The Impact of Taxes on Firm Value and the Trade-off Theory of Capital Structure

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Abstract

We offer a new perspective on testing the well-known trade-off theory of capital structure. As the corporate tax rate rises, the market value of a firm declines. On the one hand, the firm may want to raise more debt as the tax shields increase; on the other hand, the firm is financially constrained as the result of its declining market value. Consequently, corporate leverage may first increase and then decrease as the corporate tax rate rises. We offer robust empirical support for the non-linear relationship between the corporate tax rate and market leverage ratio. Our finding solves the puzzle why the tax rate is sometimes not a reliable determinant of leverage ratios in linear regressions and restores our faith in the foundation of the trade-off theory of capital structure.

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1. Introduction

In this paper, we offer a new perspective on testing the well known trade-off theory of capital structure. The key for our study is an observation that other things being equal, as the corporate tax rate rises, the market value of a firm declines. On the one hand, the firm may want to raise more debt as the tax shields increase but on the other, the firm is financially constrained as the result of its declining market value, making the expected financial distress costs higher. Consequently, the amount of debt and the market leverage ratio may increase at first and then decrease as the corporate tax rate increases. Using new estimates of corporate marginal tax rates by Blouin, Core and Guay (2010), with or without adjusting for personal taxes, we find robust empirical support for a non-linear relationship between market leverage ratios and marginal tax rates.

Our results differ from the previous interpretation and tests of the trade-off theory of capital structure. The trade-off theory predicts that firms will increase their debt level to capture fully tax benefits until the expected marginal benefits are equal to the expected marginal costs of debt[1]. The existing literature points to a monotonic positive relationship between the amount of debt and corporate tax rates. For example, in a comprehensive study on corporate capital structure decisions, Frank and Goyal (2009a, p.9) state that "[t]he trade-off theory predicts that to take advantage of higher interest tax shields, firms will issue more debt when tax rates are higher"[2]. We will show analytically that this monotonic positive relationship is true only if the negative impact of taxes on a firm's value is ignored. A more plausible specification is a non-linear specification of the relationship between leverage ratios and tax rates.

Due to the misspecification of the relationship in previous studies, the effort to find a positive linear relationship between the two has not been very fruitful. Disappointing earlier studies lead to Myers (1984) who concludes that there is "no study clearly demonstrating that a firm's tax status has predictable, material effects on its debt policy."

[1] We follow the earlier analysis of the trade-off theory addressed in Modigliani and Miller (1963), Kraus and Litzenberger (1973), Miller (1977) and DeAngelo and Masulis (1980) in which the cost of debt is financial distress.

[2] The derivations are summarized in Frank and Goyal (2007), p. 10, also in Bradley et al. (1984), p. 863.

Although several studies since the 1990s have found support for a positive linear relationship between leverage ratios and marginal tax rates in a cross-section of publicly traded firms, notably Mackie-Mason (1990), Graham (1996a, 1996b, 1999), Graham and Mills (2007), many studies omit the tax rate as one of the determinants of capital structure decisions. Some studies even suggest the opposite. For example, both Sibilkov (2009), and Campello and Giambona (2010) find a significantly negative relationship between leverage ratios and marginal corporate tax rates[3]. Frank and Goyal (2009a) categorize the tax rate in the second group of somewhat unreliable variables which may be important in the determination of leverage ratios. Because the economic principle underlining the trade-off theory is very compelling and a decision about capital structure is one of the most fundamental that managers have to make, this rather surprising conclusion calls for further study. Our study meets this challenge[4].

Our main contribution is to emphasize that the debt capacity of a firm is influenced by its marginal tax rate. Corporate leverage may decline when the tax rate goes too high. Therefore it is inappropriate to test a positive linear relationship between leverage ratios and corporate marginal tax rates. We show that a non-linear relationship between the two is robust, with or without adjusting for personal taxes. Our results also show that the tax effect survives the "persistence" effect studied by Lemmon, Roberts and Zender (2008): it cannot be subsumed in the firm's original preferred leverage position.

The rest of the paper is organized as follows. In Section 2, we discuss a firm's optimal choice of debt and derive the comparative static results of the optimal level of debt and the leverage ratio regarding the marginal tax rate. Data selection and summary statistics are contained in Section 3. The main empirical analysis between market leverage and marginal tax rates at a corporate level is contained in Section 4. As Miller (1977) points out, personal tax rates are important for corporate capital structure

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[3] See Table 3 of Sibilkov (2009) and Tables 2, 5, and 6 in Campello and Giambona (2010). Both use the marginal tax rates estimated by Professor Graham.

[4] A recent paper by Faccio and Xu (2011) also validates the importance of taxes on capital structure decisions. They find the impact of statutory changes in corporate and personal taxes in OECD countries on capital structure choices is significant. However, unlike our study, they do not consider the relationship between leverage and taxes with a large panel of data.

decisions because fundamentally shareholders have the power to decide which financing method is best for them. For this purpose, we perform a further test between market leverage and the adjusted marginal tax rate using the NBER Taxsim model in Section 5. Several additional regressions, such as the Tobit model, pooled OLS results employing an alternative method to estimate corporate marginal tax rates by Professor Graham, and pooled OLS results on book leverage ratios are reported in Section 6. Section 7 concludes.

2. Theoretical Considerations

In this section, we use a simple model to highlight the impact of the tax rate change on a firm's value and the market leverage ratio based on the trade-off theory of capital structure.

Denote t as the corporate tax rate, D the face value of debt, V_0 the before-tax value of the firm when it is all equity financed, and $\phi(D/V)$ the expected costs of debt. Following Modigliani and Miller (1963), if the debt is perpetual and interest tax shields can be used fully, then the present value of the tax shields is tD. Applying the principle of the adjusted net present value method (see Kraus and Litzenberger 1973), a firm's market value V can be decomposed into three parts: after-tax unlevered firm value, $(1-t)V_0$, plus interest tax shields, tD, and minus the expected financial distress costs, $\phi(D/V)$. That is,

$$V = (1-t)V_0 + tD - \phi(D/V) \qquad (1)$$

In this specification, the firm's value V is the market value of the firm, as only that value will reflect the *expected* bankruptcy costs. V_0 is the pre-tax unlevered firm value, which is assumed to be constant. Note also that in equation (1), for simplicity, the tax rate is both the average and the marginal tax rate faced by a firm. This treatment simplifies our theoretical analysis and is consistent with the corporate marginal tax rate estimates we will employ in the empirical tests[5].

Consistent with the observation that leverage ratios play an important role in determining credit rating, we follow previous studies (for example, Gordon and Mackie-Mason 1990) and assume that the expected costs of debt are increasing with the debt ratio at an increasing rate:

$$\phi'(D/V)>0,\ \phi''(D/V)>0. \qquad (2)$$

Assumption (2) reflects the fact that when the debt ratio is low, there is little expected bankruptcy risk. But when the debt ratio is high, then the expected distress costs of debt will be accelerating.

Furthermore, the amount of debt is capped by the firm's intrinsic value. That is, the net worth constraint requires that the amount of debt will be less than the firm's pre-tax, unlevered market value.

$$D < V_0. \qquad (3)$$

The trade-off theory states that a firm will maximize its adjusted value *V,* defined in equation (1), by choosing the optimal level of debt *D*. The first order condition for the optimization is:

$$tV - \phi'(D/V) = 0. \qquad (4)$$

This simply means that the firm will choose the optimal level of debt when the marginal benefit of the tax shield is equal to the marginal expected costs of debt.

