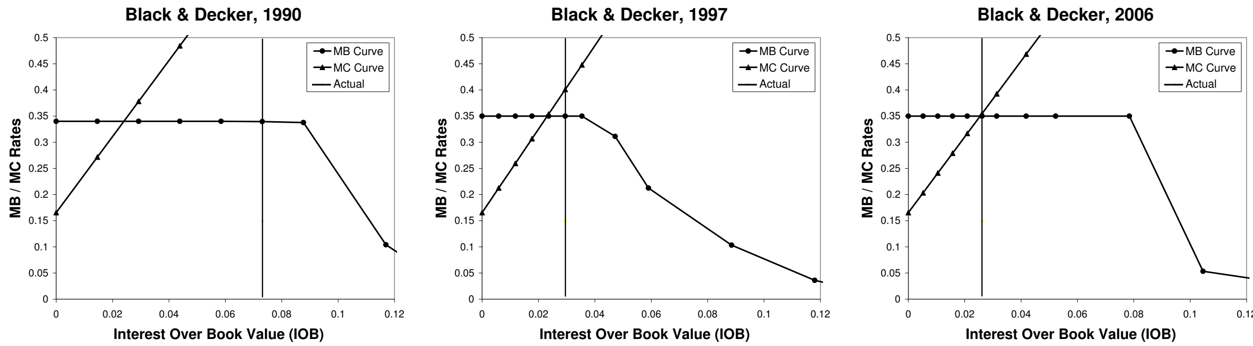

Figure 6: Marginal benefit and marginal cost curves for Black & Decker. The vertical line reflects the actual debt usage.

model-implied 'equilibrium', i.e., the point where the estimated marginal cost and marginal benefit curves intersect. In 2006 however, the firm is slightly underlevered (actual is less than the model implied optimum). This is due to a combination of the flattening of the MC curve from 1997 to 2006 and a decrease in Alltel's chosen debt level (see Table 6).

5.2.2 Black & Decker

The second panel of Table 6 displays fundamentals for Black & Decker in 1990, 1997, and 2006. Like Alltel, Black & Decker is a large firm that pays dividends and has stable sales. The firm's low collateral and intangible assets suggests high marginal costs based on our estimation results (Table 3), and less debt than Black and Decker uses in 1990. Relative to the model implied debt ratio, Black and Decker is overlevered in 1990. This excessive debt seems related to Black and Decker's highly levered acquisition of Emhart Corporation in 1989. In the mid 1990s, Black and Decker issued equity for the purpose of paying down its debt.[14] Thus by 1997, Black and Decker's actual leverage had decreased and the firm had moved closer to its model-implied optimal debt ratio. In 2006, the firm is in equilibrium as the firm's actual IOB coincides with the model implied IOB.

5.2.3 Mine Safety Appliances Co.

The third panel of Table 6 examines the financial rankings for Mine Safety Appliances Co for 1990, 1997, and 2006. Mine Safety Appliances Co is a mid-sized to large firm with stable cash flows, sales, and consistent cash holdings and dividend payments. The firm specific marginal cost curves in 1990, 1997, and 2006 have slopes of 7.441, 6.511, and 7.453, respectively. Compared with the 5.361 slope of the average firm in Sample A, this suggests that Mine

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

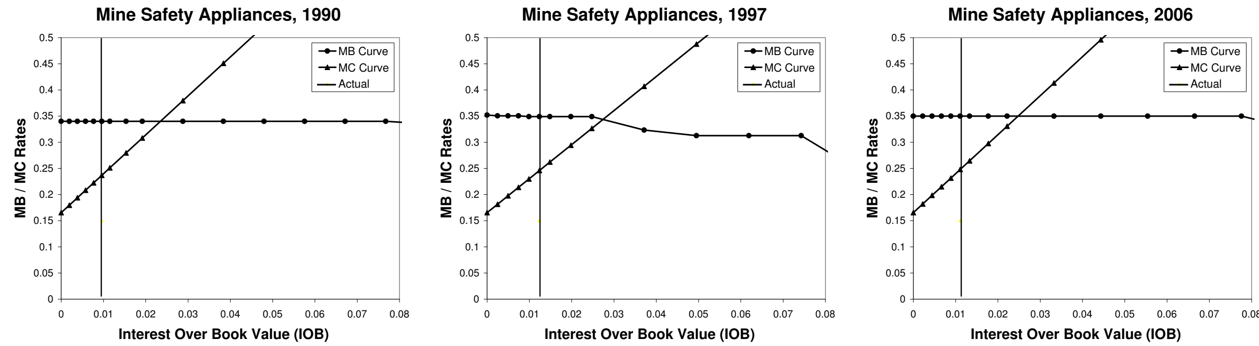

Figure 7: Marginal benefit and marginal cost curves for Mine Safety Appliances. The vertical line reflects the actual debt usage.

Safety Appliances has higher costs of debt than the average firm and therefore a lower 'optimal' IOB. Additionally, Mine Safety Appliances is also one of the most entrenched firms (above the 95th percentile) based on the Gompers, Ishii, Metrick (2003) index (GINDEX). Berger, Ofek, and Yermack (1997) argue that entrenched managers have a tendency to avoid debt. We see from Figure 7 that while the optimal IOB is low as suggested by our model, the observed IOB for Mine Safety Appliances is even lower, and the company is underlevered. This underlevering costs the firm approximately 1.1% of book value in perpetuity. Though this is just one example chosen to illustrate how to use the marginal cost curves to infer optimal capital structure, this case is consistent with the Berger, Ofek, Yermack findings.

5.2.4 U.S. Playing Card Co.

The last panel of Table 6 shows financial ratios for U.S. Playing Card Company for 1980, 1983, and 1986. We present this firm because it underwent a leveraged buyout (LBO) in 1981 but still had COMPUSTAT data until 1986. An ideal LBO target would have the potential for large gains from increasing their debt obligations, perhaps even being underlevered prior to the LBO. We see from Figure 8 that in 1980, that is indeed the case for U.S. Playing Card Company.

In 1980, the gains from levering up would amount to approximately 4.2% of the firm's asset value in perpetuity according to our calculations. The leveraged buyout for U.S. Playing Card was announced and effective in 1981. By 1983, we see a huge increase in the firm's debt to equity ratio (from 0.0284 to 0.5790), and the company became highly overlevered. However, by 1986 the marginal benefits curve has shifted upward, indicating the improved financial health of the firm (in that the firm is more likely to operate in profitable states). Furthermore, we start to see the firm slowly decreasing its debt obligations towards its model-implied optimum. Unfortunately, the company disappears from COMPUSTAT in 1986 and

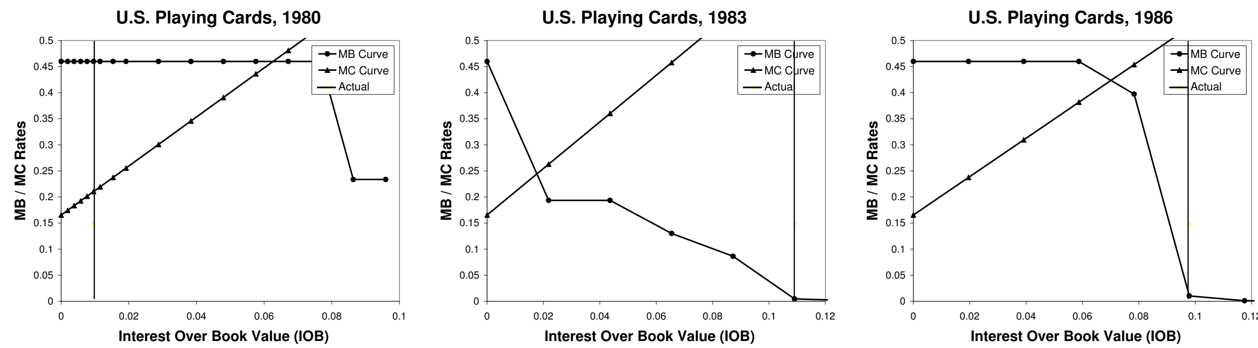

Figure 8: Marginal benefit and marginal cost curves for U.S. Playing Card. The vertical line reflects the actual debt usage. U.S. Playing Card underwent an LBO in 1981.

we cannot observe whether it eventually reaches its optimum. From what we do observe, this case is consistent with the implication that although LBOs initially put the firm in an overlevered position, there appear to be tax benefits, and the leverage is eventually paid down.

6 Quantifying the Costs and Benefits of Debt

As seen in Section 5, the intersection of the estimated marginal benefit and marginal cost functions can be used to determine the 'optimal' or 'equilibrium' interest over book for a given firm. This allows us to infer how a given firm's chosen debt level compares to the model recommended debt usage. We refer to a company as being overlevered (underlevered) if its observed debt usage is too high (low) relative to the optimum implied by the coefficients of our empirical model, which is estimated on Sample B firms. Strictly speaking, the 'optimum' should be interpreted as the representative debt ratio for firms with similar characteristics to the firm under consideration, based on coefficients estimated on Sample B. We have effectively assumed throughout that firms in Sample B operate in equilibrium. In this section, we analyze all the firms in Sample A. For expositional ease, we refer to the financially distressed and constrained firms that have chosen debt ratios that deviate from the model-implied optimum as being overlevered and underlevered, respectively. An alternative interpretation is that the constrained and distressed firms are correctly levered, given the options available to them. In this case, the results in this section should be interpreted as the cost that financial constraint or distress imposes on a company, in terms of preventing the firm from operating at the long-run, unconstrained, undistressed equilibrium (as implied by the choices and coefficient estimates of Sample B firms).

