Debt Dynamics

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Abstract

We develop a dynamic model of financial and investment policy with corporate and individual taxes, costly equity issuance, and debt constraints. The dynamic framework allows us to explain a number of empirical findings inconsistent with static tax-based theories. We show that: 1) there is no target leverage ratio; 2) firms can be savers or heavily levered; 3) leverage is path dependent and exhibits hysteresis; 4) leverage is decreasing in lagged liquidity; and 5) leverage varies negatively with an external finance weighted-average Q ratio. In the empirical section, we estimate key structural parameters using a simulation estimator.

The Miller (1977) perpetual tax shield formula has served as one of the major references for those evaluating whether taxes can explain observed financing patterns. To take a prominent example, the static trade-off theory posits that firms weigh the tax benefits of debt, as incorporated in the Miller formula, against costs associated with financial distress and bankruptcy. Against this benchmark model, a number of empirical anomalies have been alleged.

Graham (2000) finds that, "Paradoxically, large, liquid, profitable firms with low expected distress costs use debt conservatively." By debt "conservatism," Graham means that firms fail to issue sufficient debt to drive their expected marginal corporate tax rate

down to that consistent with a zero/low net benefit to debt based on the Miller formula. In yet another blow to the theory, Myers (1993) states, "The most telling evidence against the static trade-off theory is the strong inverse correlation between profitability and financial leverage... Higher profits mean more dollars for debt service and more taxable income to shield. They should mean higher target debt ratios." Baker and Wurgler (2002) reject the trade-off theory on different grounds, stating, "The trade-off theory predicts that temporary fluctuations in the market to book ratio or any other variable should have temporary effects." Based on finding a negative relationship between leverage and an "external finance weighted average market to book ratio" they conclude that "capital structure is the cumulative outcome of attempts to time the equity market."

This paper shows that the empirical literature has incorrectly rejected the null that a rational tax-based model can explain the stylized facts and prematurely accepted the alternative hypotheses of non-maximizing behavior, Myers' (1984) pecking order theory, and/or market timing. The most sensible interpretation of the literature is that it has taken a static one-off model and compared its predictions with data generated by firms making a sequence of dynamic financing decisions. Corporations do not face an infinite repetition of the Miller (1977) financing problem. Consequently, his framework is an inappropriate basis for assessing whether a rational tax-based model can explain observed leverage ratios. We show that such a model is, indeed, consistent with the stylized facts. As such, our results reconcile the puzzles cited above with the evidence presented by MacKie-Mason (1990) and Graham (1996a) that taxes matter.

We address the seeming anomalies by solving and simulating a dynamic model of investment and financing under uncertainty, where the firm faces a realistic tax environment, small equity floatation costs, and limited debt capacity. The firm maximizes its value by making two interrelated decisions: how much to invest and whether to finance this investment internally, with debt, or with external equity. The firm can either borrow or save and can be in one of three equity regimes (positive distributions, zero distributions, or equity issuance.) The firm is forward-looking, making current investment and financing decisions in anticipation of future financing needs.

The logic of our argument is as follows. Traditional formulations of the financing decision place the firm at "date zero" with no cash on hand. Such firms are at the debt versus external equity financing margin since each dollar of debt replaces a dollar of costly external equity. The problem with the traditional approach is that corporations do not spend their lives at date zero. Rather, they evolve in a stochastic way, finding themselves at different financing margins over time. Rigid application of the traditional tax shield formula is made untenable by this fact.

As an illustration, consider a firm that realized a high profit shock last period, with internal cash exceeding desired investment. Rather than choosing between debt and external equity, this firm must choose between retention and distribution of the excess funds. Note also that each dollar of debt issued by this high liquidity firm would serve to increase the distribution to shareholders, rather than replacing external equity. As intuition would suggest, our model shows that the marginal increase in debt (reduction in saving) is more attractive when it serves as a replacement for costly external equity, and is less attractive when it finances an increase in distributions to shareholders. Since high liquidity firms are more likely to be at the latter financing margin, they issue less debt.

This example illustrates the pitfalls associated with the traditional static framework. The more general message to take away is that, given the importance of a corporation's endogenous financing margin, characterization of how the tax system influences the financial and investment policies of a rational firm necessitates a forward-looking dynamic framework. Anything else is guess-work.

We highlight the main empirical findings. First, absent any invocation of market timing or adverse selection premia, the model generates a negative relationship between leverage and lagged measures of liquidity, consistent with the evidence in Titman and Wessels (1988), Rajan and Zingales (1995), and Fama and French (2002). Second, financial policy displays path dependence; large positive shocks induce spikes in investment and equity issuance, even though it is costly. Finally, even though the model features single-period debt, leverage exhibits hysteresis, since firms with high lagged debt are more likely to find themselves at the debt versus external equity margin. The combination of path dependence and hysteresis

is sufficient to generate a data series containing the main Baker and Wurgler (2002) results in a rational model without market timing or adverse selection premia.

The model is sufficiently parsimonious that it can be taken directly to data. Because of the discrete nature of the tax environment, it is impossible to generate smooth, closed-form estimating equations from the model. Therefore, we turn to simulation methods, employing the indirect inference technique in Gourieroux, Monfort, and Renault (1993) and Gourieroux and Monfort (1996). Specifically, we solve the model via value function iteration and then use this solution to generate a simulated panel of firms. Our indirect inference procedure picks parameter estimates by minimizing the distance between interesting moments from actual data and the simulated moments.

Our model is most similar to those developed by Gomes (2001) and Cooley and Quadrini (2001). The key differences between our model and that of Gomes are that we: 1) include taxation; 2) model debt issuance explicitly; and 3) allow the corporation to save. We place greater emphasis on financing since we seek to explain empirical leverage relationships, whereas Gomes focuses upon investment. Cooley and Quadrini (2001) examine industry dynamics in a model which explicitly treats the choice between debt and equity in a setting without taxes. Firms rent rather than purchase physical capital and their model imposes a cap on the equity of the firm, and hence liquid assets. This cap is rationalized by assuming the corporation earns a lower rate of return on financial investments than shareholders.

In related papers, Fischer, Heinkel, and Zechner (FHZ) (1989) and Goldstein, Ju, and Leland (GJL) (2001) analyze dynamic capital structure in continuous-time settings. We highlight our contributions. First, the FHZ and GJL models feature exogenous investment. We demonstrate that in the presence of taxes and costs of external equity, it is invalid to assume that real investment is independent of financing.[1] Second, in our model, distribution and savings policy are endogenous, allowing us to analyze high liquidity firms that find themselves at the retain versus distribute margin. In the FHZ model, the levered firm always makes a negative distribution. In the GJL model, the residual of EBIT over debt

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[1]Since debt is riskless in our model, the link between financing and real investment does not stem from equity-debt conflicts, as in Jensen and Meckling (1976) and Myers (1977).

service and corporate taxes is automatically paid to shareholders.

Our paper is also related to the public finance literature assessing the effect of the dividend tax, with Auerbach (2002) providing a recent survey. Sinn (1991) presents a deterministic model in which the firm cannot issue debt, and must choose between internal and external equity. Auerbach (2002) presents a more satisfactory treatment of the effect of taxation on financial policy. However, his model: 1) is deterministic; 2) has no real investment decision; 3) has no cost of equity issuance; 4) assumes a flat rate corporate income tax; and 5) imposes exogenous dividend and repurchase constraints.[2]

Another contribution of our model is that it endogenously determines optimal financial slack. Kim, Mauer, and Sherman (1998) bound corporate saving by setting an exogenous lower rate of return on corporate financial investments. Almeida, Campello, and Weisbach (2003) remove the precautionary motive for saving by imposing a finite horizon. Shyam-Sunder and Myers (1999) foreshadow our approach, arguing that, "tax or other costs of holding excess funds" may compel distributions. However, their discussion begs the following questions. First, exactly what are the "tax costs" associated with slack? Second, since pecking order theory assumes "taxes are second order," then at what point do taxes become first order? Finally, what is the optimal amount of slack and how does it vary with tax rates and costs of external funds? Our model answers each question explicitly.

Before proceeding, it should be noted that forty years ago Modigliani and Miller (1963) articulated the need for precisely the type of model developed in this paper, stating:

> The existence of a tax advantage for debt financing... does not necessarily mean
> that corporations should at all times seek to use the maximum possible amount
> of debt... For one thing, other forms of financing, notably retained earnings,
> may in some circumstances be cheaper still when the tax status of investors
> under the personal income tax is taken into account. More important, there
> are, as we pointed out, limitations imposed by lenders... which are not fully
> comprehended within the framework of static equilibrium models, either our

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[2]In fairness, Auerbach intends to present a simple model contrasting alternative theories.

own or those of the traditional variety.

The details of the dynamic model that Modigliani and Miller seemed to have in mind have never been worked out. Consequently, empiricists have been forced to make conjectures regarding the signs and magnitudes of the regression coefficients implied by the theory. Bridging the divide between theory and data is the objective of this paper.

The remainder of the paper is organized as follows. Section I provides several simple examples that explain the main intuitive results. Section II presents the model, and sections III and IV derive the optimal financial and investment policies, respectively. Section V shows that under reasonable parameter values, the model generates policies consistent with the stylized facts. Section VI describes our data and the indirect inference procedure. Section VII concludes.

I. The Basic Argument

The following stylized examples convey the central intuition of the dynamic model. For the purpose of simplicity, this section: 1) fixes the firm's real investment policy; 2) ignores uncertainty; and 3) assumes constant tax rates on corporate income, individual interest income, and corporate distributions, denoted (τ_c, τ_i, τ_d), respectively. These assumptions are relaxed in the model presented in Section II.

Consider the standard "date zero" firm with no internal cash evaluating the choice between debt and external equity. Assume the firm knows marginal funds will be distributed next period. Reducing debt issuance by one dollar increases next period's distribution by $1 + r(1 - \tau_c)$, with the shareholder receiving the following amount after distribution taxes:[3]

$$1 + r(1 - \tau_c)(1 - \tau_d). \tag{1}$$

Now assume that each dollar raised in the equity market costs the shareholder $1 + \lambda$, where λ may be interpreted as floatation costs. Reducing debt issuance by one dollar requires

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[3]This expression adopts Stiglitz' (1973) assumption that the dollar of equity injected into the firm is treated as a "return of capital" exempt from the distribution tax.