We are now establishing two intermediate results which state how the firm's value and optimal amount of debt change in response to a change in the tax rate. All of the proofs are in the Appendix.

Lemma 1: a. The firm's value is negatively related to the tax rate, i.e.

5 Instead of the whole schedule of marginal tax rates with different future income levels in any given year, only one estimate of the marginal tax rate per firm is given for each year in both Blouin Core and Guay (2010) and Graham (1996) data sets.

$$\frac{dV}{dt} = -\frac{(V_0 - D)}{1 - \frac{tD}{V}} < 0 \text{ ;}$$

b. The sign of the change of the optimal amount of debt with respect to the tax rate is ambiguous:

$$\frac{dD}{dt} = \underbrace{\left(\frac{tV^2 + D\phi''}{V\phi''}\right)\frac{dV}{dt}}_{negative} + \underbrace{\frac{V^2}{\phi''}}_{positive} \quad . \tag{5}$$

Equation (5) summarizes two opposing forces of an increased tax rate on the firm's optimal choice of debt level: firm's value impact and tax shield impact, respectively. When the tax rate rises, other things being equal, the value of the firm declines due to the increased tax payment, that is, $dV/dt < 0$. Consequently, the firm's willingness to borrow is reduced, which can be seen from the first term in the right-hand side of equation (5). The negative impact of the increased tax rate on the firm's value is more pronounced in a high tax regime, as the tax rate *t* has a multiplier effect: it appears in the numerator in the bracket term in equation (5). The positive tax shield impact is represented by the second term in the right-hand-side of equation (5): A higher tax rate leads to a higher amount of debt because of the tax shield. Furthermore, the higher ϕ'', i.e. the more sensitive is the firm's expected marginal distress cost with respect to the debt ratio, the lower the increase in its demand for debt. Obviously, if we ignored the impact of tax on firm value, i.e. $dV/dt = 0$, then there would be a positive relationship between tax and debt as predicted by previous studies.

Therefore, the change in the amount of debt relative to the tax rate is ambiguous. When the tax rate starts to increase from zero to a relatively small amount, the after-tax value of the firm *V* is relatively large, as the second term in equation (5) dominates. Thus dD/dt is positive. When the tax rate increases further, as the after-tax firm value declines, dD/dt will be more likely to be negative.

Since the amount of debt at the firm level can vary from zero to billions of dollars and also because smaller firms naturally have a smaller amount of debt, most of the previous empirical studies have been performed on the leverage *ratio* instead of the debt *level* in order to overcome the issues of scale. To complete the analysis, we now examine the relationship between market leverage ratio and tax rate. The book value of assets, while an important accounting concept, reflects more about the historical costs of capital stock and retained earnings rather the expected costs of debt which will be incurred in the future. The impact of marginal tax rates on the book leverage ratio will not be the focus of our current study. Nevertheless, we present the regression results for the book leverage ratio in Section 6 for the purpose of comparison with previous studies.

Intuitively, since market value is a decreasing function of the tax rate, as shown in Lemma 1, the market leverage ratio may also increase at first, as the tax rate increases, and then decline, except that the "turning point" from the positive to the negative slope is at a higher tax rate. Simple calculations show that:

$$\begin{aligned} \frac{d(D/V)}{dt} &= \frac{1}{V}\frac{dD}{dt} - \frac{D}{V^2}\frac{dV}{dt} \\ &= \underbrace{\frac{t}{\phi''}\frac{dV}{dt}}_{negative} + \underbrace{\frac{V}{\phi''}}_{positive} \end{aligned} \tag{6}$$

We summarize the results obtained so far in the following testable proposition. The key insight is that when the tax rate is already very high, there exists a negative relationship between the leverage ratio and the tax rate, because a reduced value of the firm puts a ceiling on the amount of debt it can raise.

Proposition 1: *Assume that the expected bankruptcy cost is increasing with the leverage ratio at an increasing rate. While increasing the tax rate will always reduce the firm's value, the impact on the level of debt and market leverage ratio is non-linear. Both the amount of debt and market leverage ratio may first increase and then decrease.*

A Numerical Example

Before we move to the empirical analysis based on the data, let us work out a simple numerical example which illustrates the main points. Assume that the expected bankruptcy cost takes the form of $\phi(D/V)=\left(D/V\right)^2$, which satisfies the condition that the bankruptcy cost is an increasing function of the debt ratio at an increasing rate. The pre-tax all equity financed firm is valued at $V_0 = 2$. In this case, the first-order condition in equation (4) can be simplified to a tractable quadratic equation, the solution of which is demonstrated in Figure 1. We see clearly that (a) the firm's value is decreasing with the tax rate; (b) both the level of debt and the market leverage ratio are increasing first and then decreasing with the tax rate; and (c) the "turning point" at which the slope first becomes negative is at a higher tax rate for the market leverage ratio than that for the level of debt.

[Please Insert Figure 1 here.]

In the next section, we will test Proposition 1 by using historical panel data of U.S. firms.

3. Sample and Summary Statistics

This section contains a brief description of the process of constructing the sample and variables, as well as the summary statistics.

3.1 Data Samples

Our primary sample consists of all firms in the merged Compustat/CRSP Fundamental Annual database. We then merge the primary sample with the marginal tax rate data from Blouin, Core and Guay (2010). Both data sets are offered through Wharton Research Database Services (WRDS).

The marginal tax rate (MTR) at the corporate level is defined as the present value of current and deferred income taxes to be paid per dollar of the additional taxable income of a firm. The U.S. tax code allows carryforwards (up to twenty years) and carrybacks (for two years) of taxable income over time, thus the tax implication of additional income earned today is quite complicated. It is a function of income the firm earned in prior years and that it is expected to earn in future years. Building on the approach adopted earlier by Shevlin (1990) and Graham (1997), Blouin, Core and Guay (2010) improve the estimates by incorporating the mean-reverting feature of taxable income, which they demonstrate is better than earlier studies which assume a random walk feature of future taxable incomes based on the historical volatility of annual taxable income. In our main analysis, we will use the MTR developed by Blouin, Core and Guay (hereafter MTR-BCG) to test Proposition 1. For completeness and a robust check, we will also use the MTR provided by Graham (MTR-Graham)[6]. Further, both the MTR-BCG and the MTR-Graham have two series: the pre-interest MTR and the after-interest MTR. Since the after-interest MTR already incorporates the firm's leverage choices, we have adopted the pre-interest MTR throughout our analysis following the convention in this area of research.

As explained in the previous section, we adopt the market leverage ratio as the measure of the firm’s leverage. The market leverage ratio is defined as the ratio of the market value of debt over the market value of assets. However, data on the market value of public debt are difficult to obtain. For nonpublic debt such as a bank loan, the market value is unavailable. Most empirical studies in capital structure research (e.g. Flannery and Rangan (2006), Strebulaev (2007), Frank and Goyal (2007), and Lemmon, Roberts, and Zender (2008)) thus use book value of debt instead. We follow that practice and define market leverage as the ratio of the book value of debt over the sum of the book value of debt and the market value of equity[7]. Typically the difference caused by this compromise is relatively small.