Equipped with our marginal benefit and marginal cost curves, we now quantify the gross

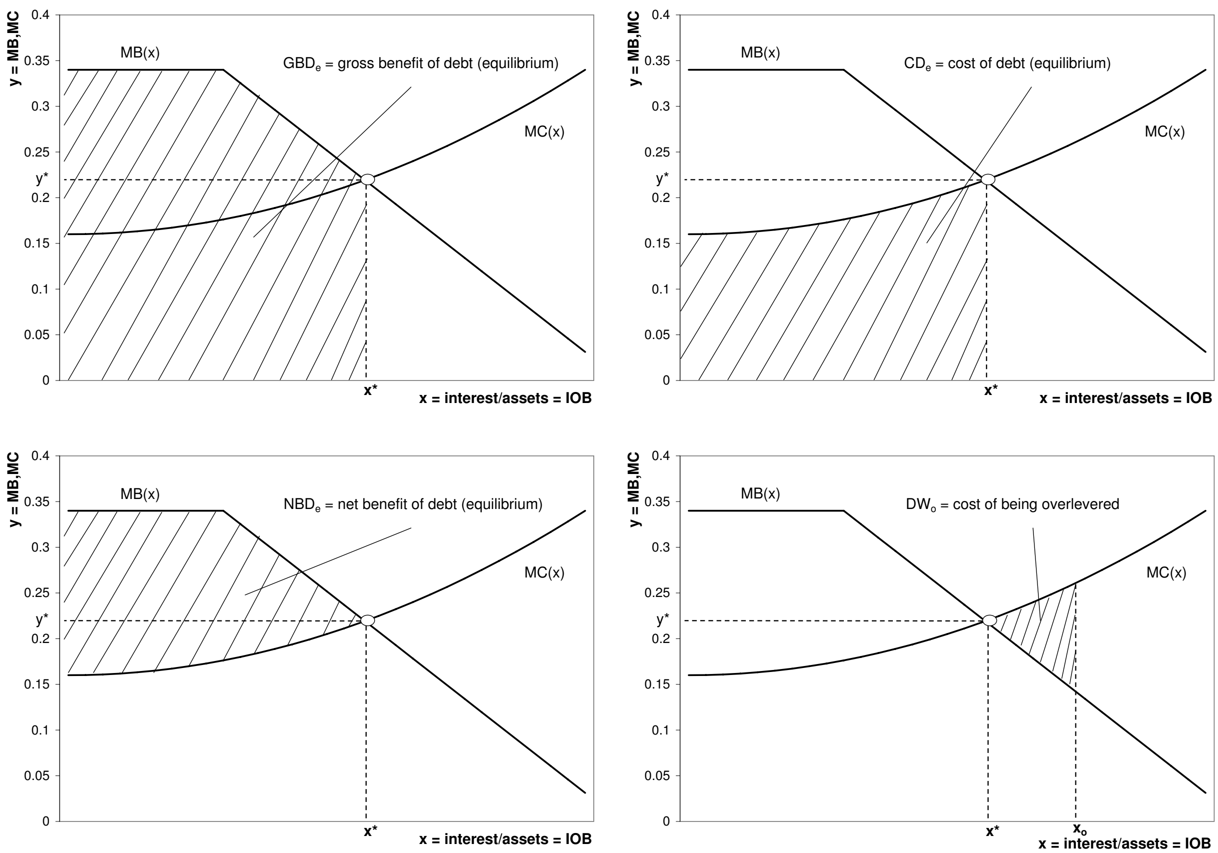

Figure 9: The figures show the marginal benefit curve of debt, $MB(x)$, the marginal cost curve of debt, $MC(x)$, and the equilibrium level of debt, x^*, that occurs where marginal cost and marginal benefit are equated. The marginal benefit level at x^* (which equals the cost level at x^*) is denoted by y^*. Panel a) depicts the equilibrium gross benefit of debt, the shaded area under the MB curve up to x^*. Panel b) depicts the equilibrium cost of debt, the shaded area under the MC curve up to x^*. Panel c) depicts the equilibrium net benefit of debt, the shaded area between the MB and MC curves up to x^*. Panel d) depicts the cost of being overlevered, the shaded area between the MC and MB curves from the equilibrium, x^*, to the observed, x_o, in the case where the actual level of debt, denoted by x_o, exceeds the equilibrium level of debt x^*.

and net benefits of debt and the costs of being "out of equilibrium."

6.1 Gross and Net Benefits of Debt

The observed (equilibrium) gross tax benefits of debt, GBD_o (GBD_e), is the area under the marginal benefit curve up to the observed (equilibrium) level of interest over book value (IOB). The observed (equilibrium) cost of debt, CD_o (CD_e), is the area under the marginal cost curve up to the observed (equilibrium) level of IOB. The observed (equilibrium) net benefits of debt, NBD_o (NBD_e), is the difference between the gross benefit of debt and the cost of debt (i.e., the area between the curves, up to the observed (equilibrium) level of IOB).

Cost measures are based on equation 12, which uses the fixed intercept varying slope model (equation 10) to estimate marginal cost curves from Sample B, as presented in the left panel of Table 3. Figure 9 illustrates how we measure the equilibrium gross benefit of debt, cost of debt, and net benefit of debt.

Table 7 reports the unconditional summary statistics for the gross benefit, cost, and net benefit of debt for all firm-year observations in Sample A. Recall that this analysis includes constrained and distressed firms that we excluded in our estimation of equation 12. All values are reported as percentages of book value in perpetuity, so for example, a gross benefit of 5% would occur if the annual benefit was 0.5% and the discount rate was 0.10.[15] We see that the average gross benefit of debt is higher at the equilibrium levels of debt (9.40%) than at the observed levels (8.81%). In contrast, the average cost of debt is lower at the equilibrium levels (6.56%) than at the observed levels (8.91%). This results in a higher net benefit of debt if firms were to operate at the equilibrium implied by our analysis, relative to their observed levels. On average, the net benefit of debt at the implied equilibrium is 2.84% of book value in perpetuity, and -0.11% at observed debt levels. Although 2.84% of book value seems modest, for a portion of the sample, the net benefits of debt are large. Figure 10a presents a histogram of firms sorted according to their equilibrium gross benefit of debt and paired with their corresponding equilibrium cost of debt (based on marginal costs calculated from equation 12). Firms above the 95th percentile have net benefits of debt that average 9.3% of book value at equilibrium levels. Figure 10b shows the time series of the observed and equilibrium gross and net benefits of debt. The drop in tax benefits around 1987 is the result of the reduction in corporate marginal tax rate following the Tax Reform Act of 1986.

The mean observed (equilibrium) cost of debt is 8.9 percent (6.8 percent) of book asset value. It is worth noting that the observed cost of debt is as high as 19.3 percent (43.6 percent) of asset value for firms in the 90th (99th) percentile of the cost distribution; and the ex ante equilibrium cost of debt is 13.0 percent (20.7 percent) of asset value for firms in the 90th (99th) percentile. Assuming that the probability of financial distress is high for our sample firms that face the highest ex ante costs of debt, we can compare our estimate to ex post cost of debt estimates from other studies. This comparison is reassuring because our numbers for the cost of debt are in the same ballpark as the 10 to 23 percent estimates from Andrade and Kaplan's (1998) analysis of 31 highly levered firms.

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

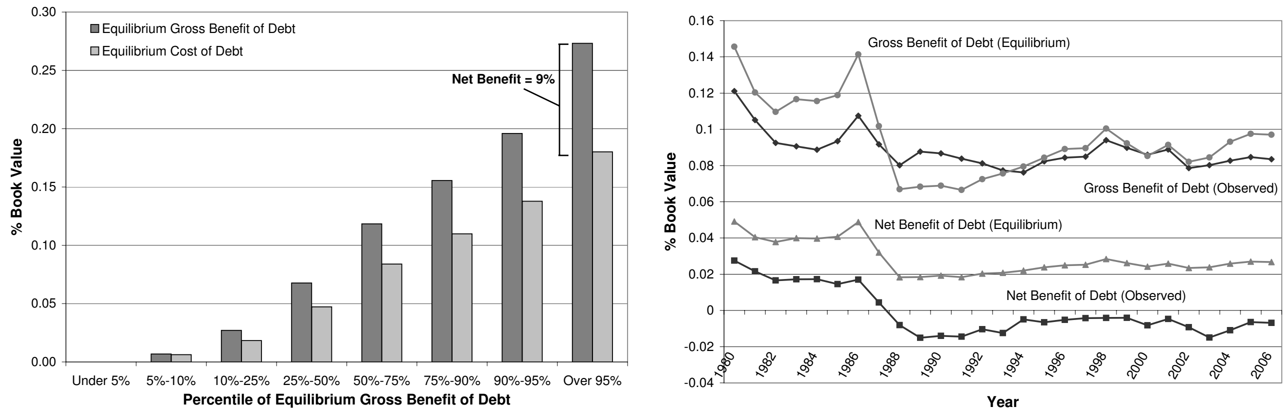

Figure 10: a) Histogram based on equilibrium gross benefit of debt percentiles with paired equilibrium cost of debt observations, b) observed and equilibrium gross benefit of debt and net benefit of debt from 1980 to 2006.

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 conservatism. The cost of being overlevered, DW_o, is the deadweight loss measured as the area between the cost and benefit curves when a firm has more debt than recommended by our model (see Figure 9d).[16] The cost of being underlevered, DW_u is the deadweight loss from leaving money on the table due to using less debt than implied by the model. Recall that one interpretation of DW_u is the cost of suboptimal debt usage (related to unconstrained debt usage) imposed by financial constraint limiting the amount of debt a firm can use. The cost of being out of equilibrium, DW_t, combines DW_o and DW_u into one measure.

Table 7 reports DW_o, DW_u, and DW_t for Sample A. The table shows that on average the cost of being out of equilibrium, DW_t, is 2.95% of book value in perpetuity. However, the cost of overlevering (on average, 4.47% of book value in perpetuity) is much higher than underlevering (on average, 1.16%). This asymmetry of higher costs to being overlevered than underlevered is consistent with the rebalancing behavior documented in Leary and Roberts (2005). In extreme cases (99th percentile), the cost of overlevering can be as high as 32.98% of book value in perpetuity, while the cost of being underlevered reaches only 6.45%.

Figure 11a graphically presents this asymmetry. Financially constrained firms are

[16] Recall that even though the benefit functions are based on *tax* benefits, *non-tax* benefits are also captured in the cost function (as negative costs). Therefore, our net measure reflects costs and non-tax benefits.