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the shareholder to give up $1 + \lambda$ in the current period. If the shareholder had been able to invest these funds on his own account, rather than contributing them to the firm for the purpose of debt reduction, he would have received:

$$(1 + \lambda)[1 + r(1 - \tau_i)]. \tag{2}$$

Therefore, it is better to leave the debt outstanding when:

$$(1 + \lambda)[1 + r(1 - \tau_i)] > 1 + r(1 - \tau_c)(1 - \tau_d) \tag{3}$$

$$\Rightarrow \frac{\lambda[1 + r(1 - \tau_i)]}{r} > \tau_i - [\tau_c + \tau_d(1 - \tau_c)]. \tag{4}$$

From condition (4) it follows that even small λ values would serve as a severe deterrent to equity issuance for a firm at this margin. This is consistent with the static pecking order theory's prediction that external equity will only be utilized as a "last resort." Note also that if there are no costs of external equity, the analysis of this case yields what we will term the "traditional" condition for dominance of debt over external equity:

$$\tau_c > \frac{\tau_i - \tau_d}{1 - \tau_d}. \tag{5}$$

Note that Miller derives his condition for the optimality of debt finance (5) by implicitly setting up a firm at the debt versus external equity margin with non-negative distributions to shareholders in all future periods.[4]

Following Graham (2000), adopt the temporary assumption that:

$$\tau_i = 29.6\%$$

$$\tau_d = 12\%.$$

Under these tax rates, the traditional condition (5) implies that debt should be issued so long as:

$$\tau_c > 20\%.$$

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[4]See Miller (1977), footnote 18.

Despite the common implicit use of condition (4) as an argument against costly external equity and condition (5) as a gauge of debt conservatism, they are only applicable if two special conditions are met: 1) the firm has no internal funds this period, and is thus at the debt versus external equity margin; and 2) the firm knows it will make a positive distribution next period.

Next consider the same firm, but assume that it has different expectations regarding next period's equity regime. In particular, assume that rather than making a distribution next period, the firm anticipates issuing external equity. That is, external equity represents next period's *marginal* source of funds.

If the firm retires a dollar of debt this period, required equity issuance next period is reduced by $1 + r(1 - \tau_c)$. Next period, this saves the shareholder:

$$(1 + \lambda)[1 + r(1 - \tau_c)]. \tag{6}$$

Reducing debt issuance by one dollar requires the shareholder to give up $1 + \lambda$ in the current period. If the shareholder had been able to invest these funds on his own account, rather than contributing them to the firm for the purpose of debt reduction, he would have received:

$$(1 + \lambda)[1 + r(1 - \tau_i)]. \tag{7}$$

In this context, it is better to leave the debt outstanding if:

$$(1 + \lambda)[1 + r(1 - \tau_i)] > (1 + \lambda)[1 + r(1 - \tau_c)] \tag{8}$$

$$\Rightarrow \tau_c > \tau_i. \tag{9}$$

For firms at this margin, it is optimal to delay equity issuance when the shareholder can earn a higher after-tax rate of return on savings than the corporation. A startling implication of this analysis is that the debt versus external equity condition does not depend on λ or τ_d. For firms at this margin, the choice is not *whether* to incur the cost of external equity, but rather *when* to incur this cost. Note also that under the assumed tax rates, the

critical corporate tax rate needed to induce debt issuance is 29.6 percent, which is above the traditional trigger given in (5), which is equal to 20 percent. This is not an artifact of the tax rates chosen in this example, since:

$$\tau_d > 0 \Rightarrow \tau_i > \frac{\tau_i - \tau_d}{1 - \tau_d}. \tag{10}$$

When $\tau_c < \tau_i$, the optimal policy is to issue sufficient equity this period to retire all debt. This analysis implies that corporations with low marginal corporate tax rates using equity as their *marginal* source of funds next period will violate the predictions of Myers' (1984) pecking order theory. In particular, all-equity finance will be optimal even though the firm has access to riskless debt. It should also be stressed that this argument is not circular. We made no assumptions regarding the source of funds this period. The firm was free to choose between debt and equity. Rather, the assumption adopted was that the firm anticipates external equity being the *marginal* source of funds *next* period.

Myers (1993) states that, "In practice the pecking order theory cannot be wholly right. A counterexample is generated every time a firm issues equity when it could have issued investment grade debt." We would argue that while such financing practices constitute a clear violation of the pecking order theory, they should not be interpreted as evidence against the existence of adverse selection premia ($\lambda > 0$), as rationalized by Myers and Majluf (1984). Rather, a dynamic specification of the capital structure decision must recognize the fact that the cost of servicing even riskless debt is affected by adverse selection premia in the equity markets.

The previous two examples illustrated how the choice between debt and external equity depends upon the firm's expected equity regime next period. As a final example, consider a cash-cow firm with internal funds well in excess of the amount needed to fund the real investment program. Rather than choosing between debt and external equity, such a firm must choose between retention and distribution of the excess funds.

Suppose the CFO anticipates that marginal funds will be distributed next period. If the funds are distributed today, the shareholder receives $(1 - \tau_d)$. By investing the funds

on his own account, he receives the following amount next period:

$$(1 - \tau_d)[1 + r(1 - \tau_i)]. \tag{11}$$

In contrast, if the funds are retained for the purpose of corporate saving, the shareholder receives the following amount next period after distribution taxes:

$$(1 - \tau_d)[1 + r(1 - \tau_c)]. \tag{12}$$

In this context, it is better to distribute, and reduce internal saving, if:

$$\tau_c > \tau_i. \tag{13}$$

The corporation will want to reduce saving so long as its tax rate exceeds 29.6 percent, which differs from the traditional trigger for the dominance of debt over external equity, which is 20 percent under the assumed tax rates. Intuitively, the shareholder prefers the firm to distribute the funds now if the he can invest at a higher after-tax rate of return than the corporation. Similar results are derived by King (1974), Auerbach (1979), and Bradford (1981).

Note also that this financing condition is independent of λ and τ_d. The possibility that distribution policy may be independent of τ_d is known in the public finance literature as the "new view" of dividend taxes. The interesting parallel between our analysis of the effect of floatation costs and the new view of dividend taxes is that when the firm's equity regime is constant across periods (either making a distribution or issuing equity), the financing rule is independent of both λ and τ_d. All that matters is the relative magnitudes of τ_c and τ_i. In fact, in the context of the full dynamic model, Lemma 4 shows that the target expected marginal corporate tax rate for a firm with a constant equity regime across adjacent periods is $\tau_c^* = \tau_i$.

The discussion above focused on some extreme circumstances. In reality, firms can be in three possible equity regimes: positive distributions, zero distributions, or negative distributions (equity issued). In addition, the equity regime next period should be modeled as the outcome of an optimizing decision over financing and real investment policies in light

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of the realized state. The model presented in the next section does so. Having said this, the simple examples provided above suggest the following insights. First, the optimal financial policy and target marginal corporate tax rate depend upon the firm's current equity regime and expectations regarding next period's equity regime. Second, optimal financial policy will exhibit path-dependence, since the firm's history determines its financing margin.

II. The Model

A. Production Technology

Time is discrete and the horizon infinite. The production of the price-taking firm requires physical capital (k) and a variable labor input (l). The space of inputs is a subset of the space of non-negative real numbers, $K \times L \subseteq \Re_+^2$. The corresponding measurable spaces are: $(K, \mathcal{K})$ and $(L, \mathcal{L})$. The firm's production function is given by f, and we impose the following conditions.

Assumption 1. The production function $f : K \times L \times Z \to \Re_+$ is strictly increasing, strictly concave, has decreasing returns in (k, l), and satisfies the Inada conditions. The technology shock z takes values in the finite set Z and follows a first-order Markov process with transition probability $\Gamma(z', z)$.

Letting w denote the wage rate, operating profits for the firm are:

$$\pi(k, z) \equiv \max_{l \geq 0} \ f(k, l, z) - wl. \tag{14}$$

Assumption 1 guarantees: the optimal labor input is unique; π is non-negative, continuous, strictly increasing, and concave in $k \in K$; and π is continuous and strictly increasing in $z \in Z$.

The evolution of the capital stock is a deterministic function of this period's investment (i), with:

$$i(k', k) \equiv k' - (1 - \delta)k. \tag{15}$$

The buy and sell price of physical capital is normalized to unity. Aside from the direct price of the capital, there are costs of adjustment (ψ) satisfying the following conditions

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which are standard.[5]

Assumption 2. The adjustment cost function $\psi : \Re \times K \to \Re_+$ is twice continuously differentiable, homogeneous degree one in (i, k), strictly increasing in i on $\Re_+$, strictly decreasing in i on $\Re_-$, strictly convex in i, and strictly decreasing and convex in k.

The total cost of the investment program (Ψ) is equal to the sum of direct costs of investment plus adjustment costs:

$$\Psi(k', k) \equiv k' - (1 - \delta)k + \psi[k' - (1 - \delta)k, k]. \tag{16}$$

B. Financing

The firm has four potential sources of funds: 1) external equity; 2) cash generated from operations; 3) single-period debt; and 4) internal savings. Our objective is to capture in a parsimonious fashion the central deviations from Modigliani and Miller's (1958) assumptions establishing the irrelevance of financial policy for total firm valuation. The model incorporates: 1) costs of equity issuance; 2) credit rationing; 3) a progressive corporate income tax; and 4) taxes on interest income and equity distributions at the individual level.

Consider first potential costs of external equity. Smith (1977) provides detailed evidence on direct floatation costs. Based on this data, Gomes (2001) estimates that the marginal floatation cost is 2.8 percent. Theory suggests that floatation costs may be the tip of the iceberg, however. In particular, Myers and Majluf (1984) demonstrate that adverse selection premia may significantly increase the costs of external equity. Based on this evidence, we assume that:

Assumption 3: For each dollar of external equity paid into the firm, there is a proportional cost $\lambda > 0$.