3.2 Control Variables

There are many other factors which are important for firms’ leverage decisions. The potential choices of control variables are plentiful. To ensure comparability with prior studies, we choose some commonly used control variables. Two groups of control

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[6] The main difference between the marginal tax rates simulated by Blouin, Core and Guay vs. those estimated by Graham is the assumption of future taxable income. While Graham adopts a random walk assumption, Blouin, Core and Guay use a mean-reverting process to simulate future taxable income which they believe to fit better with the data. Please see Blouin, Core and Guay (2010) for further explanations.

[7] Strebulaev (2007) calls this a “quasi-market leverage ratio”.

variables are adopted. The first group consists of conventional controls suggested by prior research (e.g. Titman and Wessels (1980), Rajan and Zingales (1995), and Frank and Goyal (2007)), including firm size, market-to-book, profitability, tangibility and industry median leverage. The second group includes a few additional control variables which have been suggested by more recent studies.

A firm's size matters in its financing choices for several reasons. Large firms are typically more diversified and so have cheaper access to outside financing and lower proportionate bankruptcy costs[8]. Market-to-book ratio is a measure of a firm's growth opportunities. Growth firms face more business risk and thus have a higher probability of bankruptcy. Whether profitable firms should have more or less debt is interesting, as noted in Frank and Goyal (2008) and others. Profitable firms have strong cash flows and are less likely to fall into financial distress. Thus, the trade-off theory predicts that profitable firms could borrow more, but the empirical evidence often points in the opposite direction, suggesting other explanations may be more likely[9]. Tangible assets are easier to collateralize and firms suffer a smaller loss of value in bankruptcy. Industry median leverage may capture some omitted factors that are common within each industry, such as business risk, competition environment and regulation. Firms may also see industry median leverage as a benchmark in adjusting their leverage ratio (see Hovakimian, Opler, and Titman 2001).

Besides the above conventional controls, we also include additional ones in the analysis. First, we include research and development expenses (R&D). Frank and Goyal (2007a) interpret the R&D ratio as representing the uniqueness of the firm's assets and products. Other studies (e.g. Liu 2005 and Hovakimian 2006) employ the R&D ratio[10] as the proxy for the firm's growth opportunities, as growth firms tend to spend more on R&D to maintain their growth.

We also include prior stock return, the number of analysts following, and cash flow

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[8] For example, Hennessy and Whited (2006) find that external financing costs are substantially larger for small firms than for large firms. In their simulation, bankruptcy costs are equal to 8.4% of capital for large firms and 15.1% for small firms.

[9] Profitable firms have a stronger ability to generate internal revenue. If these firms follow the financing hierarchy suggested by the pecking order theory, they should borrow less.

[10] A lot of observations in the Compustat database have missing R&D expenses. Simply dropping these observations would have reduced our sample size dramatically. Following the practice of prior research (e.g. Chang, Dasgupta, and Hilary 2006, and Byoun 2008), we set the R&D ratio to zero if the observation has no R&D expenses. Further, we create the R&D dummy, a dummy variable equal to one if the R&D expense is missing, and zero otherwise, in order to capture the effect of the missing R&D expenses.

volatility as control variables. Welch (2004) argues that firms do not actively manage capital structure to counteract the mechanistic effects of stock returns on their leverage ratios, so that stock return effects determine market-based leverage ratios. Market timing theories have similar predictions but are based on the argument that managers actively time the equity market when the stock price exhibits mispricing. Chang, Dasgupta, and Hilary (2006) employ the number of analysts covering a firm as a proxy for information asymmetry and find that firms covered by more analysts are more likely to issue equity as opposed to debt. Furthermore, operating risk may also affect the firm's leverage ratio. Fama and French (2002) relate cash flow volatility to leverage. Firms with volatile cash flows are more likely to go bankrupt. An unstable income stream also leads to less efficient utilization of a debt tax shield.

Finally, Lemmon, Roberts and Zender (2008) find persistence in leverage ratios: high (low) leveraged firms tend to remain as such. We add one additional control variable: initial leverage, which is defined as the firm's first non-missing market leverage ratio in the Compustat database.

3.3 Summary Statistics

The MTR-BCG database covers the period from 1980 to 2007. Following the common practice in capital structure research, we drop financial firms with an SIC code between 6000 and 6999. We further require that all firm-year observations have non-missing market leverage and marginal tax rate, and that market leverage lies in the closed unit interval. All the other variables in the multivariate analysis are winsorized at both the upper and lower one-percentile. Detailed variable definitions are presented in Table 1. Dollar figures are in millions and are deflated to the year 2005 dollars.

[Please Insert Table 1 Here]

Table 2 presents the statistics of the sample. The summary statistics in Panel A show that the mean and median market leverage in our sample is 0.245 and 0.174, respectively. On average, our sample firms generate 1,503.7 million dollars of sales revenue per annum and have 1,760.2 million dollars of total assets on hand, of which 31.1% are fixed assets. However, the medians of these two variables are only 141.6 million dollars and 142.7 million dollars, respectively, indicating that their high mean values are mainly driven by large firms. Our sample firms also generate an operating income that is 4.4% of their total assets and spend 18.5% of their sales revenue on R&D activities. Like sales and book assets, the high mean R&D ratio is mainly driven by firms with extremely high R&D expenses relative to sales. Moreover, our sample firms attract a mean analyst following of 3.86. They also generate a 13.8% annual return for investors and have a cash flow volatility of 6.8% on average.

Panel B of Table 2 presents the correlation matrix of the variables. The first column shows that market leverage is positively correlated with the MTR-BCG, suggesting that higher market leverage is associated with a higher marginal tax rate. Market leverage is also positively correlated with firm size, profitability and tangibility, while negatively correlated with market-to-book, R&D ratio, analyst following, stock return and cash flow volatility. The MTR is also positively correlated with firm size, profitability, tangibility, analyst following and stock return, while negatively correlated with market-to-book and R&D ratio.

[Please Insert Table 2 Here]

4. Market Leverage and Corporate Marginal Tax Rate

Our theoretical analysis predicts that market leverage first increases and then decreases with the rise of the tax rate. In this section, we perform empirical tests to examine this prediction. More specifically, we perform regressions that include the MTR and the MTR-squared as independent variables. The regression specification is as follows:

$$(D/V)_{i,t} = \alpha + \beta_1 MTR_{i,t-1} + \beta_2 MTR_{i,t-1}^{\ 2} + \gamma X_{i,t-1} + \varepsilon_{i,t} \qquad (7)$$

where i indexes firms, t indexes years, X is a set of control variables, and ε is the error term. All the independent variables are lagged for one year to control for the endogeneity in firms' financing decisions, and this treatment also fits the idea that the adjustment of capital structure is not instantaneous. We run pooled Ordinary Least Square (pooled-OLS) regressions with standard errors computed robust to heteroskedasticity and clustering at the firm level. The coefficients of interest are β_1 and β_2, which measure the change of the level of debt when the MTR increases. We predict a positive sign for the first coefficient and a negative sign for the second based on the theoretical analysis.

Before performing non-linear regressions, we run linear regressions first for comparison purposes. More specifically, we only include the MTR in the regression and examine the linear relationship between market leverage and the MTR. The regression results for the level of debt are presented in Table 3.