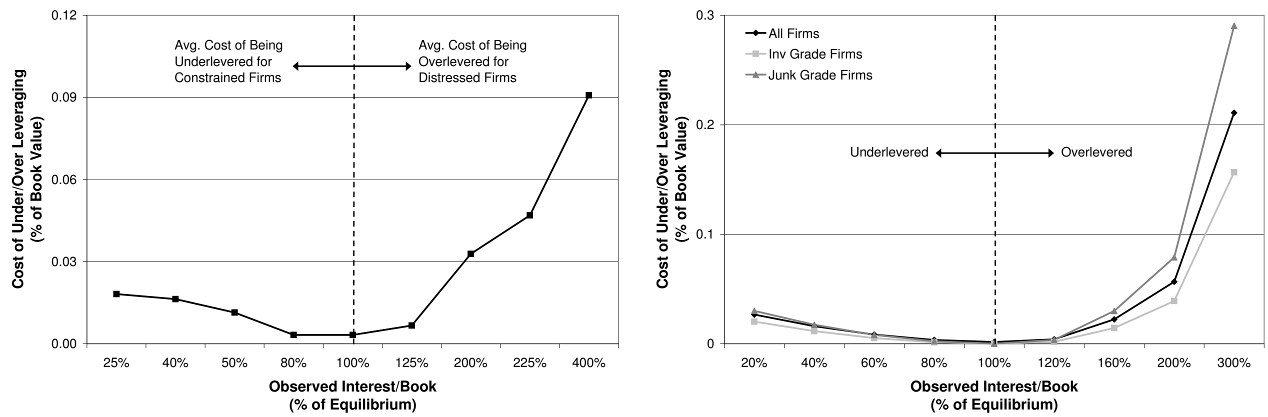

Figure 11: a) Actual deadweight costs of being under or overlevered for financially distressed firms and financially constrained firms that are out of equilibrium, b) hypothetical deadweight costs of being under or overlevered for firms in equilibrium for Sample A firms, investment grade firms, and junk rated firms.

presented to the left of the vertical line that represents recommended capital structure. Distressed firms are shown to the right of the vertical line. The figure sorts firms by how far out of equilibrium their observed IOB levels are (as percentages of the equilibrium IOB levels) and plots their costs of being under or overlevered (DW_t). Not surprisingly, the cost of being out of equilibrium is higher for firms further out of equilibrium. We see that it is far less costly for a firm to be at a quarter of its equilibrium IOB (with a deadweight cost of 2.0% of book assets) than at four times its equilibrium level (with a deadweight cost of 9.5%).

Another way to conceptualize of the cost of being under- or overlevered is to study firms that operate at or near their model-implied equilibrium and examine what the implied cost of debt would be if they were to hypothetically lever up or down. Table 8 summarizes the cost of being under or overlevered if firms that are currently within 5 percent of their equilibrium were to hypothetically change their IOB to X% of their equilibrium IOB. Panel A analyzes Sample A firms that operate near model implied equilibrium. As expected, the gross benefit of debt and cost of debt increase with IOB. As seen before, the numbers reveal that the cost of debt is disproportionately higher if a firm were to overlever versus underlever. A firm with $\frac{1}{5}$ of the equilibrium IOB would face, on average, a cost of being underlevered of only 2.7% of book assets in perpetuity. However, a firm with 3 times the equilibrium IOB will face, on average, a cost of being overlevered equal to 21.1% of book assets. It is important to note here that in the previous paragraph, we look at firms that are *actually* X% out of equilibrium. In this paragraph we look at firms that operate near or at the unconstrained and non-distressed equilibrium and ask *hypothetically* if they were X% out of equilibrium. One could argue that the extreme costs seen for these firms may be one of the reasons why

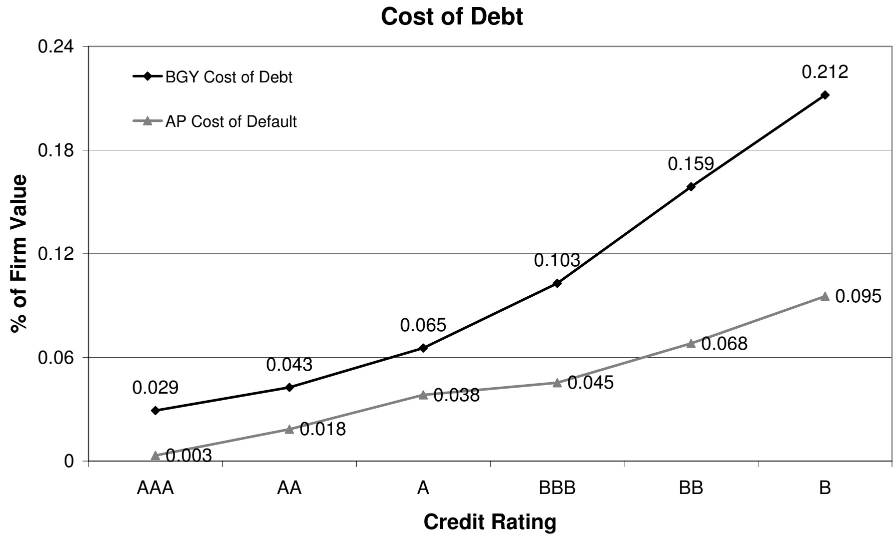

Figure 12: Comparing Almeida and Phillippon (2007) risk-adjusted net present value distress costs as a percentage of firm value against our ex ante measure of the cost of debt for AAA, AA, A, BBB, BB, and B rated firms. The Almeida and Phillippon (2007) distress costs, based on a default rate of 16.5%, are obtained from Table 4 of their paper. Our cost measures are calculated using equation 12. The numbers imply that the cost of default is about half of the total cost of debt, suggesting that the other half is due to non-default costs.

these firms choose to operate near equilibrium. It is also important to recognize that this asymmetry is partially driven by scale issues and the way we define under and overleverage. However, even at twice the optimal IOB, the cost of being overlevered is 5.7% of book assets. The asymmetrically larger costs of overleverage might help explain at least partially why some firms might use debt conservatively.

Panel B and panel C of Table 8 present the hypothetical results for firms that are in equilibrium with investment grade status and junk status based on S&P rating, respectively. For both sets of firms, the cost of being overlevered is again larger than being underlevered (see Figure 11b). While the cost of being underlevered does not differ too much across samples, the cost of being overlevered is much higher for junk rated firms. The latter result is reassuring in that our analysis implies that speculative-rated debt faces higher marginal costs than investment grade debt.

6.3 Benchmarks and Reality Checks

In Section 6.1, we showed that the 95th and 99th percentile ex ante cost of debt numbers we estimate are comparable to the ex post estimates in Andrade and Kaplan (1998). In Section 6.2, we showed that the cost of hypothetical overleverage is high for junk rated firms relative to investment grade firms. We now use the recent existing literature on bankruptcy costs of debt as a benchmark against which to compare our results. This exercise allows us to quantify the importance of bankruptcy costs among all costs of debt, to back out the implied magnitude of costs of debt other than those for bankruptcy, and to serve as a benchmark to ensure that our numbers are sensible.

Almeida and Phillippon (2007) argue that firms are more likely to face financial distress in bad times and thus, the cost of distress should reflect this. They measure the net present value of distress costs using risk adjusted default probabilities calculated for corporate bond spreads and present this in Table 4 of their paper. Figure 12 compares their risk-adjusted distress costs as a percentage of firm value to our measure of ex ante (observed) cost of debt as a percentage of firm value, CD_o, for AAA, AA, A, BBB, BB, B rated firms. It is comforting that our cost of debt numbers are in the same ballpark as the Almeida and Phillippon calculations. Our cost of debt measure is larger than the Almeida and Phillippon calculations because our numbers include more than just distress costs. For the AAA, AA, and A rated firms, our average cost of debt is 2.9%, 4.3%, and 6.5% of firm value, respectively, compared with Almeida and Phillippon's numbers of 0.3%, 1.8%, and 3.8% (under a default rate of 16.5%), respectively. Likewise, for BBB, BB, and B rated firms, our average costs of debt are 10.3%, 15.9%, and 21.2%, respectively, compared with Almeida and Phillippon's 4.5%, 6.8%, and 9.5%. Based on this comparison, expected distress costs of debt amount to approximately half of the total costs of debt. Though we present aggregated numbers in Figure 12 to allow comparison to Almedia and Phillippon, we emphasize that one advantage of our approach is that we can also estimate a firm-specific cost of debt.

7 Further Exploration & Robustness Checks

7.1 Interpreting Recent Capital Structure Theories

In this section we address recent research that explores the effect of specific factors on the cost of debt. Each of the theories we consider here suggests the inclusion of an additional control variable to the specification. Unfortunately, it turns out that these extra variables either (i) have low data quality, (ii) have many missing values and hence would lead to a small sample size, or (iii) are redundant with other control variables in the cross section or time series. For these reasons, we have not included them in the main analysis discussed in the previous sections. However, these examples illustrate that our framework can be used to analyze implications from various capital structure theories.

7.1.1 Macroeconomic Influences

Chen (2006) and Almeida and Philippon (2007) 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.

Table 9 presents the results for the analysis when we include the Moody's Baa-Aaa spread (CS) as a control variable. When the spread is high, we expect the cost of debt to be high. Thus, we expect a positive sign on the credit spread variable. We see that this is indeed true and the coefficient is significant (with a coefficient of 0.644 for the fixed intercept, varying slope model in equation 10).[17]

7.1.2 Personal Tax Penalty

Miller (1977), Green and Hollifield (2003), and others argue that despite the corporate tax deduction from using debt, investors pay higher taxes on interest income, leading to a personal tax penalty for corporate tax usage. If investors face higher interest income tax relative to capital gains tax, they will demand a premium for holding debt, which is reflected in the cost of debt and deters firms from using debt, all else equal. Graham (1999) 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 the personal tax penalty (PTP), we include this measure in our analysis as an additional cost control variables.

Table 9 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 (the coefficient indicating a MC function with a slope of 0.901 for the fixed intercept varying slope model). This is consistent with Graham's (1999) findings. However, the PTP measure is very sensitive to outliers, so we exclude it from the main specifications.