Of course, one can find arguments for and against the assumption that costs of equity issuance are linear in the amount raised. For instance, scale economies may cause direct

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[5]Early papers featuring adjustment costs include Lucas (1967), Lucas and Prescott (1971), Mussa (1977), and Abel (1983).

floatation costs to be concave in equity issuance. Alternatively, some might argue the lemons problem is more severe for firms issuing large blocks of equity. Given the opposing views, splitting the difference seems a reasonable compromise.

For the purpose of characterizing the optimal policies, we do not take a stance on whether λ represents floatation costs or an adverse selection premium. In the empirical section, we first test whether the model generates leverage dynamics consistent with the stylized facts presented by Baker and Wurgler (2002), absent any notion of adverse selection premia or market timing. Anticipating, we find that a small constant floatation cost is consistent with a negative relationship between leverage and an external finance weighted average Tobin's Q ratio.[6] In the second stage of our empirical analysis, we use indirect inference techniques to estimate the magnitude of various structural parameters, including λ. Anticipating, this analysis yields estimates of λ around 16 percent, in support of the notion that there is a substantial adverse selection premium in equity markets.

The literature on the market for loanable funds has focused upon the related problems of adverse selection and asset substitution. Jaffee and Russell (1976) discuss the potential for the quality of the credit pool to decline as the amount borrowed increases. Jensen and Meckling (1976) argue that the existence of risky debt in the financial structure creates incentives for borrowers to switch to high variance projects. Stiglitz and Weiss (1981) demonstrate that lenders, recognizing the existence of adverse selection and asset substitution problems, may ration credit rather than rely on higher promised interest rates as a device for allocating funds. A large theoretical literature follows up on this theme, deriving endogenous credit constraints. See, for instance, Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and a recent paper by Clementi and Hopenhayn (2002). Empirical support in favor of the existence of credit constraints is provided by Whited (1992).

Based on this consideration, we assume the "Intermediary" allocates funds on the basis of a screening process that ensures the borrower can repay the loan in all states. Since operating profits are increasing in physical capital, this specification of the credit allocation

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[6]The market to book ratio is an accounting construct that is not defined in our model. Average Q is the closest proxy.

process ensures that the amount the firm is able to borrow increases in firm size.

Assumption 4: The firm may borrow at interest rate r, with the Intermediary screening to ensure that the firm has sufficient internal cash at the end of the period to repay the loan in all states.

The FHZ and GJL models feature callable consol bonds with endogenous default, while our firm finances with finite maturity riskless debt. In our view, finite maturity debt represents a better approximation of reality. The relative legitimacy of riskless versus defaultable debt hinges upon the clearing mechanism in credit markets. Our model features credit rationing by a financial intermediary, with the continuous-time models assuming that debt markets clear via the promised interest rate. Here the truth resides between the extremes, depending on whether the firm relies upon intermediated debt, such as bank loans and private placements, or market debt. Empirically, intermediated debt is much more important. For example, in a sample of large public firms, Houston and James (1996) find that the mean percentage of market debt in total debt is only 17 percent, with the majority of firms (54 percent) using intermediated debt exclusively.[7] Finally, it should be noted that the objective of our model is not to predict leverage ratios, *per se*. The objective is to explain whether the dynamics of leverage ratios generated from a rational tax-based model can explain the types of regression coefficients to be found in the literature.

In the model, the endogenous state variable p' represents the face value of the debt, with payment coming due next period. If the firm is a borrower $p' > 0$. In order to allow for corporate saving, we assume that the firm may also lend, earning the pre-tax interest rate r. We let $P \subseteq \Re$ denote the set of possible values for p', and $(P, \mathcal{P})$ the corresponding measurable space. The credit rationing process imposes an upper bound on p'.

C. Taxation

Shareholders are taxed at rate τ_i on interest income, using $r(1 - \tau_i)$ as their discount rate. Following Bradford (1981), shareholders are taxed at rate τ_d on corporate distributions.

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[7]See Johnson (1997), Krishnaswami, Spindt, and Subramaniam (1999), and Denis and Mihov (2002) for additional empirical support.

It should be noted that our model does not impose any constraints on dividends or share repurchases. Nor do we make any assumption regarding whether the corporation uses dividends or share repurchases as the method for disgorging funds. Rather, we follow Bradford (1981) in assuming there is a flat rate of tax applied to the total amount distributed. This approach allows us to characterize optimal distribution policy, as distinct from optimal dividend policy. In particular, our model pins down the total amount paid to shareholders, not the means of distribution. As such, the model is silent on the "dividend puzzle."

In the context of the current U.S. income tax system, theory suggests that corporations *should* use share repurchases as the main vehicle for disgorging cash if the marginal shareholder is a taxable individual.[8] There are three advantages of share repurchases. First, capital gains enjoy a lower statutory rate for many taxpayers. Second, the shareholder's basis is excluded from tax. Finally, there is a tax free step-up in basis at death. In a detailed study, Green and Hollifield (2003) find that under an optimal repurchasing strategy, the effective tax rate on capital gains is only 60 percent of the statutory rate.[9]

The base of the corporate income tax is θ which equals operating profits LESS economic depreciation LESS interest expense PLUS interest income:

$$\theta(k, p, z) \equiv \pi(k, z) - \delta k - r\left(\frac{p}{1+r}\right). \tag{17}$$

The corporate tax function is denoted by g, with the marginal tax rate defined by:

$$g_1[\theta(k, p, z)] \equiv \tau_c[\theta(k, p, z)]. \tag{18}$$

Assumptions regarding the tax system are summarized below.

Assumption 5: Shareholders are taxed at flat rates of $\tau_i \in (0, 1)$ on interest income and $\tau_d \in (0, 1)$ on corporate distributions. The corporate income tax function $g : \Theta \rightarrow \Re$ is

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[8]Corporate shareholders may prefer dividends to repurchases due to the dividend exclusion rule.

[9]However, the failure to index the shareholders' basis can create real effective tax rates over 100 percent. See Feldstein and Summers (1979).

twice differentiable, strictly increasing and convex, satisfies $g(0) = 0$, with:

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\begin{aligned}
\lim_{\theta \to \infty} \tau_c(\theta) &\equiv \overline{\tau}_c < 1 \\
\lim_{\theta \to -\infty} \tau_c(\theta) &= 0 \\
\overline{\tau}_c &> \tau_i.
\end{aligned}
$$

In reality, firms with negative taxable income do not receive a check from the U.S. Treasury. Rather, tax losses may be carried back two years and carried forward twenty years. The convex tax schedule g is intended to capture the effects of the loss limitation provisions in a tractable way. For a careful treatment of these rules and the implications for effective marginal tax rates, the reader is referred to Graham (1996a).

The final condition states that the maximum corporate tax rate $(\overline{\tau}_c)$ is above shareholders' tax rate on interest income. This condition is imposed for the purpose of tractability, although it is not necessary. As is shown below, the condition that $\overline{\tau}_c > \tau_i$ is necessary to generate bounded savings and induce distributions of excess liquidity. If the condition is not met, then the model yields the prediction that the optimal policy for a corporation with excess liquidity is to save everything. We revisit this condition in Section III where the optimal financial policy is characterized.

D. The Firm's Problem

The cash flow to shareholders before distribution taxes or equity issuance costs is equal to:

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\pi(k, z) - p - g[\theta(k, p, z)] + \frac{p'}{1 + r} - \Psi(k', k). \tag{19}
$$

Letting Φ_d, Φ_i, and Φ_0 be indicators for positive distributions, equity issuance, and zero distributions, respectively, the cash flow to equity after distribution taxes or equity issuance costs is:

$$
e(k, p, k', p', z) \equiv [1 + \Phi_i \lambda - \Phi_d \tau_d] \left[\pi(k, z) - p - g[\theta(k, p, z)] + \frac{p'}{1 + r} - \Psi(k', k) \right]. \tag{20}
$$

Each period, the firm chooses the pair (k', p') subject to the credit rationing constraint. Without loss of generality, attention can be confined to compact K. As in Gomes (2001)

define $\overline{k}$ as follows:

$$\pi(\overline{k}, \overline{z}) - \delta\overline{k} \equiv 0. \tag{21}$$

Under Assumption 1, $\overline{k}$ is a well-defined quantity. Since $k > \overline{k}$ is not economically profitable, let:

$$K \equiv [0, \overline{k}]. \tag{22}$$

In determining the amount the firm may borrow, the lender requires that the firm have sufficient cash on hand at the start of the period in order to make the promised payment on the bond in all states. This credit rationing condition may be stated as:

$$p' \leq \pi(k', \underline{z}) - g[\theta(k', p', \underline{z})]. \tag{23}$$

The upper bound on debt based on (23) is increasing in k' and is denoted:

$$\overline{p}(k'). \tag{24}$$

In order to ensure compactness of the choice set, it is convenient to assume there is an arbitrarily high upper bound on corporate saving. In the notation of the model, this constraint places a lower bound on p' which is denoted $\underline{p}'$. Assumption 5 is a sufficient condition to ensure bounded saving.

At any given date s, the value of the shareholders' claim is:

$$V_s = E_s \left\{ \sum_{t=s}^{\infty} \left(\frac{1}{1 + r(1 - \tau_i)} \right)^{(t-s)} e_t \right\}. \tag{25}$$

The Bellman equation for this problem is:

$$V(k, p, z) = \max_{(k', p') \in K \times P} e(k, p, k', p', z) + \left[\frac{1}{1 + r(1 - \tau_i)} \right] \sum_{z'} V(k', p', z') \Gamma(z', z). \tag{26}$$

The preceding discussion implies that the set of feasible policies, $K \times P$, is compact, with the following propositions characterizing the value function and optimal policy.