[Please Insert Table 3 Here]

Column (1) of Table 3 shows that the relationship between market leverage and the MTR-BCG is positive and significant. However, when we include control variables in Columns (2) and (3), the coefficient of the MTR-BCG becomes insignificant when control variables are included in the regression. The results suggest that the linear relationship between market leverage and the MTR-BCG is not robust, which demonstrates the need to explore empirically an alternative specification. After we add one additional control variable, the initial leverage following Lemmon et al. (2008), the regression result in Column (4) shows a significantly *negative* coefficient of the marginal tax rates. This result confirms the similar findings in Sibilkov (2009) and Campello and Giambina (2010). As we will see soon, such a puzzling finding is due to the linear specification of the relationship between the marginal tax rates and leverage ratios.

Next, we investigate the nonlinear relationship between market leverage and the MTR by including the squared term of the MTR in the regression as Equation (7). The results are presented in Table 4.

[Please Insert Table 4 Here]

Consistent with our theoretical predictions, Column (1) of Table 4 shows that the coefficients for the MTR-BCG and the squared term of the MTR-BCG are positive and negative, though the second coefficient is insignificant. When control variables are included, both coefficients are significant at the 1% level. To give a visual idea of how market leverage changes with the increase of the MTR, we calculate the turning point of the relationship from the estimated coefficients. The "turning point" is 61% in Column (1) without any control variables and this may explain why in a quasi-experimental setting when there is an exogenous increase in the tax rate, one can always expect to see an increase in leverage since the marginal tax rate tends to be well below 61% (see Maccio and Xu 2011). The turning point for the MTR-BCG is 25% in Column (2), 23% in Column (3) and 21% in Column (4) when various control variables are included. Since the MTR-BCG spans from 0% to 46%, the turning points are within the range of the MTR.

The results for conventional control variables in Column (2) are largely the same as prior findings. Market leverage is positively related to firm size, tangibility and industry median leverage, and negatively related to market-to-book ratio and profitability. The coefficients are all statistically significant at the 1% level, except the coefficient for the R&D ratio, which is significant at the 5% level. The results are consistent with the trade-off theory in that large, mature firms with a high proportion of tangible assets tend to borrow more, as these firms face lower expected costs of financial distress. We also see a negative relationship between market leverage and profitability. Such a relationship at first may seem to be inconsistent with the trade-off theory, but as explained by Frank and Goyal (2008), this relationship could be consistent with the trade-off theory if we treat both the debt and equity as functions of corporate profits separately. Furthermore, the coefficients of industry median leverage are large and are highly significant, highlighting the role of industry differences in the firm's financing choices.

The results in Column (3) that add the second group of control variables are consistent with prior studies as well. The R&D ratio is negatively associated with leverage, indicating that firms with new, innovative products and growth opportunities are less likely to issue debt. The number of analyst followings is also negatively associated with leverage, consistent with the evidence in Chang, Dasgupta, and Hilary (2006). Moreover, firms with higher stock returns tend to have lower market leverage, coinciding with both the market timing theory and Welch's (2004) argument that firms do not actively manage their capital structure against stock price movement. Last, cash flow volatility is negatively related to market leverage, indicating the importance of operating risk in the firm's financing decisions.

In Column (4) we add one more control variable, initial leverage, following Lemmon, Roberts and Zender (2008), who find that a firm’s capital structure, to a large degree, depends on its historical practice. The regression supports such a view, as the initial leverage is significantly positive against the market leverage ratio. Furthermore, our results show that the tax effect survives such a test: it cannot be subsumed in the firm's original preferred leverage position. Most notably, the tax effect on leverage ratios is in stark contrast to the result under the linear regression in Column (4) of Table 3, which reports a negative significant relationship between the marginal tax rate and leverage ratios.

To sum up, the regression results confirm the prediction of the theoretical model with regard to the nonlinear relationship between the market leverage ratio and the MTR: the market leverage ratio first increases and then decreases with the rise of the MTR.

5. Adjusting Marginal Tax Rate for Personal Taxes

All our analysis so far has been based on the corporate marginal tax rate. This is suitable if the marginal investors are non-profit endowments, pension funds or mutual funds which are essentially tax-free. However, some researchers (e.g. Miller 1977) argue that because personal tax on interest income is typically higher than that on equity income (dividend or capital gain), the personal tax penalty will reduce or even eliminate the corporate tax advantage to debt, if the marginal investor is a large shareholder who needs to pay personal income taxes on dividends and capital gains. Therefore, the tax-induced optimal capital structure may not exist in equilibrium. However, Graham (1999) documents that, although personal taxes provide a disincentive to the use of debt, they do not completely eliminate the corporate tax advantage of it.

In this section, we adjust the MTR for personal tax penalties (Adjusted-MTR) and then test whether the nonlinear relationship predicted by our theoretical model holds with the adjusted-MTR. Miller (1977) proposes the formula as follows:

$$\text{Adjusted MTR} = 1 - \frac{(1 - MTR)(1 - \tau_{PS})}{1 - \tau_{PB}} \tag{8}$$

where τ_{PS} is the personal tax rate on equity income from common stock, and τ_{PB} is the personal income tax rate on income from bonds. We estimate τ_{PS} as the weighted average tax rate for dividend income and capital gains:

$$\tau_{PS} = d\tau_{PD} + (1 - d)\tau_{PCG} \tag{9}$$

where d is the dividend payout ratio, estimated for each firm as the dividend payment divided by a three-year moving average of earnings; and τ_{PD} and τ_{PCG} are personal tax rates on dividend income and capital gains respectively. Because some firms may have periods of near zero or even negative earnings, some of our dividend payout ratio estimates can be either very large or negative, and we drop observations with payout ratios beyond the closed interval of zero and one.

Finally, we obtain estimates of τ_{PD} and τ_{PCG} from the NBER Taxsim model[11]. The model calculates the dollar-weighted average marginal income tax rates for the US Individual Income Tax from micro data for a sample of US taxpayers. NBER provides personal marginal tax rates that incorporate both federal and state level taxes for interest income, dividend, short-term capital gain and long-term capital gain on an annual basis. We estimate τ_{PCG} as the rate for long-term capital gain since prior research (e.g. Bell and Jenkinson 2002) shows that the effective marginal investors in the market are typically long-term. Correspondingly, we estimate τ_{PB} as the rate for interest income and τ_{PD} as the rate for dividend.

We rerun the regression specification in Equation (7) using the adjusted Marginal Tax Rate variable on the right-hand side. The results can be found in Table 5.

[Please Insert Table 5 here]

Overall, the regression results show that even after adjusting for personal taxes, the predicted nonlinear relationship between market leverage and the tax rate still exists.

6. Additional Tests

In this section, we conduct two further tests on the non-linear relationship between the market leverage ratio and the marginal tax rates using the same marginal tax estimates by Blouin, Core and Guay (2010): Random effects (RE) Panel Data Regressions and Tobit Regressions. We then re-run some of the regressions using the earlier estimates on marginal tax rates by Graham. Finally, for the ease of comparison with the existing study on capital structure, we then include the regression results for book leverage ratios.

6.1 Random effects Panel Data Regressions

First, we check the robustness of our results using alternative regression techniques. We

[11] See http://www.nber.org/~taxsim/marginal-tax-rates. Details of the Taxsim model are available in Feenberg and Coutts (1993).

run random-effects panel regressions[12] with the same regression specification as Equation (7). The results of the generalized least squares (GLS) Random effects panel data regressions are presented in Table 6, which show that the results from random-effect panel regressions are largely the same as those from pooled OLS. The coefficients of the MTR and the squared term of the MTR are significantly positive and negative, respectively.