7.2 Alternative Instruments for Specification (i)

7.2.1 Specifications (vii, ix): The kink in the marginal benefit curve

In specification (i), we use the area measure, $A_{i,t}$, to summarize the variation in the marginal benefit curve of debt. If the marginal benefit curve was linear with a constant slope and

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

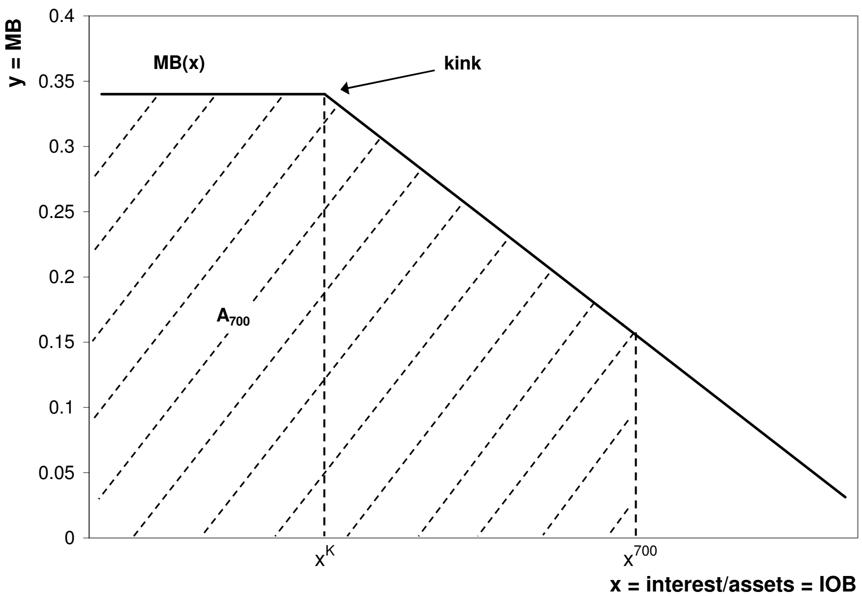

Figure 13: The kink of a marginal benefit curve is the point at which the curve begins to slope downwards. The interest expense over book assets ratio associated with the kink in the benefit curve is denoted x^K. A_{700} is the area under the entire marginal benefit curve extending out to 700% of the observed interest expense over book assets, x^{700}.

an intercept that varied, summarizing benefit variation would be possible using just the the area, the y-intercept, or the x-intercept of each function. However, the variation of the marginal benefit curves is caused by more than just parallel shifts. Although the area measure reasonable captures the shape of the marginal benefit curve, a more detailed representation of the various shapes of the marginal benefit function can be achieved by also including a second instrument: the amount of interest expense over book assets associated with the kink in the marginal benefit curve, $x^K_{i,t}$ (see Figure 13).[18] In specification (vii), we use both the area under the marginal benefit curve, $A_{i,t}$, and the interest expense over book assets associated with the kink in the MB curve, $x^K_{i,t}$, as identifying instruments. Specification (ix) repeats specification (vii) with firm fixed effects. Table 10 shows the resulting marginal cost curve coefficients when estimating equations 10 and 5 using Sample B. We see that when we additionally include the kink as an instrument, our estimation results are very similar and qualitatively identical to specifications (i) and (iv), where we use only the area measure $A_{i,t}$.

7.2.2 Specifications (viii, x): Area under marginal benefit curve up to 700%

The area measure we use in specification (i), $A_{i,t}$, captures the entire area under marginal benefit curve from 0% up to 1000% of the observed interest expense over book assets, $x^*_{i,t}$.

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

One can argue that since the marginal benefit curves of debt as derived in Graham (2000) are simulated (see Section 3.1), the MB curve is more precise for values closer to $x^*_{i,t}$. As such, we estimate in specification (viii) the marginal cost curve of debt using as the identifying instrument the area under the marginal benefit curve only up to 700% of $x^*_{i,t}$ instead of the full area up to 1000% of $x^*_{i,t}$ (see Figure 13). Specification (x) repeats specification (viii) with firm fixed effects. Table 10 presents the results for specifications (viii) and (x) estimated using Sample B. The results are qualitatively identical and quantitatively similar to specifications (i) and (vii).

7.3 Alternative Financial Constraint and Distress Measures

As discussed previously, our estimation procedure depends on the assumption that unconstrained and non-distressed firms optimize their capital structures. 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 the Cleary (1999) index, hereafter called CL, and the Whited and Wu (2005) index, hereafter called WW. Separately, we also tighten our definition of being financially unconstrained to include only firms that have made long term debt or equity adjustments in the top quartile (as opposed to above the median). Finally, we tighten our definition of being financially non-distressed to include firms with ZSCOREs in the top quartile.

Cleary (1999) calculates a general financial constraint measure by grouping firms into categories based on whether they increase or decrease dividend payments. Using this classification procedure, Cleary (1999) performs discriminant analysis to obtain a measure for financial constraint. We reproduce this procedure over Cleary's (1999) sample period of 1987 to 1994 to obtain the coefficients for our CL index. In a recent paper, Whited and Wu (2005) derive an alternative measure of financial constraint by formulating the dynamic optimization problem of a firm that faces the constraint that the distributions of the firm (e.g., dividends) need to exceed a certain lower bound. They parameterize the Lagrange multiplier on this constraint and estimate its coefficients with GMM. Effectively, the WW index indicates that a firm is financially constrained if its sales growth is considerably lower than its industry's sales growth. In other words, a highly constrained firm is a slow growing firm in a fast growing industry. An unconstrained firm is a fast growing firm in a slow growing industry.

The formula for the CL index is given by

$$\begin{aligned} CL_{i,t} = \quad & 0.176CUR_{i,t-1} - 0.0003FC_{i,t-1} + 0.008SL_{i,t-1} - 2.802NI_{i,t-1} \\ & +0.018SG_{i,t-1} + 4.372DEBT_{i,t-1}, \end{aligned} \tag{14}$$

and the WW index is given by

$$\begin{aligned} WW_{i,t} = \quad & -0.091CF_{i,t} - 0.062DDIV_{i,t} + 0.021LTD_{i,t} - 0.044LTA_{i,t} \\ & +0.102ISG_{i,t} - 0.035SG_{i,t}, \end{aligned} \tag{15}$$

where CF is cash flows, LTD is long-term debt, 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 firm's 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 used throughout the paper, we also perform our analysis using the following samples:

C : CL below median and ZSCORE above median,

D : WW below median and ZSCORE above median,

E : LTDEIR above 3rd quartile and ZSCORE above median, and

F : LTDEIR above 3rd quartile and ZSCORE above 3rd quartile.

The estimation results are presented in Table 11. The slopes range from 3.424 to 5.305 and the intercepts range from 0.167 to 0.228 for the fixed intercept, varying slope analysis. These are similar to the results we obtain in Table 3. Furthermore the qualitative and quantitative results on all control variables except BTM match fairly well. There is no BTM effect on the marginal cost curve for samples C, D, and F. The fixed slope, varying intercept model leads to the same conclusions, except that here the BTM variable has a stronger effect and is correctly negative in sign. Overall, these robustness samples produce results that are largely consistent with those in our main analysis.

8 Conclusion

We use panel data from 1980 to 2006 to estimate the cost function for corporate debt. We simulate debt tax benefit curves and assume that for financially unconstrained and non-distressed 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, intangibles, size, book-to-market, cash flows, cash holdings, and whether the firm pays dividends. Our findings are robust to several different identification strategies, and also to 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, and we quantify the welfare costs to the firm from being away from the model-recommended optimal capital structure. Finally, our estimates indicate that the perpetual net benefits of debt are about 3% of asset value.

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Appendix A: Identification

In this appendix we discuss our estimation procedure in a stylized example where both the marginal cost and the marginal benefit curves are linear. We address specifically where and how our approach differs from the standard OLS approach. We then explain why the area under the marginal benefit curve is a reasonable instrument for the location of the curve.

A stylized model

Suppose that the marginal cost and the marginal benefit curves are both linear functions of the interest-over-book (IOB) value x_t:

$$\begin{aligned} MC_t(x_t) &= bx_t + \xi_t \\ MB_t(x_t) &= dx_t + \eta_t, \end{aligned}$$

where $b > 0$ and $d < 0$. We omit intercepts for ease of exposition. In this specification, ξ_t represents parallel shifts of the marginal cost curve and η_t represents parallel shifts of the marginal benefit curve. We allow for a correlation between ξ_t and η_t so, potentially,

$$cov(\xi_t, \eta_t) \neq 0.$$

In equilibrium (the optimum), it holds that

$$y_t^* = MC_t(x_t^*) = MB_t(x_t^*).$$

Substituting we find

$$\begin{aligned} bx_t + \xi_t &= dx_t + \eta_t \\ x_t^* &= \frac{\eta_t - \xi_t}{b - d} \\ y_t^* &= b\left(\frac{\eta_t - \xi_t}{b - d}\right) + \xi_t = d\left(\frac{\eta_t - \xi_t}{b - d}\right) + \eta_t, \end{aligned}$$

which indicates that if $\xi_t > 0$ (i.e., a parallel upward shift of the marginal cost curve), optimal leverage decreases, and if $\eta_t > 0$, (i.e., a parallel upward shift of the marginal benefit curve), leverage increases. Now suppose that we perform a simple OLS regression of y_t^* on x_t^*. The resulting coefficient is given by:

$$\beta = \frac{cov(y_t^*, x_t^*)}{var(x_t^*)} = b + \frac{(b-d)\left[cov(\xi_t, \eta_t) - var(\xi_t)\right]}{var(\eta_t - \xi_t)}.$$

Note that when $var(\eta_t) = 0$, meaning that the marginal benefit curve does not shift, this expression simplifies to

$$\beta = d.$$

In other words, estimating this equation with the marginal benefit function fixed, so all variation comes from the marginal cost curve, produces results that map out the marginal benefit curve. On the other hand, to identify the cost curve, when $var\left(\xi_t\right) = 0$, the marginal cost curve does not shift and the expression simplifies to

$$\beta = b.$$

When both variances are greater than zero, the OLS approach does not estimate either of the curves properly and we end up with an estimate somewhere between b and d. For our sample, Table B presents the OLS results from directly estimating equations 10 and 5. As the results indicate, the estimated slopes are neither positive nor significant, implying the OLS is effectively estimating a line that lies somewhere between the marginal benefit and marginal cost curves.