Proposition 1 *There is a unique function $V : K \times P \times Z \to \Re_+$ satisfying (26).*

Proof. See Appendix. ■

Proposition 2 *For each $z \in Z$, the function $V(\cdot, \cdot, z)$ is strictly concave. The optimal policy $h(\cdot, \cdot, z) : K \times P \to K \times P$ is unique and continuous.*

Proof. See Appendix. ■

Proposition 3 *At all $(k, p, z) \in K \times P \times Z$ such that the optimal distribution to equity is nonzero, the function $V(\cdot, \cdot, z)$ is differentiable in its first two arguments with:*

$$V_i(k, p, z) = e_i(k, p, z) \text{ for } i = 1, 2.$$

Proof. *Follows from the Envelope Theorem of Benveniste and Scheinkman (1979), applied as in the proof of Theorem 9.10 in Stokey and Lucas (1989).* ■

Concavity of the value function in k is due to the fact that the profit function is concave in k and the convexity of the adjustment cost function (ψ) in its second argument. Concavity of the value function in the level of debt is due to the fact that the marginal corporate tax shield declines as more debt is issued and the fact that the net payment to equity (20) is a concave function of the firm's distribution, given in (19).

III. Optimal Financial Policy

The firm's budget constraint may be restated as:

$$\frac{p'}{1+r} - \frac{e(k, p, k', p', z)}{1 + \Phi_i \lambda - \Phi_d \tau_d} = \Psi(k', k) - [\pi(k, z) - p - g(\theta(k, p, z))]. \tag{27}$$

The left side represents sources of external finance and the right side represents the excess of investment costs over internal cash. The optimal financial policy is derived for a given funding requirement. Section IV characterizes the optimal real investment policy given the method of financing.

Firms are said to be *unconstrained* relative to a given program (k', k) if they have sufficient internal funds to finance investment without issuing debt or equity. The unconstrained

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firm satisfies:

$$\pi(k, z) - p - g(\theta(k, p, z)) > \Psi(k', k) \tag{28}$$

$$\Rightarrow \frac{p'}{1+r} - \frac{e(k, p, k', p', z)}{1 + \Phi_i\lambda - \Phi_d\tau_d} < 0.$$

Note that for the unconstrained firm, positive distributions to shareholders $(e > 0)$ are consistent with a zero debt policy $(p' = 0)$.

Firms are said to be *constrained* relative to a given program (k', k) if they must borrow and/or issue equity in order to finance the investment. The constrained firm satisfies:

$$\pi(k, z) - p - g(\theta(k, p, z)) < \Psi(k', k) \tag{29}$$

$$\Rightarrow \frac{p'}{1+r} - \frac{e(k, p, k', p', z)}{1 + \Phi_i\lambda - \Phi_d\tau_d} > 0.$$

In contrast to the unconstrained firm, if the constrained firm has zero debt, then it must issue equity.

Aside from the kink point at which $e = 0$, application of the implicit function theorem to (27) yields:

$$\frac{\partial e}{\partial p'} = \frac{1 + \Phi_i\lambda - \Phi_d\tau_d}{1 + r}. \tag{30}$$

Since the objective function is kinked, we determine the optimal financial policy using perturbation arguments. The debt constraint is ignored for the sake of expositional simplicity. Clearly, if the debt level derived using the perturbation argument is above the amount allowed under the debt constraint, then the optimal debt level is equal to $\overline{p}(k')$.

Consider the firm in an arbitrary state (k, p, z) evaluating a candidate financing policy p' satisfying $e(k, p, k', p', z) \neq 0$. Now consider a perturbation calling for a small increase in p' used to finance an increase in e. Assuming differentiability of the value function, the change in the maximand (Δ) is equal to:[10]

$$\Delta(k, p, k', p', z) = \frac{1 + \Phi_i\lambda - \Phi_d\tau_d}{1+r} + \left[\frac{1}{1 + r(1 - \tau_i)}\right] \sum_{z'} V_2(k', p', z')\Gamma(z', z). \tag{31}$$

---

[10] For further discussion of differentiability of the value function in stochastic dynamic programming problems, see Benveniste and Scheinkman (1979), Araujo (1991), Santos (1991), and Milgrom and Segal (2002).

The envelope condition from Proposition 3 implies that for states in which the distribution to equity is nonzero:

$$
\begin{aligned}
V_2(k', p', z') &= e_2(k', p', k'', p'', z') \qquad\qquad (32) \\
&= -[1 + \Phi_i'\lambda - \Phi_d'\tau_d]\left[\frac{1 + r(1 - \tau_c(\theta(k', p', z')))}{1 + r}\right]
\end{aligned}
$$

It is shown below that the firm's expected equity regime next period hinges upon the value of debt or savings at the start of that period (p'). In particular, high savings make it probable that positive distributions occur, while large debt burdens are associated with equity issuance. Intermediate values of p' will be associated with zero distributions. Having established concavity of the value function in Proposition 2, it follows that the derivative of the value function within the zero distribution region lies somewhere between the extremes implied by (32):

$$
V_2(k', p', z') \in \left(-(1 + \lambda)\left[\frac{1 + r(1 - \tau_c(\theta(k', p', z')))}{1 + r}\right], -(1 - \tau_d)\left[\frac{1 + r(1 - \tau_c(\theta(k', p', z')))}{1 + r}\right]\right).
$$
$$(33)$$

We denote the derivative of the value function in zero distribution states as:

$$
\begin{aligned}
V_2(k', p', z') &\equiv -[1 + \phi(k', p', z')]\left[\frac{1 + r(1 - \tau_c(\theta(k', p', z')))}{1 + r}\right] \qquad (34) \\
\phi(k', p', z') &\equiv \phi \in (-\tau_d, \lambda).
\end{aligned}
$$

Substitution of (32) and (34) into (31) and multiplying through by $(1 + r)$ yields an expression for the gain from a dollar reduction in saving or dollar increase in debt issuance. The term MB represents the marginal benefit of the policy change in terms of increased cash flow to shareholders this period. The term MC represents the discounted cost of the policy change in terms of decreased savings or increased debt service next period:

$$
(1 + r) * \Delta(k, p, k', p', z) = MB(k, p, k', p', z) - MC(k', p', z) \qquad (35)
$$

$$
MB(k, p, k', p', z) \equiv 1 + \Phi_i\lambda - \Phi_d\tau_d \qquad (36)
$$

$$MC(k', p', z) \equiv \sum_{z'} \frac{[1 + \Phi_i' \lambda - \Phi_d' \tau_d + \Phi_0' \phi][1 + r(1 - \tau_c(\theta(k', p', z')))]}{1 + r(1 - \tau_i)} \Gamma(z', z). \quad (37)$$

Recall that the financial perturbation holds constant the investment program (k'), with the current state (k, p, z) fixed. Therefore, the only argument in the MB function that is being changed is p'. From (36) it follows that the MB schedule is simply a downward step-function in p'. To see this, note that for firms with high saving, a one dollar reduction in saving replaces a dollar of equity issuance, giving the shareholder a marginal benefit of $1 + \lambda$. Conversely, for firms issuing a high amount of debt, a dollar increase in debt goes toward a distribution, giving the shareholder a marginal benefit of $1 - \tau_d$. As one increases p', the MB schedule jumps down from $1 + \lambda$ to $1 - \tau_d$ at a unique switch-point, denoted $p_0'(k, p, k', z)$, where:

$$e[k, p, k', p_0', z] \equiv 0 \quad (38)$$

$$\Rightarrow \frac{p_0'(k, p, k', z)}{1 + r} \equiv \Psi(k', k) - [\pi(k, z) - p - g(\theta(k, p, z))]. \quad (39)$$

Intuitively, the term on the right side of (39) tells us how much debt the firm must issue in order for the distribution to shareholders to just equal zero. For severely constrained firms, p_0' will be a large positive number. Such firms must issue a large amount of debt in order to reduce the external equity requirement to zero. Conversely, for firms with ample internal cash, p_0' will be a negative number, meaning that the firm can simultaneously save and make a positive distribution to shareholders. Clearly, the sign of p_0' depends on firm status, with:

$$\text{Unconstrained} \quad \Rightarrow \quad p_0'(k, p, k', z) < 0$$
$$\text{Constrained} \quad \Rightarrow \quad p_0'(k, p, k', z) > 0.$$

In evaluating an increase in debt or reduction in saving, the shareholder compares the marginal benefit with the marginal cost, with the latter represented by the MC schedule. If the firm increases debt issuance by a dollar, the cost to the shareholder is the discounted value of the after-tax cost of debt service, with the expectation in (37) taking into account

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the stochastic marginal source of funds. The effect of decreasing saving is analogous to the effect of increasing debt. In the model, there is nothing magical about crossing the threshold where $p' = 0$. If the firm decreases saving by a dollar, the shareholder recognizes that the firm's saving account balance next period is lowered by $1 + r(1 - \tau_c)$, with the MC schedule reflecting the fact that the shadow value of internal savings is highest when the firm is in the equity issuance regime next period.

Two factors cause the MC schedule to be upward sloping in p'. First, increasing p' reduces next period's taxable income (θ') in every state (z'). For a firm considering increasing debt issuance, this means that the marginal tax shield benefit is declining in the amount of debt issued. This feature of the model is consistent with the detailed firm-by-firm analysis in Graham (2000). Symmetrically, the corporation's after-tax rate of return declines as the amount saved increases. This effect serves as a counter-weight against the corporation's incentive to engage in precautionary saving in order to avoid the costs of external equity. The second factor causing the MC schedule to slope upward is that increasing p' increases the likelihood of the firm being in the positive equity issuance regime next period. This property of the optimal financing strategy is demonstrated below.

Ignoring debt constraints for the sake of expositional simplicity, we conjecture the following asymptotic properties of the MC schedule. Firms with arbitrarily high savings will converge to the maximum corporate tax rate and find it optimal to make a distribution. Therefore:

$$\lim_{p' \downarrow -\infty} MC(k', p', z) = \frac{(1 - \tau_d)[1 + r(1 - \overline{\tau}_c)]}{1 + r(1 - \tau_i)}. \tag{40}$$

It follows that:

$$\overline{\tau}_c > \tau_i \Rightarrow \lim_{p' \downarrow -\infty} MC(k', p', z) < 1 - \tau_d \tag{41}$$

$$\overline{\tau}_c \leq \tau_i \Rightarrow \lim_{p' \downarrow -\infty} MC(k', p', z) \geq 1 - \tau_d. \tag{42}$$

Assumption 5 ruled out the case of $\overline{\tau}_c \leq \tau_i$. However, if this condition does hold, then the result will be that unconstrained corporations will never make distributions, since internal

savings earn a higher after-tax rate of return than that earned by shareholders investing on their private accounts. To see this, note that for a firm with arbitrarily high saving, the current net benefit to shareholders from making a distribution is $1 - \tau_d$. However, this benefit is exceeded by the cost in terms of the reduction in next period's corporate savings balance, as given in (42). In contrast, under the working assumption that $\overline{\tau}_c > \tau_i$, incremental precautionary saving eventually becomes suboptimal due to the rate of return effect.