[Please Insert Table 6 here.]

6.2 Tobit Model Regressions

While the extant literature largely uses the uncensored regression models, the fact that the market leverage ratio is non-negative indicates that it is more appropriate to use a censored regression model, i.e. the Tobit model. Table 7 reports the results. It shows that the non-linear regression results remain very robust. The relevant coefficients are statistically significant at the 1% level.

[Please Insert Table 7 Here.]

6.3 Regressions based on an Alternative MTR

In our previous analysis, we conducted tests based on the MTR-BCG. In this section, we would also like to use the alternative MTR estimated by Professor John Graham. Although we have achieved largely the same qualitative results as expected because two estimates are highly correlated with the coefficient of correlation at 0.816, one notable difference is that the "break point", when the relationship between the market leverage ratio and the MTR turns to negative, is smaller than under the MTR-BCG. Table 8 reports the regression results. Similar to the previous results in Table 3, we see that without the non-linear term, the relationship between the market leverage ratio and marginal tax rates can be negative when a host of control variables are added. However, with the non-linear specification we have obtained robust results that the market leverage ratio will first be increasing and then decreasing with marginal tax rates. We have also

[12] Since a firm's initial leverage is used as a control variable, there is no need to run a fixed effects panel data regression analysis.

obtained the regression results for adjusted MRTs with personal taxes and under the Tobit regression models. There are no substantial differences between the results under the MRT-BCG and those under the MRT-Graham and thus the regression results for the adjusted MTR under Graham and Tobit regressions using Graham estimates are omitted here.

[Please Insert Table 8 here.]

6.3 Regression Results for Book Leverage Ratios against the MTR

As stated previously, our theoretical results are more suitable for testing market leverage ratios against the MTR. Nevertheless, previous studies often report regression results based on book leverage ratios as well. For ease of comparison, we report the pooled OLS regression results for the non-linear relationship between book leverage ratios and the MTR, using both BCG and Graham estimates for corporate marginal tax rates. Since the book leverage ratio is mainly the level of debt relative to the firm's historical capital stock, with adjustment for retained earnings and other changes specified by accounting rules, the regression is closer to the test of the level of debt against the MTR, if we take the view that the book value is relatively constant when compared with the market value of the firm. Coupled with the high degree of correlation between the book leverage ratio and the market leverage ratio, we expect that the non-linear relationship will hold for such regressions. The results in Table 9 confirm this observation. More interestingly, the "turning point" where the relationship between leverage and the MTR is lower for book leverage than for market leverage, confirming the theoretical prediction (illustrated in Figure 1) that the level of debt will make the "turn" before the market leverage ratio. Using MTR_BCG, the turning point is 18%, 14%, and 10%, respectively, in Columns (7) to (9) of Table 9, compared to 25%, 23%, and 21% reported in Columns (2) to (4) in Table 4.

[Please Insert Table 9 here.]

7. Conclusions

The trade-off theory of capital structure predicts that firms will increase their debt level to fully capture tax benefits until the marginal tax benefits are equal to the expected marginal costs of debt. The extant literature often hypothesizes that there exists a positive linear relationship between the leverage ratios and marginal tax rates. In this paper we offer a new perspective and test of this well-known theory. As the corporate tax rate rises, the market value of a firm declines. On the one hand, the firm may want to raise more debt as the tax shields increase; on the other, the firm is financially constrained as a result of its declining market value. Consequently, corporate leverage may first increase and then decrease as the corporate tax rate rises. Using the new estimates of corporate marginal tax rates by Blouin, Core and Guay (2010) we find robust empirical support for this non-linear relationship between market leverage ratio and marginal tax rate. Our finding solves the puzzle why the tax rate is sometimes not a reliable determinant of leverage ratios in linear regressions and restores our faith in the foundation of the trade-off theory of capital structure.

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Table 1
Variable Definition

Words in italics refer to variable names and abbreviations in parentheses refer to the item name of the Merged Compustat/CRSP Fundamental Annual database.

Variable	Definition
Total Debt	Short-term Debt (DLC) + Long-term Debt (DLTT)
Market Equity	Stock Price (PRCC_F) * Shares Outstanding (CSHPRI)
Market Leverage	Total Debt / (Total debt + Market Equity)
Firm Size	Log (Sales (SALE)), where Sales is deflated to 2005 dollars.
Market-to-Book	(Market Equity + Total Debt + Preferred Stock (PSTKL) – Deferred Tax Credit (TXDITC)) / Book Assets (AT)
Profitability	Operating Income before Depreciation (OIBDP) / Book Assets (AT)
Tangibility	Net Property, Plant and Equipment (PPENT) / Book Assets (AT)
Industry Med. Lev.	Median leverage of industries defined by three-digit SIC codes.
R&D Ratio	R&D Expenses (XRD) / Sales (SALE), where missing R&D Expenses are set to zero.
R&D Dummy	Dummy variable equal to one if R&D Expenses are missing, and zero otherwise.
Analyst Following	The maximum number of analysts who make annual earnings forecasts in any month during a 12-month period. Data come from I/B/E/S Historical Summary.
Stock Return	One-year cumulative stock return. Data come from CRSP monthly file.
Cash Flow Volatility	Standard deviation of quarterly Profitability, measured over a twelve quarters moving window. Minimum of four quarterly observations are required. Data come from the Compustat Quarterly database.
Initial Leverage	The firm’s first non-missing market leverage ratio in the Compustat database.

Table 2
Descriptive Statistics

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2009. We drop financial firms and merge the sample with the marginal tax rate data from John Graham and Blouin, Core and Guay (2010). Panel A presents the mean, standard deviation (S.D.), 25-percentile, median, and 75-percentile for each variable. Panel B presents the correlation matrix for variables in the multivariate analysis. Dollar figures are in millions and are deflated to 2005 dollars.

Panel A. Summary Statistics

	Mean	S.D.	25%	Median	75%
Market Leverage	0.245	0.243	0.025	0.174	0.404
MTR-BCG	0.298	0.117	0.240	0.333	0.350
Sales	1,503.7	4,541.5	28.3	141.6	722.3
Book Assets	1,760.2	5,481.7	33.6	142.7	736.8
Firm Size	4.975	2.416	3.433	5.003	6.614
Market-to-Book	1.698	1.770	0.754	1.103	1.869
Profitability	0.044	0.247	0.016	0.105	0.166
Tangibility	0.311	0.244	0.111	0.244	0.463
R&D Ratio	0.185	0.890	0.000	0.000	0.049
Analyst Following	3.860	6.114	0.000	1.000	5.000
Stock Return	0.138	0.681	-0.271	0.022	0.361
Cash Flow Volatility	0.068	0.103	0.018	0.035	0.071
Observations			147,603		

Panel B. Correlation Matrix

	Market Leverage	MTR -BCG	Firm Size	Market-to -Book	Profitability	Tangibility	R&D	Analyst Following	Stock Return	Cash Flow Volatility
Market Leverage	1.000									
MTR-BCG	0.125	1.000								
Firm Size	0.171	0.560	1.000							
Market-to-Book	-0.408	-0.300	-0.250	1.000						
Profitability	0.008	0.614	0.487	-0.244	1.000					
Tangibility	0.294	0.179	0.155	-0.185	0.165	1.000				
R&D Ratio	-0.143	-0.324	-0.314	0.296	-0.465	-0.132	1.000			
Analyst Following	-0.097	0.262	0.649	0.055	0.225	0.141	-0.044	1.000		
Stock Return	-0.189	0.090	0.056	0.231	0.192	-0.031	-0.018	0.013	1.000	
Cash Flow Volatility	-0.134	-0.441	-0.435	0.334	-0.531	-0.140	0.268	-0.206	-0.064	1.000

Table 3
Linear Relationship between Market Leverage Ratio and Marginal Tax Rate

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2007. We drop financial firms and merge the sample with the marginal tax rate data from Blouin, Core and Guay (2010). The table presents the regression results for the market leverage ratio against the MTR. All the independent variables are lagged for one year. We run a pooled-OLS regression with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity.