To properly estimate the marginal cost curve we therefore need an instrument. Let us call this instrument z_t. The instrument needs to satisfy two criteria. It needs to be correlated with shifts of the marginal benefit curve, and it needs to be uncorrelated with shifts of the marginal cost curve:

$$\begin{aligned} cov\left(z_t, \eta_t\right) &\neq 0 \\ cov\left(z_t, \xi_t\right) &= 0. \end{aligned}$$

Now suppose that we have the luxury of observing the whole marginal benefit curve. This corresponds to observing the coefficient b and, more importantly, shifts as captured by η_t. Graphically, we can measure η_t by employing the vertical distance between the marginal benefit curves at any point x_t along the x-axis. Recall that all marginal benefit curves are parallel in this appendix, so it does not matter at which x_t we measure the distance. In this case, meeting the first requirement is straightforward. We simply pick

$$z_t = \eta_t.$$

This will ensure that in fact

$$corr\left(z_t, \eta_t\right) = corr\left(\eta_t, \eta_t\right) = 1.$$

However, this instrument does not necessarily satisfy the second requirement, because shifts in the marginal benefit curve and the marginal cost curve may be correlated if

$$cov\left(\xi_t, \eta_t\right) \neq 0.$$

We resolve this by projecting η_t on a set of control variables C:

$$\eta_t = \sum_{c=1}^{C} \beta_c c_t + \varepsilon_t. \tag{16}$$

In this case, ε_t will have zero correlation with ξ_t as long as the control variables accurately capture the shifts of the marginal cost curve. All that remains in ε_t are pure shifts in benefits that are uncorrelated with cost effects. We can then use ε_t as the identifying instrument to recover the marginal cost curve of debt. This is the approach that we use in panel data specification (i) in the main paper.

Now, to address the efficacy of using the area under the curve to proxy for the curve. Suppose that we observe the marginal benefit curves over a domain $\left[0, \bar{X}\right]$, then another way to measure the shifts of the curve is simply to compute the area under each of the curves. This area measure can be written as

$$A_t = \bar{A} + \bar{X}\eta_t$$

for some constant $\bar{A}$. Note that the area is a linear function of η_t and therefore using the area measure on the left-hand side of equation 16 is equivalent to using η_t.

If the two measures η_t and A_t are equivalent, then why do we bother using the area measure A_t? When the marginal benefit curve is not linear and the shifts of the curve are not parallel, then we can no longer measure the shifts of the curves by simply looking at the shifts of the intercepts, because the shifts of the curve may be different at each value of x_t along the x-axis. For example, consider Figure 2. The shapes of the marginal benefit curves are not only non-linear but not analytically tractable. If we just rely on the intercepts to describe the marginal benefit curves, then $MB_1(x)$ and $MB_2(x)$ would be summarized as the same curve, which they obviously are not. The intercept shift at the initial values of x are not equal to the intercept shift at later values of x. The area measure provides an attractive alternative because it equally weights the shift of the marginal benefit curve at each value of x_t. Using the area measure, we get $A_1 \geq A_2$, correctly recognizing that $MB_1(x) \supseteq MB_2(x)$.

Table B: Basic OLS coefficient estimates of equations 10 and 5 (without instruments).

	Varying Slope, Fixed Intercept		Fixed Slope, Varying Intercept	
	Sample A	Sample B	Sample A	Sample B
Constant	0.274 ***	0.335 ***	0.281 ***	0.298 ***
	(0.009)	(0.008)	(0.007)	(0.007)
IOB	-0.041	-0.908 ***	-0.449 ***	-0.140
	(0.069)	(0.083)	(0.087)	(0.107)
COL*IOB	-0.156 ***	0.017		
	(0.031)	(0.044)		
INTANG*IOB	-0.262 ***	-0.238 ***		
	(0.050)	(0.080)		
LTA*IOB	0.294 ***	0.306 ***		
	(0.053)	(0.052)		
BTM*IOB	-0.101 **	0.035		
	(0.042)	(0.062)		
CF*IOB	1.353 ***	1.850 ***		
	(0.082)	(0.124)		
CASH*IOB	-0.048	0.199 ***		
	(0.056)	(0.077)		
DDIV*IOB	0.962 ***	0.552 ***		
	(0.057)	(0.063)		
COL			-0.007 ***	0.005 ***
			(0.001)	(0.002)
INTANG			-0.012 ***	-0.006 *
			(0.002)	(0.003)
LTA			0.012 ***	0.009 ***
			(0.002)	(0.002)
BTM			-0.001	-0.001
			(0.002)	(0.004)
CF			0.074 ***	0.070 ***
			(0.004)	(0.006)
CASH			0.000	0.009 ***
			(0.002)	(0.002)
DDIV			0.034 ***	0.020 ***
			(0.003)	(0.003)
No. Obs.	79552	28731	79552	28731
R^2	0.2618	0.1916	0.4007	0.1924

Appendix B

Corporate tax rates over the period 1980 to 2006. 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. Note that the numbers in this table do not fully reflect the effect of TRA 1986 for firms with differing fiscal year-ends, as discussed in the text. We use the phase-in in our actual analysis.

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
2006	0.150	0.150	0.250	0.340	0.390	0.340	0.340	0.340	0.350	0.380	0.350

Appendix C

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

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

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

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

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

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

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

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

HCR = S&P Historical Long-Term Debt Ratings (180) organized in ten credit rating groups:

1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C, 10=D

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

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

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

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.

Table 1: Sample construction. y^* is the 'equilibrium' marginal benefit level, x^* is the observed or 'equilibrium' interest payments over book value (IOB), and C is the set of control (cost) variables. $C \equiv \{COL, INTANG, LTA, BTM, CF, CASH, DDIV\}$. 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. CL and WW are financial constraint measures as defined by Cleary (1999) and Whited and Wu (2005) indices respectively.

Sample		No. Obs
All firm-year obs. with marginal benefit (MB) curves and COMPUSTAT data in 1980-2006		124,189
Non-M&A firm-years with positive book value, common equity, capital, and sales		110,002
Sample excluding finance and insurance, utilities, and public administration industries		91,343
Sample with non-missing $(y^*_{i,t}, x^*_{i,t}, C_{i,t})$ variables:	Sample A	79,552
Sample of financially unconstrained and non-distressed firm-years: LTDEIR above median and ZSCORE above median	Sample B	28,731
For robustness checks:		
Sample of financially unconstrained and non-distressed firms-years: CL below median and ZSCORE above median	Sample C	20,319
Sample of financially unconstrained and non-distressed firms-years: WW below median and ZSCORE above median	Sample D	20,737
Sample of financially unconstrained and non-distressed firms-years: LTDEIR above third quartile and ZSCORE above median	Sample E	14,875
Sample of financially unconstrained and non-distressed firms-years: LTDEIR above third quartile and ZSCORE above third quartile	Sample F	6,936

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

Sample A: All Firms						
	No. Obs.	Mean	Std. Dev.	Min	Med	Max
IOB	79552	0.032	0.024	0.000	0.026	0.132
COL	79552	0.493	0.232	0.000	0.513	1.000
INTANG	79552	0.061	0.119	0.000	0.000	1.000
LTA	79552	5.007	2.160	-1.872	4.854	12.989
BTM	79552	0.764	0.638	0.035	0.586	4.639
CF	79552	0.090	0.155	-0.814	0.118	0.398
CASH	79552	0.143	0.182	0.000	0.069	1.000
DDIV	79552	0.382	0.486	0.000	0.000	1.000
AREA	78927	0.033	0.027	0.000	0.028	0.137
HCR	13785	4.191	1.308	1.000	4.000	10.000
ZSCORE	75905	1.617	2.051	-13.493	1.976	5.586
CL	54559	0.300	1.323	-1.503	0.071	15.192
WW	64602	-0.221	0.119	-0.517	-0.216	0.121
Sample B: Financially Unconstrained and Non-distressed Firms (LTDEIR above median and ZSCORE above median)						
	No. Obs.	Mean	Std. Dev.	Min	Med	Max
IOB	28731	0.030	0.022	0.000	0.025	0.132
COL	28731	0.497	0.203	0.000	0.516	0.976
INTANG	28731	0.057	0.099	0.000	0.007	0.791
LTA	28731	5.319	1.882	0.096	5.176	12.211
BTM	28731	0.691	0.549	0.035	0.540	4.598
CF	28731	0.161	0.081	-0.568	0.159	0.398
CASH	28731	0.125	0.149	0.000	0.065	0.993
DDIV	28731	0.477	0.499	0.000	0.000	1.000
AREA	28426	0.042	0.027	0.000	0.038	0.137
HCR	4936	3.823	1.245	1.000	4.000	10.000
ZSCORE	28731	2.798	0.754	1.790	2.650	5.586
CL	21570	-0.068	0.695	-1.502	-0.137	10.916
WW	25046	-0.244	0.106	-0.517	-0.240	0.121

Table 3: Marginal cost of debt using firms in Sample B. We present GMM estimates of the coefficients in equations 10 and 5. The error functions are defined according to equations 11 and 9 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 six different specifications, denoted by (i)-(vi): (i) the area under the marginal benefit curve $A_{i,t}$, (ii) the corporate tax rates from eleven tax brackets across time, (iii) a dummy for December fiscal year-end firms, a dummy for implementation of Tax Reform Act of 1986, and the difference-in-difference dummy that is the product of the two. Specifications (iv)-(vi) repeat (i)-(iii) with firm fixed effects. Specifications (iii) and (xi) include only firms with fiscal year ends of June and December. The set of control variables is $C \equiv \{COL, INTANG, LTA, BTM, CF, CASH, DDIV\}$, where COL is collateralizable assets over total book assets, INTANG is intangible assets over total book assets, LTA is log of total assets expressed in 2000 dollars, BTM is book equity to market equity, CF is net cashflow over total book values, CASH is cash holdings over total book values, DDIV is an indicator for dividend paying firms. 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, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2007). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***. The cost of debt measure is calculated by integrating under the marginal cost curve up to the model implied equilibrium.