Firms with arbitrarily high amounts of debt will drive their marginal corporate tax rate down to zero and find it optimal to issue equity at the margin. Therefore:

$$\lim_{p' \uparrow \infty} MC(k', p', z) = \frac{(1 + \lambda)(1 + r)}{1 + r(1 - \tau_i)} > 1 + \lambda. \tag{43}$$

The final mathematical detail worthy to note is that given the Markovian nature of the problem, the MC schedule depends only upon the current shock (z) and the future policies chosen by the firm (k', p').

Examining (37), we conjecture that a number of factors determine the marginal cost of debt service. First, upward shifts in the marginal corporate tax rate schedule can be expected to shift the entire MC schedule downward. This is the standard corporate tax-shield effect. Second, increases in τ_i shift the MC schedule upward. This is the discount rate effect. Third, holding fixed the probability of being in the alternative equity regimes, high values of λ and low values of τ_d are associated with higher MC schedules. However, it must be stressed that the probability of being in the various regimes is endogenous. For instance, high values of λ will induce debt conservatism aimed at reducing the probability of being in the equity issuance regime. Fourth, policies (k', p') creating a high probability of being in the equity issuance regime imply higher marginal costs. Finally, equity issuance will occur when there are large positive innovations to profitability, causing the optimal physical capital stock to increase by a large amount. Firms that are "caught by surprise" may find it optimal to incur the costs of equity issuance, rather than pass-up compelling growth options. We conjecture that the probability of being in the equity issuance regime is a function of volatility.

A. Alternative Scenarios

The optimal financing policies can be separated into three cases, and we consider each in turn.

Low Marginal Costs of Debt Service

Consider first the firm facing a low MC schedule, in the sense that the marginal cost of debt at $p' = 0$ is less than the after-tax marginal benefit to a positive distribution:

$$MC(k', 0, z) < 1 - \tau_d \tag{44}$$

Referring to (37), the low marginal cost scenario occurs when the following properties hold at $p' = 0$: 1) the probability of being in the positive distribution equity regime next period is high; and 2) the expected marginal corporate tax rate is high. It is easily verified that a necessary condition for this scenario is that $\tau_c > \tau_i$ in some state. Due to the progressivity of the tax schedule, the second necessary condition may be stated as:

$$\tau_c[\theta(k', 0, \overline{z})] > \tau_i. \tag{45}$$

The low marginal cost of debt service scenario is depicted in Figure 1. Note that the MC schedule is increasing in p' due to convexity of the corporate tax schedule and the equity regime effect discussed above. Given this MC schedule, the optimal financing policy hinges upon the firm's equity regime switch-point, given in (39).

Consider first a firm that needs to raise a substantial amount of external finance with $p'_0/(1+r) > H$. For this firm, the marginal benefit of debt issuance is $1 + \lambda$ for debt levels less than or equal to H. Starting from the far left, the marginal benefit of reducing saving or increasing debt exceeds the marginal cost until the debt level H is reached. Increasing debt beyond H is suboptimal since the marginal cost of debt service exceeds the marginal benefit. Equity issuance makes up the rest of the financing gap. Therefore:

$$\frac{p'_0(k, p, k', z)}{1+r} > H \Rightarrow \frac{p'}{1+r} = H > 0 \text{ and } e(k, p, k', p', z) < 0. \tag{46}$$

These firms are at what we term an "interior" optimal financial policy with the perturbation gain from additional debt (35) approaching zero in right and left neighborhoods about H.

The optimality condition says that, when evaluated at H, the expected discounted marginal cost of debt service is just equal to the cost of equity issuance:

$$1 + \lambda = \sum_{z'} \frac{[1 + \Phi_i' \lambda - \Phi_d' \tau_d + \Phi_0' \phi][1 + r(1 - \tau_c(\theta(k', H, z')))]}{[1 + r(1 - \tau_i)]} \Gamma(z', z). \qquad (47)$$

Now consider firms with $p_0'/(1+r) < L$. The optimal debt issuance is equal to $L < H$, with the lower debt level attributable to the fact that the marginal dollar of debt goes towards a distribution rather than replacing costly external equity. The relevant marginal benefit schedule is $1 - \tau_d$, which exceeds the marginal cost to the left of L, but is less than the marginal cost for higher debt levels. Since debt issuance exceeds $p_0'/(1+r)$, it follows that a positive distribution is made. Summarizing, we have:

$$\frac{p_0'(k, p, k', z)}{1 + r} < L \Rightarrow \frac{p'}{1 + r} = L > 0 \text{ and } e(k, p, k', p', z) > 0. \qquad (48)$$

These firms are also at an interior optimal financial policy with the perturbation gain from additional debt (35) approaching zero in right and left neighborhoods about L. The optimality condition says that, when evaluated at L, the expected discounted marginal cost of debt service is just equal to the after-tax benefit from the distribution:

$$1 - \tau_d = \sum_{z'} \frac{[1 + \Phi_i' \lambda - \Phi_d' \tau_d + \Phi_0' \phi][1 + r(1 - \tau_c(\theta(k', L, z')))]}{[1 + r(1 - \tau_i)]} \Gamma(z', z). \qquad (49)$$

Note that this scenario generates a clear violation of the static pecking order theory, in that firms with sufficient internal funds to finance the investment program still issue debt. Here, the tax shield benefits of debt are sufficient to induce even the unconstrained firm to borrow.

Finally, consider firms with intermediate funding needs, with:

$$\frac{p_0'(k, p, k', z)}{1 + r} \in [L, H]. \qquad (50)$$

For such firms, the MB schedule jumps down from $1 + \lambda$ to $1 - \tau_d$ somewhere in the interval $[L, H]$. It follows that increasing debt issuance is optimal so long as doing so substitutes

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for a dollar of equity issuance, but is suboptimal if doing so finances a positive distribution. Optimal debt issuance is equal to $p_0'/(1+r)$, implying that the distribution to equity is just equal to zero. Summarizing, we have:

$$\frac{p_0'(k, p, k', z)}{1 + r} \in [L, H] \Rightarrow p' = p_0' > 0 \text{ and } e(k, p, k', p_0', z) = 0. \tag{51}$$

These firm are at what we term a "corner" financial policy. The perturbation gain from additional debt issuance (35) is strictly positive to the left of the optimal leverage and strictly negative to the right. That is, for debt levels less than p_0', the firm finds it profitable to increase the amount of debt because it replaces external equity, saving shareholders $1+\lambda$. However, once p_0' is reached, additional debt issuance is not profitable, since the next unit of debt goes towards financing a distribution, giving shareholders the smaller marginal benefit $1 - \tau_d$. It is easily verified that at p_0':

$$
\begin{aligned}
1 + \lambda &> \sum_{z'} \frac{[1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\phi][1 + r(1 - \tau_c(\theta(k', p_0', z')))]}{[1 + r(1 - \tau_i)]} \Gamma(z', z) \tag{52} \\
1 - \tau_d &< \sum_{z'} \frac{[1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\phi][1 + r(1 - \tau_c(\theta(k', p_0', z')))]}{[1 + r(1 - \tau_i)]} \Gamma(z', z).
\end{aligned}
$$

High Marginal Costs of Debt Service

Figure 2 depicts a firm facing high marginal costs of debt service, with:

$$MC(k', 0, z) > 1 + \lambda. \tag{53}$$

From (37) it follows that in order for (53) to be satisfied, the probability of being in the equity issuance regime next period must be high under the zero debt policy ($p' = 0$). In addition, a necessary condition for (53) is that the tax rate on interest income exceed the corporate tax rate in some state. Due to progressivity of the tax schedule, the necessary condition may be stated as:

$$\tau_c[\theta(k', 0, \underline{z})] < \tau_i.$$

Following the same logic as above, it is easily verified that the optimal policy in the

event of high marginal costs of debt service is as follows:

$$\frac{p_0'(k,p,k',z)}{1+r} \;>\; H \Rightarrow \frac{p'}{1+r} = H < 0 \text{ and } e(k,p,k',p',z) < 0 \tag{54}$$

$$\frac{p_0'(k,p,k',z)}{1+r} \;<\; L \Rightarrow \frac{p'}{1+r} = L < 0 \text{ and } e(k,p,k',p',z) > 0$$

$$\frac{p_0'(k,p,k',z)}{1+r} \;\in\; [L,H] \Rightarrow p' = p_0' < 0 \text{ and } e(k,p,k',p',z) = 0.$$

It can be seen that the firm always saves in this scenario regardless of the magnitude of p_0'. Debt is completely avoided. This is due to the fact that the high probability of being in the equity issuance regime next period, in conjunction with the relatively low marginal corporate tax rate, leads to high marginal costs of debt service. Recall that a similar result was obtained in Section I, where it was shown that if the *marginal* source of funds *next* period is external equity, then all debt will be retired so long as $\tau_c < \tau_i$.

Firms with $p_0'/(1+r) > H$ exhibit a striking departure from the static pecking order. These firms simultaneously save and issue equity, despite the fact that riskless debt finance is available. The reason is that issuing the riskless debt does not allow the firm to escape the costs of equity issuance. Rather, doing so simply delays the day of reckoning, since it is probable that the marginal source of funds next period will be external equity. Firms with $p_0'/(1+r) < L$ simultaneously save and make distributions. When $p_0'/(1+r) \in [L,H]$, the firm saves and adopts a policy of zero distributions and zero equity issuance. Once again, firms with negative, positive, and zero distributions satisfy conditions 47, 49, and 52, respectively.