Market Leverage Ratio

	(1)	(2)	(3)	(4)
MTR-BCG	0.432	0.009	-0.030	-0.103
	(33.30)***	(0.494)	(-1.542)	(-5.554)***
Firm Size		0.008	0.021	0.017
		(8.763)***	(15.89)***	(13.87)***
Market-to-Book		-0.036	-0.026	-0.022
		(-47.50)***	(-33.14)***	(-30.51)***
Profitability		-0.151	-0.162	-0.137
		(-22.02)***	(-19.79)***	(-17.28)***
Tangibility		0.113	0.109	0.086
		(14.17)***	(12.45)***	(10.10)***
Industry Med. Lev.		0.540	0.479	0.372
		(44.25)***	(34.71)***	(26.66)***
R&D Ratio			-0.003	-0.005
			(-2.501)**	(-3.856)***
R&D Dummy			0.036	0.023
			(8.881)***	(5.936)***
Analyst Following			-0.006	-0.004
			(-18.35)***	(-14.72)***
Stock Return			-0.027	-0.032
			(-24.04)***	(-28.66)***
Cash Flow Volatility			-0.084	-0.065
			(-6.081)***	(-4.898)***
Initial Leverage				0.290
				(25.40)***
Year Fixed-effect	No	Yes	Yes	Yes
Observations	85,558	85,558	85,558	85,558
Adjusted- R^2	0.040	0.315	0.349	0.396

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

Table 4
Non-linear Relationship between Market Leverage Ratio and Marginal Tax Rate

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2007. We drop financial firms and merge the sample with the marginal tax rate data from Blouin, Core and Guay (2010). The table presents the regression results for the market leverage ratio against the MTR. All the independent variables are lagged for one year. We run a pooled-OLS regression with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity. Initial leverage is defined as the firm's first non-missing market leverage ratio in the Compustat database.

Market Leverage Ratio

	(1)	(2)	(3)	(4)
MTR-BCG	0.751	0.864	0.662	0.574
	(16.00)***	(16.21)***	(11.75)***	(10.49)***
MTR-BCG^2	-0.613	-1.736	-1.429	-1.397
	(-6.898)***	(-17.24)***	(-12.88)***	(-12.97)***
Firm Size		0.010	0.023	0.019
		(10.75)***	(17.15)***	(15.15)***
Market-to-Book		-0.034	-0.025	-0.021
		(-46.63)***	(-32.46)***	(-29.72)***
Profitability		-0.188	-0.186	-0.160
		(-26.12)***	(-22.26)***	(-19.70)***
Tangibility		0.115	0.111	0.088
		(14.40)***	(12.70)***	(10.36)***
Industry Med. Lev.		0.536	0.478	0.370
		(44.04)***	(34.71)***	(26.68)***
R&D Ratio			-0.001	-0.003
			(-0.705)	(-2.017)**
R&D Dummy			0.035	0.022
			(8.763)***	(5.802)***
Analyst Following			-0.006	-0.004
			(-18.41)***	(-14.78)***
Stock Return			-0.027	-0.031
			(-23.35)***	(-27.96)***
Cash Flow Volatility			-0.076	-0.057
			(-5.501)***	(-4.300)***
Initial Leverage				0.290
				(25.46)***
Year Fixed-effect	No	Yes	Yes	Yes
Observations	85,558	85,558	85,558	85,558
Adjusted- R^2	0.041	0.319	0.352	0.398

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

Table 5
Non-linear Relationship between Market Leverage and Adjusted Marginal Tax Rate

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2007. We drop financial firms and merge the sample with the marginal tax rate data from Blouin, Core and Guay (2010). The MTR-BCG data is then adjusted according to Miller (1977). We use the personal tax rates provided by NBER Taxsim Model. All the independent variables are lagged for one year. We run a pooled-OLS regression with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity.

	Market Leverage ratio			
	(5)	(6)	(7)	(8)
Adjusted-MTR-BCG	0.415	0.441	0.338	0.251
	(12.58)***	(13.70)***	(10.31)***	(7.964)***
Adjusted-MTR-BCG^2	-0.159	-1.327	-1.139	-1.068
	(-1.942)*	(-18.49)***	(-15.02)***	(-14.56)***
Firm Size		0.012	0.024	0.021
		(11.75)***	(16.96)***	(15.70)***
Market-to-Book		-0.037	-0.027	-0.024
		(-42.47)***	(-29.43)***	(-27.87)***
Profitability		-0.184	-0.181	-0.160
		(-23.13)***	(-18.97)***	(-17.12)***
Tangibility		0.117	0.115	0.094
		(13.63)***	(12.37)***	(10.41)***
Industry Med. Lev.		0.523	0.464	0.368
		(39.77)***	(31.31)***	(24.76)***
R&D Ratio			-0.001	-0.002
			(-0.371)	(-1.418)
R&D Dummy			0.033	0.021
			(7.842)***	(5.196)***
Analyst Following			-0.006	-0.005
			(-17.77)***	(-14.82)***
Stock Return			-0.026	-0.030
			(-20.88)***	(-24.56)***
Cash Flow Volatility			-0.094	-0.071
			(-4.422)***	(-3.441)***
Initial Leverage				0.264
				(22.35)***
Year Fixed-effect	No	Yes	Yes	Yes
Observations	69,576	69,576	69,576	69,576
Adjusted-R^2	0.033	0.314	0.345	0.385

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

Table 6
Non-linear Relationship between Market Leverage and Marginal Tax Rate: Random Effects Panel Data Regression

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2009. We drop financial firms and merge the sample with the marginal tax rate data from John Graham and Blouin, Core and Guay (2010). The table presents the regression results for market leverage ratio against the MTR and the squared term of the MTR. All the independent variables are lagged for one year. We run a random-effect panel regression, with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity.