	(10) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$ (slope varies)						(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$ (intercept varies)					
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Constant	0.165 ***	0.146 ***	0.076 **	-0.042	0.171 ***	-0.095	0.105 ***	0.060 ***	-0.056	-0.152 ***	0.051	-0.761 *
	(0.013)	(0.018)	(0.036)	(0.033)	(0.029)	(0.117)	(0.015)	(0.022)	(0.056)	(0.039)	(0.040)	(0.404)
IOB	5.447 ***	5.986 ***	9.440 ***	12.737 ***	4.480 ***	15.063 ***	6.016 ***	7.461 ***	12.114 ***	13.804 ***	7.445 ***	35.456 ***
	(0.486)	(0.802)	(1.397)	(1.169)	(1.095)	(4.360)	(0.534)	(0.816)	(1.903)	(1.246)	(1.294)	(13.503)
COL*IOB	-0.691 ***	-0.682 ***	-0.264	0.440	0.339 *	-1.278						
	(0.113)	(0.161)	(0.198)	(0.308)	(0.184)	(0.816)						
INTANG*IOB	-0.487 ***	-0.434 ***	-0.261	-0.276	-0.215	-0.064						
	(0.108)	(0.118)	(0.199)	(0.215)	(0.131)	(0.341)						
LTA*IOB	0.556 ***	0.731 ***	0.880 ***	0.524	1.729 ***	5.575 ***						
	(0.084)	(0.103)	(0.164)	(0.427)	(0.348)	(1.595)						
BTM*IOB	-0.274 ***	-0.331 ***	-0.460 ***	-0.567 ***	-0.343 ***	-0.901 ***						
	(0.075)	(0.075)	(0.127)	(0.143)	(0.079)	(0.255)						
CF*IOB	1.540 ***	2.985 ***	3.864 ***	1.374 ***	3.202 ***	4.295 ***						
	(0.183)	(0.179)	(0.347)	(0.232)	(0.185)	(0.460)						
CASH*IOB	1.544 ***	3.378 ***	6.085 ***	2.893 ***	2.311 ***	5.270 ***						
	(0.225)	(0.349)	(0.777)	(0.308)	(0.342)	(1.197)						
DDIV*IOB	0.871 ***	1.114 ***	1.486 ***	0.927 ***	1.006 ***	1.996 ***						
	(0.081)	(0.105)	(0.202)	(0.183)	(0.102)	(0.427)						
COL							-0.021 ***	-0.027 ***	-0.011	-0.021 **	0.002	-0.101 *
							(0.004)	(0.006)	(0.008)	(0.009)	(0.007)	(0.055)
INTANG							-0.011 ***	-0.012 ***	-0.006	-0.009 *	-0.005	-0.017
							(0.004)	(0.004)	(0.007)	(0.005)	(0.004)	(0.017)
LTA							0.018 ***	0.022 ***	0.027 ***	0.108 ***	0.058 ***	0.288 ***
							(0.002)	(0.003)	(0.005)	(0.013)	(0.014)	(0.110)
BTM							-0.020 ***	-0.024 ***	-0.036 ***	-0.039 ***	-0.024 ***	-0.097 ***
							(0.003)	(0.004)	(0.007)	(0.005)	(0.004)	(0.035)
CF							0.088 ***	0.087 ***	0.099 ***	0.114 ***	0.097 ***	0.137 ***
							(0.007)	(0.006)	(0.011)	(0.009)	(0.007)	(0.029)
CASH							0.051 ***	0.061 ***	0.115 ***	0.080 ***	0.055 ***	0.158 ***
							(0.007)	(0.008)	(0.019)	(0.009)	(0.007)	(0.056)
DDIV							0.038 ***	0.042 ***	0.052 ***	0.049 ***	0.035 ***	0.098 ***
							(0.004)	(0.004)	(0.007)	(0.005)	(0.004)	(0.036)
No. Obs.	28426	28505	17035	28426	28505	17035	28426	28505	17035	28426	28505	17035
Fixed Effects?	N	N	N	Y	Y	Y	N	N	N	Y	Y	Y

Table 4: Marginal cost of debt using firms in Sample A. We present GMM estimates of the coefficients in equations 10 and 5. The error functions are defined according to equations 11 and 9 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 six different specifications, denoted by (i)-(vi): (i) the area under the marginal benefit curve $A_{i,t}$, (ii) the corporate tax rates from eleven tax brackets across time, (iii) a dummy for December fiscal year-end firms, a dummy for implementation of Tax Reform Act of 1986, and the difference-in-difference dummy that is the product of the two. Specifications (iv)-(vi) repeat (i)-(iii) with firm fixed effects. Specifications (iii) and (xi) include only firms with fiscal year ends of June and December. The set of control variables is $C \equiv \{COL, INTANG, LTA, BTM, CF, CASH, DDIV\}$, where COL is collateralizable assets over total book assets, INTANG is intangible assets over total book assets, LTA is log of total assets expressed in 2000 dollars, BTM is book equity to market equity, CF is net cashflow over total book values, CASH is cash holdings over total book values, DDIV is an indicator for dividend paying firms. 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, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2007). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***. The cost of debt measure is calculated by integrating under the marginal cost curve up to the model implied equilibrium.

	(10) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$ (slope varies)						(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \delta_c c_{i,t} + \xi_{i,t}$ (intercept varies)					
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Constant	0.006	0.095 ***	-0.032	-0.228 ***	0.084 *	-0.488 **	-0.006	0.046 **	-0.080	-0.311 ***	0.009	-0.884 *
	(0.011)	(0.022)	(0.040)	(0.042)	(0.044)	(0.223)	(0.014)	(0.021)	(0.049)	(0.050)	(0.058)	(0.487)
IOB	9.417 ***	6.493 ***	11.552 ***	16.854 ***	6.683 ***	27.835 ***	8.683 ***	6.991 ***	11.474 ***	18.412 ***	8.142 ***	38.272 **
	(0.376)	(0.969)	(1.444)	(1.386)	(1.678)	(7.941)	(0.454)	(0.812)	(1.530)	(1.607)	(1.959)	(15.989)
COL*IOB	-1.011 ***	-0.822 ***	-0.977 ***	0.228	-0.068	-1.908 ***						
	(0.109)	(0.120)	(0.148)	(0.223)	(0.149)	(0.668)						
INTANG*IOB	-0.573 ***	-0.557 ***	-0.572 ***	-0.464 **	-0.277 ***	-0.154						
	(0.097)	(0.074)	(0.111)	(0.196)	(0.072)	(0.271)						
LTA*IOB	0.688 ***	0.368 ***	0.269	1.045 **	1.039 ***	4.216 ***						
	(0.105)	(0.090)	(0.181)	(0.464)	(0.307)	(1.518)						
BTM*IOB	-0.315 ***	-0.284 ***	-0.370 ***	-0.505 ***	-0.418 ***	-0.820 ***						
	(0.055)	(0.041)	(0.074)	(0.110)	(0.060)	(0.195)						
CF*IOB	2.280 ***	2.936 ***	3.773 ***	2.343 ***	2.317 ***	3.948 ***						
	(0.135)	(0.145)	(0.165)	(0.158)	(0.196)	(0.597)						
CASH*IOB	2.355 ***	2.164 ***	4.306 ***	3.214 ***	2.254 ***	7.092 ***						
	(0.243)	(0.454)	(0.738)	(0.299)	(0.477)	(1.928)						
DDIV*IOB	1.616 ***	1.888 ***	2.639 ***	1.188 ***	1.448 ***	3.005 ***						
	(0.096)	(0.132)	(0.258)	(0.181)	(0.146)	(0.725)						
COL							-0.033 ***	-0.029 ***	-0.029 ***	-0.052 ***	-0.016 **	-0.104 **
							(0.004)	(0.004)	(0.005)	(0.007)	(0.008)	(0.045)
INTANG							-0.018 ***	-0.016 ***	-0.016 ***	-0.011 **	-0.008 ***	-0.010
							(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.011)
LTA							0.017 ***	0.017 ***	0.016 ***	0.077 ***	0.036 ***	0.145 **
							(0.003)	(0.003)	(0.005)	(0.013)	(0.009)	(0.072)
BTM							-0.011 ***	-0.009 ***	-0.012 ***	-0.023 ***	-0.015 ***	-0.035 **
							(0.002)	(0.002)	(0.003)	(0.004)	(0.002)	(0.014)
CF							0.095 ***	0.090 ***	0.102 ***	0.107 ***	0.081 ***	0.143 ***
							(0.005)	(0.005)	(0.006)	(0.009)	(0.008)	(0.038)
CASH							0.072 ***	0.058 ***	0.098 ***	0.110 ***	0.059 ***	0.198 **
							(0.008)	(0.008)	(0.016)	(0.012)	(0.011)	(0.080)
DDIV							0.071 ***	0.064 ***	0.082 ***	0.077 ***	0.050 ***	0.124 ***
							(0.004)	(0.005)	(0.008)	(0.007)	(0.006)	(0.046)
No. Obs.	78927	78825	50763	78927	78825	50763	78927	78825	50763	78927	78825	50763
Fixed Effects?	N	N	N	Y	Y	Y	N	N	N	Y	Y	Y

Table 5: Marginal benefit and marginal cost functions of debt for the average (representative) firm in Sample A and Sample B. The marginal benefit curve is calculated by taking the average of the marginal tax rates and interest expenses over book assets at 0%, 20%, 40%, ..., 1000% of observed IOB. The marginal cost curve is calculated using equation 12 and the sample means of the standardized value of the cost control variables.

	Sample A			Sample B		
	Interest Over Book Value (IOB)	Marginal Benefit (MB)	Marginal Cost (MC)	Interest Over Book Value (IOB)	Marginal Benefit (MB)	Marginal Cost (MC)
0% of Observed	0.0000	0.2983	0.1654	0.0000	0.3515	0.1654
20% of Obs.	0.0063	0.2929	0.1999	0.0060	0.3483	0.1979
40% of Obs.	0.0127	0.2872	0.2343	0.0119	0.3448	0.2304
60% of Obs.	0.0190	0.2812	0.2688	0.0179	0.3406	0.2629
80% of Obs.	0.0253	0.2746	0.3032	0.0239	0.3362	0.2954
100% of Obs.	0.0316	0.2672	0.3377	0.0298	0.3307	0.3278
120% of Obs.	0.0380	0.2588	0.3721	0.0358	0.3242	0.3603
160% of Obs.	0.0506	0.2423	0.4410	0.0477	0.3104	0.4253
200% of Obs.	0.0633	0.2249	0.5099	0.0596	0.2938	0.4903
300% of Obs.	0.0949	0.1870	0.6822	0.0895	0.2519	0.6527
400% of Obs.	0.1265	0.1549	0.8545	0.1193	0.2120	0.8152
500% of Obs.	0.1581	0.1300	1.0268	0.1491	0.1780	0.9776
600% of Obs.	0.1898	0.1113	1.1990	0.1789	0.1527	1.1401
700% of Obs.	0.2214	0.0970	1.3713	0.2088	0.1324	1.3025
800% of Obs.	0.2530	0.0862	1.5436	0.2386	0.1167	1.4650
900% of Obs.	0.2846	0.0773	1.7158	0.2684	0.1038	1.6274
1000% of Obs.	0.3163	0.0704	1.8881	0.2982	0.0937	1.7899

Table 6: Key financial characteristics for Alltel, Black & Decker, Mine Safety Appliances Corp., and U.S. Playing Card. TA is total assets expressed in thousands of 2000 dollars, MCAP is market capitalization expressed in thousands of 2000 dollars, D/E is the debt to equity ratio, COL is collateralizable assets over total book assets, INTANG is intangible assets over total book assets, BTM is the book equity to market equity ratio, CF is net cashflow over total book value, CASH is cash holdings over total book value, DIVIDENDS is total dividend payout over total book assets, and SALES is sales over total book assets. All firms with non-missing data within a given year are sorted into deciles. Both decile rankings and actual values for each firm and year are provided.