Intermediate Marginal Costs of Debt Service

The last scenario to be considered features an MC schedule satisfying:

$$1 - \tau_d < MC(k',0,z) < 1 + \lambda. \tag{55}$$

From (37) it can be seen that this scenario is most likely to emerge when the probability of being in either the positive distribution or equity issuance regimes is not too high. Figure

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3 graphs the situation confronting the firm. It is easily verified that:

$$
\begin{aligned}
\frac{p_0'(k,p,k',z)}{1+r} &> H \Rightarrow \frac{p'}{1+r} = H > 0 \text{ and } e(k,p,k',p',z) < 0 \qquad (56) \\
\frac{p_0'(k,p,k',z)}{1+r} &< L \Rightarrow \frac{p'}{1+r} = L < 0 \text{ and } e(k,p,k',p',z) > 0 \\
\frac{p_0'(k,p,k',z)}{1+r} &\in [L,H] \Rightarrow p' = p_0' \text{ and } e(k,p,k',p',z) = 0.
\end{aligned}
$$

Unconstrained firms do not issue debt and do not tap external equity. Those unconstrained firms with $p_0'/(1+r) < L$ make a positive distribution to shareholders, while those with $p_0'/(1+r) \in [L,0)$ set the distribution to zero. Severely constrained firms, with $p_0'/(1+r) > H$ utilize a mixture of debt and equity finance. Constrained firms with $p_0'/(1+r) \in (0,H)$ use debt as their marginal source of funds, issuing no equity and making no distribution to shareholders. Once again, firms with negative, positive, and zero distributions satisfy conditions 47, 49, and 52, respectively.

Note that when the firm faces intermediate marginal costs of debt service, the financing policy resembles Myers' (1984) pecking order theory. However, we have said nothing about asymmetric information or adverse selection premia! Under a broad range of assumptions, a rational tax-based model with no asymmetric information will generate a data series that resembles the pecking order. Therefore, even if firms appear to follow the rules of thumb provided by the pecking order, this does not imply that informational concerns are the reason for this behavior. Tax concerns offer an alternative explanation.

B. Leverage Hysteresis

The analysis in the previous subsection implies that regardless of the marginal costs of debt service:

$$
\frac{\partial p'}{\partial p} \geq 0.
$$

To see this, note that the optimal debt commitment (p') is weakly increasing in p_0'. Further, we know from (39) that p_0' is strictly increasing in lagged debt (p). This is the formal basis for leverage hysteresis. Stepping away from the math, the hysteresis effect is due to the fact

that, *ceteris paribus*, higher lagged debt (p) causes the firm to occupy the high portion of the marginal benefit schedule $(1+\lambda)$ over a longer stretch. That is, with higher lagged debt more debt must be issued this period before the marginal unit of debt serves to increase distributions rather than replacing external equity.

The theory thus offers a rational explanation for the debt conservatism paradox posited by Graham (2000). Highly liquid firms may issue less debt because they face a different marginal benefit schedule than others. More specifically, firms with high lagged profits have lower equity regime switch-points p'_0, implying weakly less debt will be issued in order to finance a given investment program.

C. The Target Corporate Tax Rate

Using the Miller (1977) tax shield formula, Graham (2000) integrates under what he terms "net of personal tax benefit curves" to determine the target corporate tax rate. In a dynamic setting, the traditional target marginal corporate tax rate is most likely incorrect. As shown in (47) and (49), the expected marginal corporate tax rate under the optimal policy is a complicated function of the current equity regime and expectations regarding next period's equity regime. Based on these optimality conditions, one should expect to see substantial cross-sectional variation in the target expected marginal corporate tax rate.

To focus ideas, the following Lemma derives the expected marginal corporate tax rate for the special case of a constant equity regime:

Lemma 4 *If the debt constraint does not bind and the probability of being in the same non-zero equity regime next period is equal to one, then:*

$$\sum_{z'} \tau_c[\theta(k', p', z')]\Gamma(z', z) = \tau_i > \frac{\tau_i - \tau_d}{1 - \tau_d}. \tag{57}$$

Clearly, the ratio in (5) is a faulty basis for gauging debt conservatism or poor tax planning on the part of corporations. To take a concrete example, return to the tax rate assumptions in Section I, and consider the CFO of a high liquidity firm making distributions at the margin each period. Suppose also that the corporation finds itself with an

expected marginal corporate tax rate equal to 28 percent given its current plan. Application of the target tax rate formula in (5) suggests that the corporation should make a *larger* distribution and *reduce* the amount saved, driving down the expected marginal tax rate to 20 percent. However, the firm in this example should actually *reduce* its distribution and *increase* savings, since under the current plan it earns a higher after-tax return than shareholders, who face a tax rate of 29.6 percent on interest income.

D. Shareholder Disagreements and Tax Clienteles

Assumption 5 imposed the condition that the corporation's shareholders have identical tax rates. In actuality, shareholders have heterogeneous tax characteristics. For instance, pension funds, labor unions, foundations, and universities are either fully or largely exempt from tax. In contrast, the combination of federal and state taxes can push the marginal tax rate on interest income above 40 percent for high income investors. In our model, shareholder heterogeneity would result in disagreements regarding financial policy. For instance, high tax rate investors exhibit a relatively strong preference for retentions, while low tax rate investors would lean towards distributions. We are not the first to note that tax rate heterogeneity leads to violations of shareholder unanimity. Masulis and Trueman (1988) discuss shareholder disagreements in the context of an all-equity firm. Grinblatt and Titman (2002) discuss hypothetical disagreements between Bill Gates and institutional investors at Microsoft.

We leave unresolved the thorny positive and normative issues of how corporations arbitrate shareholder disagreements stemming from tax rate differences. Clearly, heterogeneity is mitigated to the extent investors sort into tax clienteles. In the equilibria posited by Miller (1977) and DeAngelo and Masulis (1980), tax exempt institutions and low bracket investors hold corporate debt, with high bracket investors holding equity. While portfolio decisions are probably influenced by tax considerations at the margin, other concerns must be present. For instance, Auerbach and King (1983) demonstrate that the Miller equilibrium relies upon an extreme form of asset spanning with separability of tax and risk characteristics. More recently, Allen, Bernardo, and Welch (2000) present a model in which

the adoption of a high dividend payout ratio tilts the firm's tax clientele towards institutional investors, allowing them to signal quality and/or commit to monitoring. Given the competing considerations, we feel the theory does not support any particular assumption regarding shareholder tax rates, preferring to let the data speak for itself.

Whatever the cause, Allen and Santomero (1998) present evidence indicating the relative importance of institutional investors has increased. For instance, individual ownership of equity fell from around 85 percent in the mid-1960's to roughly 50 percent in recent years. Institutional shareholders have taken up the slack, with pension funds playing the biggest role. Due to the relatively large blocks they hold and their ability to coordinate, institutions are likely to have a disproportionate influence on corporate decision-making. The corresponding decline in the shareholder weighted average tax rate on interest income (τ_i) caused by the shift in shareholder composition makes it much more likely that the condition $\tau_i < \overline{\tau}_c$ will be satisfied by the vast majority of corporations. Based on the model, we would predict that the decline in τ_i should have encouraged distributions on the part of firms with excess liquidity. Similarly, for those firms needing external funds, debt finance should have become more attractive since debt service is discounted at a higher rate. Given space limitations, testing whether changes in tax rates and shareholder composition have had the predicted effect is beyond the scope of this paper.

E. Effect of Municipal Bonds

In the model presented above there is a single taxable riskless bond with pre-tax yield r, with no tax exempt financial assets. In actuality, investors have the option to invest in tax exempt municipal bonds. In this subsection, we discuss how the introduction of such an asset affects our analysis. To do so, let r_m denote the yield on the municipal bond and τ_m denote the tax rate of the marginal investor in municipal bonds, with:

$$r_m = (1 - \tau_m)r \tag{58}$$
$$\Rightarrow \quad \tau_m = \frac{r - r_m}{r}.$$

Using this procedure, Graham (2000) estimates $\tau_m = 29.6\%$ in recent years.

The municipal bond yield represents a lower bound on the shareholder's discount rate, since he can earn:

$$\max\{r(1 - \tau_i), r_m\}. \tag{59}$$

The municipal bond yield also represents the lower bound on the after-tax return to corporate saving. Now recall that a basic property of the model is that in order for the corporation to be willing to distribute excess funds, rather than invest them in financial assets, it must be the case that as corporate saving becomes arbitrarily high, the rate of return must fall strictly below the shareholder's discount rate. Therefore, with the introduction of a tax exempt municipal bond, the necessary and sufficient conditions to induce distributions are:

$$\tau_i < \overline{\tau}_c$$
$$\tau_i < \tau_m.$$

The necessity of the first condition was discussed above. The second condition states that the representative shareholder must face a tax rate on interest income strictly less than that of the marginal investor in municipal bonds. To see this, suppose to the contrary the representative shareholder is Bill Gates, with $\tau_i = 40\% > \tau_m = 29.6\%$. Gates strictly prefers municipal over taxable bonds when investing on his personal account. Therefore, he uses the municipal bond yield as his discount rate. However, the yield on the municipal bond represents a lower bound on the after-tax return to Microsoft's saving. Consequently, Gates strictly prefers retentions over distributions. This seems to be a reasonable depiction of reality. Microsoft's apparent debt conservatism may be viewed as a rational response given Gates' financial investment opportunity set.