Market Leverage Ratio

	(1)	(2)	(3)	(4)
MTR-BCG	0.191	0.179	0.113	0.087
	(4.606)***	(4.087)***	(2.458)**	(1.904)*
MTR-BCG^2	-0.293	-0.511	-0.392	-0.384
	(-3.879)***	(-6.355)***	(-4.522)***	(-4.459)***
Firm Size		0.028	0.033	0.027
		(26.77)***	(24.99)***	(21.44)***
Market-to-Book		-0.020	-0.014	-0.013
		(-37.42)***	(-24.49)***	(-23.14)***
Profitability		-0.148	-0.126	-0.122
		(-24.59)***	(-18.90)***	(-18.49)***
Tangibility		0.159	0.148	0.124
		(19.62)***	(17.05)***	(14.69)***
Industry Med. Lev.		0.417	0.401	0.349
		(39.03)***	(35.24)***	(30.58)***
R&D Ratio			0.003	0.002
			(2.400)**	(1.577)
R&D Dummy			0.030	0.018
			(7.730)***	(4.757)***
Analyst Following			-0.004	-0.003
			(-12.95)***	(-11.91)***
Stock Return			-0.026	-0.028
			(-29.52)***	(-31.54)***
Cash Flow Volatility			-0.061	-0.051
			(-5.322)***	(-4.611)***
Initial Leverage				0.373
				(36.17)***
Year Fixed-effect	No	Yes	Yes	Yes
Observations	85,558	85,558	85,558	85,558
Overall R^2	0.029	0.282	0.321	0.378

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

Table 7
Non-linear Relationship between Market Leverage and Marginal Tax Rate: Tobit Regression Results

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2007. We drop financial firms and merge the sample with the marginal tax rate data from Blouin, Core and Guay (2010). The MTR-BCG data are then adjusted according to Miller (1977). All the independent variables are lagged for one year. We run a pooled-OLS regression with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity.

Market Leverage Ratio

	(1)	(2)	(3)	(4)
MTR-BCG	0.661	0.665	0.459	0.352
	(23.82)***	(18.01)***	(11.28)***	(9.107)***
MTR-BCG^2	-0.394	-1.669	-1.331	-1.279
	(-7.515)***	(-23.42)***	(-16.48)***	(-16.70)***
Firm Size		0.017	0.032	0.027
		(42.31)***	(55.45)***	(49.63)***
Market-to-Book		-0.048	-0.036	-0.032
		(-88.73)***	(-62.31)***	(-58.67)***
Profitability		-0.187	-0.191	-0.162
		(-39.65)***	(-34.93)***	(-31.27)***
Tangibility		0.136	0.140	0.113
		(42.20)***	(39.79)***	(33.40)***
Industry Med. Lev.		0.596	0.527	0.400
		(113.1)***	(88.59)***	(67.01)***
R&D Ratio			-0.001	-0.003
			(-1.191)	(-3.265)***
R&D Dummy			0.033	0.017
			(20.85)***	(11.37)***
Analyst Following			-0.007	-0.006
			(-55.73)***	(-44.98)***
Stock Return			-0.031	-0.037
			(-25.67)***	(-31.46)***
Cash Flow Volatility			-0.095	-0.073
			(-9.567)***	(-7.955)***
Initial Leverage				0.341
				(85.52)***
Year Fixed-effect	No	Yes	Yes	Yes
Observations	85,558	85,558	85,558	85,558
F Stat	2401.75	2031.00	1710.44	2122.32
P-value	0.000	0.000	0.000	0.000

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

Table 8
Linear vs. Non-linear Relationship between Market Leverage and Marginal Tax Rate: Employing the Marginal Tax Rates from Graham

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2009. We drop financial firms and merge the sample with the marginal tax rate data obtained from Professor John Graham's website. The table presents both the regression results for market leverage ratio against the MTR and the squared term of the MTR. All the independent variables are lagged for one year. We run a pooled-OLS regression with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity. Initial leverage is defined as the firm's first non-missing market leverage ratio in the Compustat database. Columns (1) to (4) are linear regression results, while Columns (5) to (8) are non-linear regression results.

Market Leverage Ratio

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
MTR-Graham	0.166	-0.079	-0.098	-0.128	0.280	0.383	0.235	0.210
	(13.15)***	(-5.641)***	(-6.864)***	(-9.374)***	(6.994)***	(9.237)***	(5.417)***	(5.062)***
(MTR-Graham)^2					-0.241	-1.041	-0.769	-0.782
					(-3.018)***	(-11.68)***	(-7.989)***	(-8.469)***
Firm Size		0.009	0.024	0.019		0.009	0.025	0.019
		(8.875)***	(17.95)***	(14.60)***		(9.454)***	(18.29)***	(14.94)***
Market-to-Book		-0.041	-0.028	-0.025		-0.040	-0.028	-0.024
		(-41.17)***	(-28.85)***	(-27.12)***		(-40.66)***	(-28.51)***	(-26.76)***
Profitability		-0.172	-0.183	-0.158		-0.188	-0.191	-0.166
		(-19.71)***	(-18.72)***	(-16.47)***		(-21.38)***	(-19.61)***	(-17.38)***
Tangibility		0.098	0.100	0.079		0.099	0.101	0.080
		(11.08)***	(10.65)***	(8.536)***		(11.23)***	(10.76)***	(8.651)***
Industry Med. Lev.		0.536	0.470	0.378		0.534	0.469	0.377
		(40.99)***	(32.53)***	(25.57)***		(40.81)***	(32.51)***	(25.55)***
R&D Ratio			-0.004	-0.006			-0.002	-0.004
			(-2.133)**	(-3.306)***			(-0.968)	(-2.068)**
R&D Dummy			0.032	0.020			0.032	0.020
			(7.329)***	(4.725)***			(7.301)***	(4.688)***
Analyst Following			-0.007	-0.005			-0.007	-0.005
			(-19.34)***	(-15.11)***			(-19.36)***	(-15.12)***
Stock Return			-0.032	-0.037			-0.032	-0.036
			(-23.74)***	(-27.26)***			(-23.53)***	(-27.05)***
Cash Flow Volatility			-0.133	-0.099			-0.137	-0.103
			(-6.757)***	(-5.274)***			(-7.000)***	(-5.525)***
Initial Leverage				0.265				0.265
				(22.07)***				(22.11)***
Year Fixed-effect	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	67,885	67,885	67,885	67,885	67,885	67,885	67,885	67,885
Adjusted-R^2	0.008	0.307	0.341	0.383	0.009	0.310	0.342	0.384

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

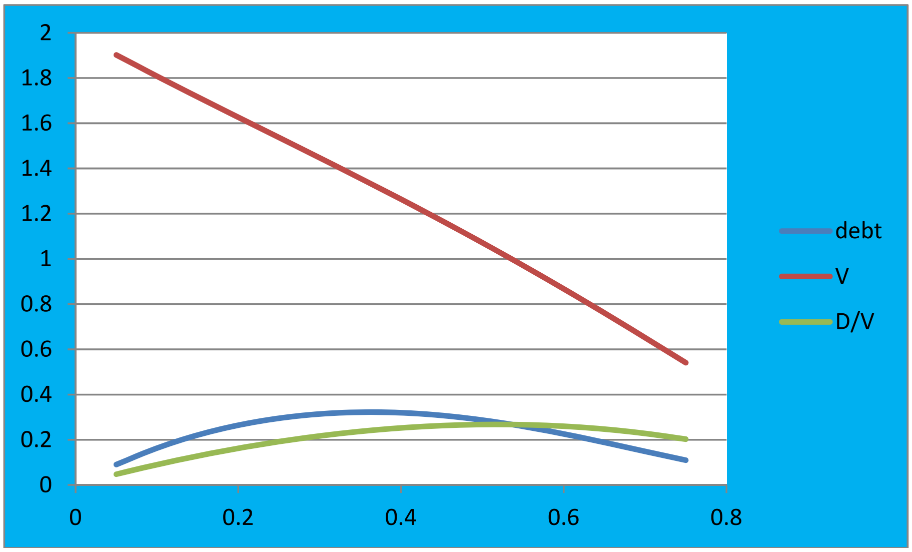
Table 9
Non-linear Relationship between Book Leverage and Marginal Tax Rate: Employing the Marginal Tax Rates from both BCG and Graham

The original sample contains all firms in the Merged Compustat/CRSP Fundamental Annual database between 1980 and 2009. We drop financial firms. The table presents the regression results for book leverage ratio against the MTR and the squared term of the MTR for both BCG and Graham estimates of corporate marginal tax rates. All the independent variables are lagged for one year. We run a pooled-OLS regression with *t*-statistics (in parentheses) computed using standard errors robust to both clustering at the firm level and heteroskedasticity. Initial leverage is defined as the firm's first non-missing market leverage ratio in the Compustat database. Columns (1) to (4) are non-linear regression results under the MTR-Graham, while Columns (5) to (8) are non-linear regression results under the MTR-BCG.