	Alltel					
	1990		1997		2006	
	Decile	Value	Decile	Value	Decile	Value
TA	10	3458.1	10	6043.5	10	15669.2
MCAP	10	3639.6	10	8196.0	10	19771.1
D/E	9	0.3450	9	0.3327	6	0.1470
COL	8	0.7026	7	0.5780	5	0.2971
INTANG	9	0.1052	9	0.1077	10	0.5766
BTM	3	0.3640	3	0.2879	7	0.5470
CF	9	0.2075	9	0.2112	7	0.1422
CASH	3	0.0162	1	0.0029	5	0.0509
DIVIDENDS	10	0.0389	10	0.0369	9	0.0224
SALES	3	0.5998	4	0.5793	3	0.4298
	Black & Decker					
	1990		1997		2006	
	Decile	Value	Decile	Value	Decile	Value
TA	10	7762.1	10	5750.9	8	4482.6
MCAP	9	754.9	10	3964.2	9	4925.2
D/E	10	0.4679	8	0.3029	7	0.2230
COL	3	0.2838	4	0.3152	5	0.3212
INTANG	1	0.0000	1	0.0000	9	0.2809
BTM	9	1.6073	6	0.4848	2	0.2018
CF	6	0.1183	6	0.1312	8	0.1703
CASH	3	0.0142	5	0.0460	4	0.0445
DIVIDENDS	7	0.0041	8	0.0085	8	0.0208
SALES	4	0.8205	5	0.9216	8	1.2286
	Mine Safety Appliances Corporation					
	1990		1997		2006	
	Decile	Value	Decile	Value	Decile	Value
TA	8	584.0	7	436.0	6	767.6
MCAP	8	426.4	7	318.7	7	1138.5
D/E	4	0.0555	4	0.0302	5	0.1252
COL	7	0.6011	7	0.5813	4	0.2870
INTANG	1	0.0000	6	0.0045	7	0.1073
BTM	6	0.8529	8	0.8007	4	0.3258
CF	7	0.1441	7	0.1419	7	0.1399
CASH	8	0.1547	5	0.0490	5	0.0682
DIVIDENDS	8	0.0120	8	0.0103	9	0.0275
SALES	6	1.0698	7	1.2163	7	1.0168
	U.S. Playing Card					
	1980		1983		1986	
	Decile	Value	Decile	Value	Decile	Value
TA	3	28.3	5	96.1	6	133.3
MCAP	3	17.1	6	107.7	5	55.7
D/E	2	0.0284	10	0.5790	9	0.3687
COL	5	0.5646	8	0.7364	7	0.6325
INTANG	1	0.0000	1	0.0000	1	0.0000
BTM	6	0.9710	1	0.2115	3	0.4193
CF	5	0.1223	7	0.1440	5	0.0902
CASH	9	0.1535	6	0.0852	3	0.0204
DIVIDENDS	1	0.0000	1	0.0000	1	0.0000
SALES	7	1.6628	5	0.9334	4	0.8091

Table 7: Summary statistics for benefits and costs of debt. Cost measures are based on equation 12, which uses the fixed intercept, varying slope model (equation 10) to estimate marginal cost curves from Sample B. The observed (equilibrium) gross benefits of debt, GBD_o (GBD_e), is the area under the marginal benefit curve up to the observed (equilibrium) level of interest over book value (IOB). The observed (equilibrium) cost of debt, CD_o (CD_e), is the area under the marginal cost curve up to the observed (equilibrium) level of IOB. The observed (equilibrium) net benefits of debt, NBD_o (NBD_e), is the area under the marginal benefit curve minus the area under the marginal cost curve up to the observed (equilibrium) IOB. Observed is defined as the actual IOB that the firm employs. Equilibrium is defined as the intersection of the marginal benefit and cost curves. The cost of being overlevered, DW_o, is the deadweight loss from additional costs due to observed IOB being greater than the equilibrium. The cost of being underlevered, DW_u, is the deadweight loss from lower benefits due to observed IOB being below the equilibrium. The cost of being out of equilibrium, DW_t, combines DW_o and DW_u into one measure.

Panel A: All Firms in Sample A										
	No. Obs.	Mean	Std. Dev.	1%	10%	25%	Median	75%	90%	99%
Observed gross benefits of debt (GBD_o)	79552	0.0881	0.0793	0.0000	0.0036	0.0251	0.0709	0.1291	0.1946	0.3450
Observed costs of debt (CD_o)	79552	0.0891	0.0907	0.0000	0.0117	0.0299	0.0645	0.1172	0.1933	0.4359
Observed net benefits of debt (NBD_o)	79552	-0.0011	0.0645	-0.2528	-0.0674	-0.0125	0.0156	0.0319	0.0468	0.0821
Equilibrium gross benefits of debt (GBD_e)	79552	0.0940	0.0814	0.0000	0.0000	0.0129	0.0957	0.1406	0.1870	0.3078
Equilibrium costs of debt (CD_e)	79552	0.0656	0.0544	0.0000	0.0000	0.0097	0.0681	0.0988	0.1304	0.2076
Equilibrium net benefits of debt (NBD_e)	79552	0.0284	0.0330	0.0000	0.0000	0.0019	0.0268	0.0416	0.0572	0.1049
Cost of being out of equilibrium (DW_t)	79552	0.0295	0.0576	0.0000	0.0003	0.0025	0.0105	0.0293	0.0780	0.2726
Cost of overlevering (DW_o)	42915	0.0447	0.0710	0.0000	0.0005	0.0039	0.0188	0.0565	0.1185	0.3298
Cost of underlevering (DW_u)	36637	0.0116	0.0266	0.0000	0.0002	0.0018	0.0067	0.0149	0.0250	0.0645

Table 8: Conditional summary statistics of benefit and cost of debt for firms in equilibrium. Measures are based on the marginal cost curves described in equation 12. The gross benefits of debt, GBD, is the area under the marginal benefits curve up to the indicated level of interest over book value (IOB). The cost of debt, CD is the area under the marginal cost curve up to the indicated level of IOB. The net benefits of debt, NBD, is the area under the marginal benefits curve minus the area under the marginal cost curve up to the indicated IOB. Equilibrium is defined as the intersection of the marginal benefit and cost curves. The cost of being overlevered, DW_o, is the deadweight loss from additional costs due to having IOB above the equilibrium. The cost of being underlevered, DW_u, is the deadweight loss from lower benefits due to having IOB below the equilibrium. The cost of being out of equilibrium, DW_t, combines DW_o and DW_u into one measure.

	Panel A: All firms in Sample A						
	N	GBD	CD	NBD	DW_t	DW_o	DW_u
20% of equilibrium IOB	3420	0.0269	0.0134	0.0135	0.0267		0.0267
40% of equilibrium IOB	3420	0.0537	0.0296	0.0241	0.0161		0.0161
60% of equilibrium IOB	3420	0.0804	0.0485	0.0319	0.0084		0.0084
80% of equilibrium IOB	3420	0.1070	0.0703	0.0367	0.0035		0.0035
at equilibrium IOB	3420	0.1334	0.0948	0.0386	0.0017	0.0015	0.0018
120% of equilibrium IOB	3420	0.1583	0.1221	0.0362	0.0041	0.0041	
160% of equilibrium IOB	3420	0.2030	0.1851	0.0179	0.0223	0.0223	
200% of equilibrium IOB	3420	0.2428	0.2592	-0.0164	0.0566	0.0566	
300% of equilibrium IOB	3420	0.3225	0.4933	-0.1708	0.2110	0.2110	
400% of equilibrium IOB	3420	0.3772	0.7969	-0.4198	0.4600	0.4600	
500% of equilibrium IOB	3420	0.4139	1.1703	-0.7563	0.7965	0.7965	
	Panel B: Investment grade rated firms						
	N	GBD	CD	NBD	DW_t	DW_o	DW_u
20% of equilibrium IOB	669	0.0232	0.0120	0.0112	0.0203		0.0203
40% of equilibrium IOB	669	0.0464	0.0264	0.0200	0.0115		0.0115
60% of equilibrium IOB	669	0.0696	0.0433	0.0263	0.0052		0.0052
80% of equilibrium IOB	669	0.0927	0.0626	0.0302	0.0014		0.0014
at equilibrium IOB	669	0.1159	0.0844	0.0315	0.0000	0.0000	0.0000
120% of equilibrium IOB	669	0.1384	0.1086	0.0298	0.0017	0.0017	
160% of equilibrium IOB	669	0.1816	0.1644	0.0171	0.0144	0.0144	
200% of equilibrium IOB	669	0.2225	0.2301	-0.0076	0.0391	0.0391	
300% of equilibrium IOB	669	0.3119	0.4371	-0.1252	0.1567	0.1567	
400% of equilibrium IOB	669	0.3798	0.7055	-0.3258	0.3573	0.3573	
500% of equilibrium IOB	669	0.4271	1.0352	-0.6081	0.6397	0.6397	
	Panel C: Junk rated firms						
	N	GBD	CD	NBD	DW_t	DW_o	DW_u
20% of equilibrium IOB	298	0.0327	0.0166	0.0161	0.0300		0.0300
40% of equilibrium IOB	298	0.0653	0.0366	0.0287	0.0174		0.0174
60% of equilibrium IOB	298	0.0978	0.0599	0.0380	0.0081		0.0081
80% of equilibrium IOB	298	0.1302	0.0865	0.0438	0.0023		0.0023
at equilibrium IOB	298	0.1624	0.1164	0.0460	0.0001	0.0000	0.0001
120% of equilibrium IOB	298	0.1921	0.1496	0.0425	0.0036	0.0036	
160% of equilibrium IOB	298	0.2422	0.2261	0.0161	0.0300	0.0300	
200% of equilibrium IOB	298	0.2830	0.3159	-0.0329	0.0790	0.0790	
300% of equilibrium IOB	298	0.3540	0.5985	-0.2444	0.2905	0.2905	
400% of equilibrium IOB	298	0.3950	0.9642	-0.5691	0.6152	0.6152	
500% of equilibrium IOB	298	0.4193	1.4130	-0.9937	1.0398	1.0398	

Table 9: Alternative control specifications. GMM estimation of the coefficients in equations 10 and 5 for all firms in Sample B. The error functions are defined according to equations 11 and 9 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 $C \equiv \{COL, INTANG, LTA, BTM, CF, CASH, DDIV\}$, and one of each alternative control specification: $\{CS, PTP\}$. COL is collateralizable assets over total book assets, INTANG is intangible assets over total book assets, LTA is log of total assets expressed in 2000 dollars, BTM is book equity to market equity, CF is net cashflow over total book values, CASH is cash holdings over total book values, DDIV is an indicator for dividend paying firms. CS is the spread between Moody's Baa rate and Aaa rate, and PTP is the personal tax penalty as measured in Graham (1999). 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 ***.