IV. Optimal Real Investment Policy

Consider the firm in an arbitrary state (k, p, z) evaluating an investment plan k' satisfying $e(k, p, k', p', z) \neq 0$. To pin down the optimal real investment policy, we evaluate the

effect on the maximand of a small increase in k' to be financed in accordance with the optimal financial policy. Assuming differentiability of the value function, the change in the maximand is given by:

$$\Delta(k, p, k', p', z) = \frac{de(k, p, k', p', z)}{dk'} + \left(\frac{1}{1 + r(1 - \tau_i)}\right) \sum_{z'} \left[V_1(k', p', z') + \left(\frac{\partial p'}{\partial k'}\right) V_2(k', p', z')\right] \Gamma(z', z).$$

(60)

The first term in (60) represents the cost to the shareholder in terms of the current distribution. The first term in the expectation is simply the discounted value of a unit of installed capital, with the second representing the costs associated with servicing incremental debt. From the firm's budget constraint, the investment funding condition may be stated as:

$$\frac{de}{dk'} = -[1 + \Phi_i \lambda - \Phi_d \tau_d] \left[\Psi_1(k', k) - \left(\frac{1}{1 + r}\right) \left(\frac{\partial p'}{\partial k'}\right)\right]$$

(61)

From (31), we know that for firms at an interior optimum financial policy:

$$-\frac{[1 + \Phi_i \lambda - \Phi_d \tau_d][1 + r(1 - \tau_i)]}{1 + r} = \sum_{z'} V_2(k', p', z') \Gamma(z', z).$$

(62)

Substituting (61) and (62) into (60), the incremental gain from increasing the capital stock is:

$$\Delta(k, p, k', p', z) = \sum_{z'} \left(\frac{V_1(k', p', z')}{1 + r(1 - \tau_i)}\right) \Gamma(z', z) - [1 + \Phi_i \lambda - \Phi_d \tau_d] \Psi_1(k', k).$$

(63)

The first term in (63) represents the expected discounted value of the marginal unit of installed capital, with the second representing the marginal cost of investment, which takes into account the firm's source of equity.

The envelope condition from Proposition 3 implies that for states in which the distribution to equity is nonzero:

$$V_1(k', p', z') = [1 + \Phi'_i \lambda - \Phi'_d \tau_d][\pi_1(k', z')(1 - \tau_c(\theta(k', p', z'))) + \delta \tau_c(\theta(k', p', z')) - \Psi_1(k'', k')].$$

(64)

Having established concavity of the value function in Proposition 2, it follows that the derivative of the value function within the zero distribution region lies somewhere between

the extremes given in (64):

$$
V_1(k', p', z') \in \left(\begin{array}{c} (1 - \tau_d)[\pi_1(k', z')(1 - \tau_c(\theta(k', p', z'))) + \delta\tau_c(\theta(k', p', z')) - \Psi_1(k'', k')], \\ (1 + \lambda)[\pi_1(k', z')(1 - \tau_c(\theta(k', p', z'))) + \delta\tau_c(\theta(k', p', z')) - \Psi_1(k'', k')] \end{array} \right)
$$

We denote the derivative of the value function in zero distribution states as:

$$
V_1(k', p', z') \equiv [1 + \widehat{\phi}(k', p', z')][\pi_1(k', z')(1 - \tau_c(\theta')) + \delta\tau_c(\theta') - \Psi_1(k'', k')] \quad (65)
$$

$$
\widehat{\phi}(k', p', z') \equiv \widehat{\phi} \in (-\tau_d, \lambda).
$$

Substituting (64) and (65) into (63) yields:

$$
\Delta(k, p, k', p', z) = -(1 + \Phi_i\lambda - \Phi_d\tau_d)\Psi_1(k', k) + \quad (66)
$$

$$
\sum_{z'}[1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\widehat{\phi}]\left(\frac{\pi_1(k', z')(1 - \tau_c(\theta')) + \delta\tau_c(\theta') - \Psi_1(k'', k')}{1 + r(1 - \tau_i)}\right)\Gamma(z', z)
$$

Note that the gain function may exhibit a downward jump if there is some level of capital investment, call it k_0', at which the distribution to equity switches from negative to positive. Some firms would then find themselves at a corner solution for capital investment, finding it profitable to increase the capital stock up to k_0', yet unwilling to incur the costs of external equity.

Interior financing solutions entailing nonzero distributions to equity satisfy:[11]

$$
\Psi_1(k', k) = \sum_{z'} \left[\frac{1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\widehat{\phi}}{1 + \Phi_i\lambda - \Phi_d\tau_d} \right] \left[\frac{\pi_1(k', z')[1 - \tau_c(\theta')] + \delta\tau_c(\theta') - \Psi_1(k'', k')}{1 + r(1 - \tau_i)} \right] \Gamma(z', z).
$$

$$
(67)
$$

The optimal investment policy is a function of the current equity regime and expectations over the future equity regime and profitability. The term on the left side of the equation is the direct marginal cost of adjusting the physical capital stock. Since Ψ is convex in its first argument, the higher the right side of equation, the higher is k'.

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[11]The optimality condition for the firm with a binding debt constraint contains an extra benefit term attributable to the increase in $\overline{p}$.

The first bracketed term reflects the potential for shifts in equity regimes across periods. *Ceteris paribus*, investment incentives are stronger when the firm is currently in the positive distribution equity regime as opposed to the equity issuance regime. Intuitively, the incentive to invest is stronger when the funds used for investment have a low opportunity cost. For a firm that is currently making a distribution, the opportunity cost of retaining a marginal dollar is only $1 - \tau_d$. In contrast, the opportunity cost of a dollar of external equity is $1 + \lambda$. It should also be noted that, *ceteris paribus,* the incentive for real investment is stronger when the firm expects to issue equity *next period*. This is because investment in physical capital represents a device for generating internal funds in future periods, with those funds being most valuable when they substitute for costly external equity.

Further insight into the relationship between the firm's financial condition and its real investment policy is obtained by combining condition (67) with the optimality conditions for interior financial policies given in (47) and (49):

$$
\sum_{z'} [1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\widehat{\phi}] \left[\frac{\pi_1(k', z')[1 - \tau_c(\theta')] + \delta\tau_c(\theta') - \Psi_1(k'', k')}{\Psi_1(k', k)} \right] \Gamma(z', z)
$$
$$
= \sum_{z'} [1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\phi][1 + r(1 - \tau_c(\theta'))]\Gamma(z', z). \tag{68}
$$

This condition implies that the corporation should strive for rough equality between the benefit from the marginal dollar spent on physical capital and the return the corporation can earn on its financial investments, if it is a saver, or the after-tax cost of debt, if it is a borrower.

V. Simulation

Our empirical strategy proceeds as follows. First, we present a simulation of the model based on reasonable parameter values that we glean from previous studies. In particular, we limit the size of λ to capture the existence only of flotation costs. Our intent is to ascertain whether our theory, with only a small external finance premium, can produce a cross section that embodies the anomalies we seek to explain. This exercise allows us to discriminate between our maximizing framework and other theories as vehicles for explaining

observed phenomena. In Section VI we use our data from COMPUSTAT to estimate the basic structural parameters of the model. Since one of these parameters is λ, we will be able to estimate the magnitude of costs of external equity. Finally, we check the sensitivity of the model to variations in some of the key model parameters.

A. Design

In order to simulate our model, we need to choose functional forms for $\pi\left(k,z\right)$ and $\psi\left(k',k\right)$. We start with the profit function:

$$\pi\left(k,z\right) = zk^{\alpha}, \tag{69}$$

where $\alpha < 1$ captures decreasing returns to scale. The shock z follows an $AR\left(1\right)$ process in logs:

$$\ln\left(z'\right) = \rho\ln\left(z\right) + \varepsilon', \tag{70}$$

where $\varepsilon' \sim N\left(0,\sigma_{\varepsilon}^{2}\right)$. We transform (70) into a discrete-state Markov chain using the method in Tauchen (1986), letting z have 5 points of support from $\left[-\sigma_{\varepsilon}\left/\sqrt{1-\rho^{2}}\right., \sigma_{\varepsilon}\left/\sqrt{1-\rho^{2}}\right.\right]$.

Finally, to parameterize the adjustment cost function, $\psi\left(k',k\right)$, we use a quadratic that has been used widely in the empirical investment literature:

$$\psi\left(k',k\right) = \left(\frac{a}{2}\left(\frac{k'-(1-\delta)k}{k}\right)^{2}\right)k. \tag{71}$$

The state space for (k,p,z) is discrete. k lies in the set

$$\left[\overline{k}, \overline{k}\left(1-d\right)^{1/2}, \overline{k}\left(1-d\right), \ldots, \overline{k}\left(1-d\right)^{20}\right],$$

where $\overline{k}$ is defined by (21). The state space for p is more complicated, because debt issuance is restricted by (23), which in turn depends on the level of the capital stock. Therefore, the state space for p will depend on the level of k. To create the state space, we first construct a set of all candidate values for p. We start by setting its upper endpoint equal to the maximum over all possible k and z of the left side of (23) and the lower endpoint equal to

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-2 times the upper endpoint. The candidate set contains 40 equally spaced points in this interval. Next, we specify the state space for p by choosing feasible points in the candidate set that satisfy (23) for each element of the state space for k. These state spaces for k and p appear to be sufficient for our purposes in that the optimal policy never occurs at an endpoint of the state space for k or at the lower endpoint of the state space for p.

Next we need to define the tax environment. For τ_d we use the estimate in Graham (2000) of 0.12. In view of the above discussion of the impact of municipal bonds, we set the tax rate on interest income, τ_i, equal to 0.25: a number slightly less than the Graham (2000) estimate of 0.296. To define the marginal corporate income tax schedule, we let $\mathcal{N}(\theta, \mu_\tau, \sigma_\tau)$ be the cumulative normal distribution function with mean μ_τ and standard deviation σ_τ. The marginal tax rate function is

$$\tau_c(\theta) = 0.35 \mathcal{N}(\theta, \mu_\tau, \sigma_\tau);$$

the tax bill for positive θ is given by

$$\int_0^\theta \tau_c(x)\, dx;$$

and the tax bill for negative θ is given by

$$-\int_\theta^0 \tau_c(x)\, dx.$$

For our first exercise, we parameterize our model along the lines of Gomes (2000), Cooper and Ejarque (2000), and Whited (1992). From Gomes we take $\rho = 0.62$, $\sigma_\varepsilon = 0.15$, $\delta = 0.145$, and $\lambda = 0.028$. Because Gomes uses a technological specification slightly different from ours, we turn to Cooper and Ejarque, who use an identical production function, and we set $\alpha = 0.689$. From Whited we take $a = 1$. Our two remaining parameters are (μ_τ, σ_τ), which we set so that the average realized marginal corporate tax rate is 0.30. Finally, we use a real risk-free interest rate of 0.025. As will be seen below, the stylized facts we generate with this simple simulation hold up when we base it on a parameterization obtained from our simulated moments estimation.