Book Leverage Ratio

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MTR-Graham	0.027	0.134	0.016	-0.006				
	(0.696)	(3.021)***	(0.342)	(-0.130)				
MTR-Graham^2	-0.012	-0.540	-0.288	-0.297				
	(-0.159)	(-5.767)***	(-2.888)***	(-3.068)***				
MTR-BCG					0.273	0.350	0.210	0.148
					(5.536)***	(5.963)***	(3.294)***	(2.385)**
MTR-BCG^2					-0.190	-0.972	-0.726	-0.720
					(-2.204)**	(-8.983)***	(-6.026)***	(-6.141)***
Firm Size		0.009	0.017	0.012		0.011	0.017	0.013
		(9.864)***	(13.75)***	(10.12)***		(12.10)***	(14.32)***	(11.65)***
Market-to-Book		-0.008	-0.003	0.000		-0.008	-0.003	0.000
		(-7.841)***	(-2.127)**	-0.421		(-9.739)***	(-3.574)***	(-0.00931)
Profitability		-0.150	-0.146	-0.122		-0.137	-0.136	-0.112
		(-14.37)***	(-12.90)***	(-10.97)***		(-16.41)***	(-13.57)***	(-11.38)***
Tangibility		0.119	0.116	0.099		0.134	0.129	0.110
		(13.95)***	(12.73)***	(11.08)***		(17.27)***	(15.11)***	(13.22)***
Industry Med. Lev.		0.580	0.540	0.454		0.572	0.532	0.433
		(32.72)***	(28.60)***	(23.58)***		(36.57)***	(30.93)***	(24.80)***
R&D Ratio			-0.003	-0.004			-0.001	-0.002
			(-0.890)	(-1.470)			(-0.380)	(-1.134)
R&D Dummy			0.020	0.010			0.026	0.015
			(5.075)***	(2.579)***			(6.994)***	(4.133)***
Analyst Following			-0.003	-0.002			-0.003	-0.002
			(-10.71)***	(-6.347)***			(-10.07)***	(-5.935)***
Stock Return			-0.015	-0.019			-0.013	-0.017
			(-11.08)***	(-13.48)***			(-11.00)***	(-14.21)***
Cash Flow Volatility			-0.004	0.024			0.001	0.017
			(-0.159)	-1.044			-0.031	-1.008
Initial Leverage				0.211				0.236
				(19.01)***				(22.32)***
Year Fixed-effect	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	67,885	67,885	67,885	67,885	85,558	85,558	85,558	85,558
Adjusted-R^2	0.000	0.200	0.216	0.252	0.009	0.210	0.230	0.270

Figure 1: The relationship between the tax rate and the optimal amount of debt and the debt ratio: A numerical example given in Section 2



The above graph is the simulated result of the relationship between the optimal amount of debt, the firm value, the market leverage ratio and the tax rate. $\phi(D/V) = (D/V)^2$, $V_0 = 2$.

tax rate	D	V	D/V
0.05	0.090465	1.902262	0.047557
0.1	0.163475	1.808174	0.090409
0.15	0.220997	1.716575	0.128743
0.2	0.264535	1.626454	0.162645
0.25	0.295261	1.536908	0.192113
0.3	0.314123	1.447118	0.217068
0.35	**0.32194**	1.356339	0.237359
0.4	0.319487	1.263897	0.252779
0.45	0.307585	1.169207	0.263071
0.5	0.287187	1.071797	**0.267949**
0.55	0.259471	0.971354	0.267122
0.6	0.225909	0.867773	0.260332
0.65	0.188314	0.761202	0.247391
0.7	0.148827	0.65209	0.228231
0.75	0.109831	0.541187	0.202945

Appendix:

1: Proof of the First-order Condition in Equation (4).

Proof: Total differentiation of the firm's value function (1) yields:
$dV = tdD - \phi' \frac{VdD - DdV}{V^2}$

$$\frac{dV}{dD} = \frac{t - \frac{\phi'}{V}}{1 - \frac{D\phi'}{V^2}} \qquad \text{(A1)}$$

The optimal amount of debt is achieved if $tV - \phi_D = 0$, provided that the denominator of (A1) is positive. But when $tV - \phi_D = 0$, the denominator is always positive, because by substituting this equation into (A1), $1 - \frac{D\phi'}{V^2} = 1 - \frac{tD}{V}$. As the tax shield tD is less than the firm's total market value, $tD < V$, the firm's optimal choice of debt can be characterized by equation (4). Now we need to verify that the second order condition for value maximization is satisfied.

$$\frac{d^2V}{dD^2} = \frac{-\frac{\phi''}{V^2}\frac{d(D/V)}{dD}}{\left(1 - \frac{D\phi'}{V^2}\right)}, \text{ (using the first-order condition)}$$

$$= -\frac{\phi''}{V^3\left(1 - \frac{D\phi'}{V^2}\right)} < 0. \qquad \text{Q.E.D.}$$

2: Proof of Lemma 1.

Proof: Using the implicit function theorem,

$$dV = -V_0 dt + Ddt + tdD - \phi' \frac{VdD - DdV}{V^2}$$

$$= -V_0 dt + Ddt + \left(t - \frac{\phi'}{V}\right) dD + \frac{\phi' D}{V^2} dV$$

$$= -V_0 dt + Ddt + \frac{\phi' D}{V^2} dV \qquad \text{(applying the first-order condition (4)).}$$

Thus,

$$\frac{dV}{dt} = -\frac{\left(V_0 - D\right)}{1 - \frac{\phi' D}{V^2}} = -\frac{\left(V_0 - D\right)}{1 - \frac{tD}{V}} < 0, \text{ since } D < V_0, \text{ and } tD < V.$$

To get dD/dt, we need to totally differentiate the first order condition:

$$tdV + Vdt = \phi'' \frac{VdD - DdV}{V^2}.$$

$$\left(t + \frac{D\phi''}{V^2}\right)\frac{dV}{dt} = \frac{\phi''}{V}\frac{dD}{dt} - V.$$

Thus,

$$\frac{dD}{dt} = \underbrace{\left(\frac{tV^2 + D\phi''}{V\phi''}\right)\frac{dV}{dt}}_{negative} + \underbrace{\frac{V^2}{\phi''}}_{positive} \qquad \text{(A2)}$$

Q.E.D.