(10) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$		
	CS	PTP
Constant	0.188 ***	0.201 ***
	(0.011)	(0.009)
IOB	4.565 ***	4.123 ***
	(0.365)	(0.304)
COL*IOB	-0.618 ***	-0.600 ***
	(0.101)	(0.096)
INTANG*IOB	-0.310 ***	-0.227 **
	(0.092)	(0.092)
LTA*IOB	0.625 ***	0.747 ***
	(0.074)	(0.073)
BTM*IOB	-0.411 ***	-0.369 ***
	(0.065)	(0.057)
CF*IOB	1.440 ***	1.287 ***
	(0.168)	(0.160)
CASH*IOB	1.397 ***	1.222 ***
	(0.200)	(0.170)
DDIV*IOB	0.647 ***	0.842 ***
	(0.082)	(0.080)
CS*IOB	0.644 ***	
	(0.135)	
PTP*IOB		0.901 ***
		(0.125)
No. Obs.	28426	24925

(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \delta_c c_{i,t} + \xi_{i,t}$		
	CS	PTP
Constant	0.133 ***	0.161 ***
	(0.015)	(0.011)
IOB	5.099 ***	4.353 ***
	(0.444)	(0.338)
COL	-0.019 ***	-0.015 ***
	(0.003)	(0.003)
INTANG	-0.008 ***	-0.002
	(0.003)	(0.003)
LTA	0.019 ***	0.023 ***
	(0.002)	(0.002)
BTM	-0.021 ***	-0.021 ***
	(0.003)	(0.003)
CF	0.085 ***	0.072 ***
	(0.006)	(0.006)
CASH	0.045 ***	0.040 ***
	(0.006)	(0.004)
DDIV	0.032 ***	0.039 ***
	(0.003)	(0.003)
CS	0.019 ***	
	(0.004)	
PTP		0.034 ***
		(0.004)
No. Obs.	28426	24925

Table 10: Alternative identifying instruments for specification (i). GMM estimation of the coefficients in equations 10 and 5 for all firms in Sample B. The error functions are defined according to equations 11 and 9 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 $C \equiv \{COL, INTANG, LTA, BTM, CF, CASH, DDIV\}$. COL is collateralizable assets over total book assets, INTANG is intangible assets over total book assets, LTA is log of total assets expressed in 2000 dollars, BTM is book equity to market equity, CF is net cashflow over total book values, CASH is cash holdings over total book values, DDIV is an indicator for dividend paying firms. 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 ***. The cost of debt measure is calculated by integrating under the marginal cost curve up to the model implied equilibrium.

	(10) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$				(5) $MC_{i,t} = a + bx_{i,t} + \sum_{c\in C} \delta_c c_{i,t} + \xi_{i,t}$			
	(vii)	(viii)	(ix)	(x)	(vii)	(viii)	(ix)	(x)
Constant	0.179 ***	0.191 ***	-0.020	0.003	0.104 ***	0.128 ***	-0.146 ***	-0.096 ***
	(0.011)	(0.010)	(0.031)	(0.026)	(0.015)	(0.013)	(0.039)	(0.030)
IOB	4.860 ***	4.510 ***	11.888 ***	11.271 ***	6.075 ***	5.267 ***	13.693 ***	12.111 ***
	(0.454)	(0.393)	(1.110)	(0.932)	(0.523)	(0.461)	(1.243)	(0.981)
COL*IOB	-0.635 ***	-0.568 ***	0.500 *	0.497 *				
	(0.105)	(0.093)	(0.291)	(0.282)				
INTANG*IOB	-0.475 ***	-0.467 ***	-0.285	-0.238				
	(0.107)	(0.099)	(0.211)	(0.186)				
LTA*IOB	0.559 ***	0.464 ***	0.682 *	0.069				
	(0.079)	(0.071)	(0.397)	(0.354)				
BTM*IOB	-0.196 ***	-0.190 ***	-0.505 ***	-0.454 ***				
	(0.075)	(0.068)	(0.143)	(0.126)				
CF*IOB	1.736 ***	1.444 ***	1.568 ***	1.186 ***				
	(0.166)	(0.167)	(0.203)	(0.210)				
CASH*IOB	1.393 ***	1.212 ***	2.775 ***	2.556 ***				
	(0.210)	(0.184)	(0.297)	(0.250)				
DDIV*IOB	0.844 ***	0.812 ***	0.965 ***	0.792 ***				
	(0.076)	(0.070)	(0.178)	(0.164)				
COL					-0.020 ***	-0.018 ***	-0.020 **	-0.015 *
					(0.004)	(0.003)	(0.009)	(0.008)
INTANG					-0.011 ***	-0.011 ***	-0.008	-0.008 *
					(0.003)	(0.003)	(0.005)	(0.005)
LTA					0.018 ***	0.017 ***	0.106 ***	0.092 ***
					(0.002)	(0.002)	(0.013)	(0.012)
BTM					-0.020 ***	-0.017 ***	-0.039 ***	-0.035 ***
					(0.003)	(0.003)	(0.005)	(0.005)
CF					0.087 ***	0.087 ***	0.112 ***	0.110 ***
					(0.007)	(0.007)	(0.009)	(0.008)
CASH					0.052 ***	0.046 ***	0.080 ***	0.074 ***
					(0.006)	(0.006)	(0.009)	(0.008)
DDIV					0.038 ***	0.036 ***	0.049 ***	0.045 ***
					(0.004)	(0.003)	(0.005)	(0.005)
No. Obs.	28395	28411	28395	28411	28395	28411	28395	28411
Fixed Effects?	N	N	Y	Y	N	N	Y	Y

Table 11: Analysis on alternative definitions of being financially unconstrained (C) CL index below median, (D) WW index below median, (E) LTDEIR in the top quartile, and financially non-distressed (F) ZSCORE in the top quartile. GMM estimation of the coefficients in equations 5 and 10. The error functions are defined according to equations 9 and 11 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 $C \equiv \{COL, INTANG, LTA, BTM, CF, CASH, DDIV\}$, where COL is collateralizable assets over total book assets, INTANG is intangible assets over total book assets, LTA is log of total assets expressed in 2000 dollars, BTM is book equity to market equity, CF is net cashflow over total book values, CASH is cash holdings over total book values, DDIV is an indicator for dividend paying firms. 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, clustered standard errors are reported in the parentheses. Standard errors are clustered by both firm and year as in Thompson (2006) and Petersen (2007). Significance at the 10% level is indicated by *, 5% level by **, and 1% level by ***. The cost of debt measure is calculated by integrating under the marginal cost curve up to the model implied equilibrium.

	(10) $MC_{i,t} = a + bx_{i,t} + \sum_{c \in C} \theta_c c_{i,t} x_{i,t} + \xi_{i,t}$				(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	0.205 ***	0.228 ***	0.167 ***	0.222 ***	0.168 ***	0.152 ***	0.100 ***	0.139 ***
	(0.008)	(0.008)	(0.015)	(0.012)	(0.009)	(0.014)	(0.017)	(0.019)
IOB	4.928 ***	3.424 ***	5.305 ***	3.559 ***	5.113 ***	5.106 ***	5.924 ***	4.726 ***
	(0.385)	(0.292)	(0.534)	(0.512)	(0.493)	(0.442)	(0.579)	(0.601)
COL*IOB	-0.825 ***	-0.847 ***	-0.608 ***	-0.580 ***				
	(0.153)	(0.147)	(0.122)	(0.132)				
INTANG*IOB	-0.656 ***	-0.723 ***	-0.389 ***	-0.483 ***				
	(0.157)	(0.141)	(0.110)	(0.148)				
LTA*IOB	0.402 ***	0.378 ***	0.529 ***	0.274 **				
	(0.113)	(0.130)	(0.107)	(0.138)				
BTM*IOB	0.075	0.101	-0.343 ***	-0.111				
	(0.109)	(0.127)	(0.084)	(0.096)				
CF*IOB	1.449 ***	1.842 ***	1.290 ***	1.275 ***				
	(0.252)	(0.289)	(0.182)	(0.205)				
CASH*IOB	0.661 **	0.505 **	1.683 ***	0.840 ***				
	(0.284)	(0.229)	(0.244)	(0.249)				
DDIV*IOB	1.078 ***	0.894 ***	0.741 ***	0.741 ***				
	(0.115)	(0.114)	(0.093)	(0.100)				
COL					-0.017 ***	-0.026 ***	-0.019 ***	-0.021 ***
					(0.004)	(0.004)	(0.004)	(0.005)
INTANG					-0.011 ***	-0.016 ***	-0.009 **	-0.012 **
					(0.003)	(0.004)	(0.004)	(0.005)
LTA					0.011 ***	0.006 *	0.018 ***	0.013 ***
					(0.002)	(0.003)	(0.003)	(0.004)
BTM					-0.005	-0.008 *	-0.024 ***	-0.013 ***
					(0.004)	(0.005)	(0.004)	(0.004)
CF					0.075 ***	0.084 ***	0.083 ***	0.081 ***
					(0.006)	(0.009)	(0.007)	(0.008)
CASH					0.026 ***	0.025 ***	0.054 ***	0.032 ***
					(0.005)	(0.005)	(0.007)	(0.007)
DDIV					0.035 ***	0.035 ***	0.034 ***	0.033 ***
					(0.004)	(0.004)	(0.004)	(0.004)
No. Obs.	20182	20608	14690	6816	20182	20608	14690	6816
Fixed Effects?	N	N	N	N	N	N	N	N