Of special interest in this set of parameters are the choices of ρ and σ_ε, which produce a transition matrix of

$$
\begin{bmatrix}
0.434 & 0.247 & 0.185 & 0.093 & 0.040 \\
0.287 & 0.243 & 0.232 & 0.149 & 0.088 \\
0.170 & 0.205 & 0.250 & 0.205 & 0.170 \\
0.088 & 0.149 & 0.232 & 0.243 & 0.287 \\
0.040 & 0.093 & 0.185 & 0.247 & 0.434
\end{bmatrix}.
$$

Note that at a value of 0.04, the probability of transitioning from the highest to lowest state is non-negligible. This rationalizes Assumption 4, which requires the firm to be able to repay its loan in all states. Whereas a lender would be unlikely to care about a tiny probability of default, it would be much more likely to care about a probability that is close to the usual VAR value of 0.05. It is not essential that we restrict the number of states or the support of ε to produce our results; in fact, none of our simulations or estimations are materially affected by these choices. What is important is that we *can* generate the results that we do with a small state space.

We solve the model via iteration on the Bellman equation, which produces the value function $V(k, p, z)$ and the policy function $\{k', p'\} = h(k, p, z)$. Our model simulation proceeds by taking a random draw from the distribution of ε each period, updating the z shock, and then computing $V(k, p, z)$ and $h(k, p, z)$. For our initial exercise, we simulate the model for 1000 time periods, dropping the first 50 observations in order to allow the firm to work its way out of a possibly sub-optimal starting point.

Knowledge of h and V also allows us to compute interesting quantities such as cash flow, Tobin's Q, debt, and distributions. Specifically, we define our variables to mimic the sorts of variables used in the literature.

Ratio of investment to the "book value" of assets	$(k' - (1 - \delta)k)/k$
Ratio of cash flow to the book value of assets	$(\pi(k, z) - g[\theta(k, p, z)] - p)/k$
Tobin's Q	$(V(k, p, z) + p'/(1 + r))/k'$
Ratio of debt to the "market value" of assets	$(p'/(1 + r))/(V(k, p, z) + p'/(1 + r))$
Ratio of EBITDA to the book value of assets	$\pi(k, z)/k$
Ratio of equity issuance to the book value of assets	$e(k, p, k', p', z)/k$

.

Here we have scaled all variables by the book value of assets, except for debt. We adopt this convention because of the use of market leverage in Rajan and Zingales (1995) and Baker and Wurgler (2002).[12]

B. Results

Before presenting our simulation results we examine the properties of the simulated policy function, $\{k', p'\} = h(k, p, z)$. We start with the investment rule, where we note first that the choice of k' depends on the current level of debt. If two firms with identical (k, z) come into the current period with different stocks of outstanding debt, the one with higher debt never chooses a higher k' and usually chooses a lower k'. Second, the rule exhibits sluggish adjustment in that a large shock is usually necessary for the firm to want to alter its capital stock. This sluggishness is more pronounced for firms with high k and low p. The debt hysteresis described below is in part due to this sluggish capital stock adjustment.

The debt rule also has interesting properties. First, it is clear that the choice of p' not only depends on (k, z) but on the current level of p. Firms with identical (k, z) and different p almost always choose different levels of p'. Further the condition

$$\frac{\partial p'}{\partial p} \geq 0$$

always holds. As will be seen below, this hysteresis is important for generating behavior that appears to look like market timing. Second, large firms with low profit shocks tend

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[12]It is worth noting that the results reported below change little when we normalize debt by the book value of assets.

to hold the most cash. This result is consistent with observed "debt conservatism." Third, the debt rule displays substantial persistence: for a firm with a given (k, p) a large shock is required for an adjustment of debt policy. Finally, the firm bumps up against its debt constraint only if it has both a small capital stock and a large shock, and in the simulations described and reported below, the constraint binds at most six percent of the time. This result is particularly important in that it suggests that our results are not driven by our decision to clear the debt market via a rationing mechanism.

The results from this simulation are in Table I, where we present summary statistics on debt and investment, as well as several coefficients from regressions commonly run in the empirical capital structure literature. Note in the first row of the table that the simulated firm on average issues debt, though note in the second line that it holds cash 31 percent of the time. The traditional trade-off theory implies that a firm with our tax schedule should never hold cash. In contrast, such "debt conservatism" is in our model a rational decision in the face of tax incentives and costly external equity. This result on cash holdings also emphasizes the point made earlier that static models of capital structure are by nature inappropriate, since the firm's financing margin can change over time. We also find that the firm does undertake on average positive investment, but that this rate of investment has a substantial standard deviation. This result underscores the idea that allowing an endogenous investment decision is crucial to understanding capital structure changes. Finally, when the firm does issue equity, the ratio of issuance to assets is on average 0.067. In calculating this figure, we have only averaged over those observations in which the firm actually does issue equity, which account for 12 percent of the simulated sample.

The more interesting results are the signs of the regression coefficients. First, we examine the effect of liquidity on debt, as in Table IX in Rajan and Zingales (1995). Our first measure of liquidity, cash flow, comes in with a negative coefficient in a regression of the debt to assets ratio on lagged Q and cash flow. Second, as seen in the next line of the table, this result is robust to our use of EBITDA, as in Rajan and Zingales, as a measure of liquidity. The intuition for these negative coefficients lies in the endogeneity of the firm's equity regime. In our model, firms that have experienced high profits have lower equity regime

switch points and therefore tend to issue less debt. Finally, we run a regression similar to the one in equation (5) in Baker and Wurgler (2002), where once again the debt to assets ratio is the left side variable. The regressors are lagged Q, lagged EBITDA, and lagged external finance weighted Q. This latter variable is constructed as in Baker and Wurgler (2002), where we use a 20 period moving average to calculate weighted Q.[13] It is striking that we can replicate the "market timing" result in Baker-Wurgler with a time-invariant λ only equal to 0.028 to represent flotation costs. Our result is a product not of the cumulative attempts to time the equity market, but is merely a product of debt hysteresis and the fact that firms with large productivity shocks simultaneously have high Qs and tend to finance large desired investment with equity.

VI. Simulated Moments Parameter Estimation

Our data are from the full coverage 2002 Standard and Poor's COMPUSTAT industrial files. We select a sample by first deleting firm-year observations with missing data. Next, we delete observations in which total assets, the gross capital stock, or sales are either zero or negative. To avoid rounding errors, we delete firms whose total assets are less than two million dollars and gross capital stocks are less than one million dollars. Further, we delete observations that fail to obey standard accounting identities. Finally, we omit all firms whose primary SIC classification is between 4900 and 4999 or between 6000 and 6999, since our model is inappropriate for regulated or financial firms. We end up with an unbalanced panel of firms from 1993 to 2001 with between 592 and 1128 observations per year. We truncate our sample period below at 1993, because our tax parameters are relevant only for this period; see Graham (2000).

Structural estimation of this model faces several challenges. First, the existence of different equity regimes prevents the derivation of an Euler equation or decision rule that is a smooth function of the data. To deal with these issues, we opt for an estimation technique based on simulation of the model. Specifically, we estimate the structural parameters of

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[13]Although seemingly arbitrary, this window length matters little for any results.

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the model via the indirect inference method proposed in Gourieroux, Monfort, and Renault (1993) and Gourieroux and Monfort (1996). This procedure chooses the parameters to minimize the distance between moments of data simulated by our model and the corresponding moments from our actual data. Because the moments of the simulated data depend on the underlying structural parameters, minimizing this distance will, under certain conditions discussed below, provide consistent estimates of the structural parameters. Another appealing feature of this approach is that it allows us to establish a link between our model and existing, less structural empirical evidence.

We now give a brief outline of this procedure. The goal is to estimate a vector of structural parameters, b, by matching a set of *simulated moments*, denoted as m, with the corresponding set of actual *data moments*, denoted as M. The candidates for the moments to be matched include simple summary statistics, OLS regression coefficients, and coefficient estimates from non-linear reduced-form models.

Without loss of generality, the moments to be matched can be represented as the solution to the maximization of a criterion function

$$\hat{M}_N = \arg\max_M J_N\left(y_N, M\right),$$

where y_N is a data matrix of length N. For example, the sample mean of a variable, x, can be thought of as the solution to minimizing of the sum of squared errors of the regression of x on a constant. We estimate $\hat{M}_N$ and then construct S simulated data sets based on a given parameter vector. For each of these data sets, we estimate m by maximizing an analogous criterion function

$$\hat{m}^s_{N'}\left(b\right) = \arg\max_m J_{N'}\left(y^s_{N'}, m\right),$$

where $y^s_{N'}$ is a simulated data matrix of length N'. Note that we express the simulated moments, $\hat{m}^s_{N'}\left(b\right)$, as explicit functions of the structural parameters, b. The indirect estimator

of b is then defined as the solution to the minimization of

$$\hat{b} = \arg\min_b \left[\hat{M}_N - \frac{1}{S}\sum_{h=1}^{S}\hat{m}_{N'}^s(b)\right]' \hat{W}_N \left[\hat{M}_N - \frac{1}{S}\sum_{h=1}^{S}\hat{m}_{N'}^s(b)\right]$$

$$\equiv \arg\min_b \hat{G}_N' \hat{W}_N \hat{G}_N$$

where $\hat{W}_N$ is a positive definite matrix that converges in probability to a deterministic positive definite matrix W. In our application, a consistent estimator of W is given by $\left[N\operatorname{var}\left(\hat{M}_N\right)\right]^{-1}$. Since our moment vector consists of both means and regression coefficients, we use the influence-function approach in Erickson and Whited (2000) to calculate this covariance matrix. Specifically, we stack the influence functions for each of our moments and then form the covariance matrix by taking the sample average of the inner product of this stack.

The indirect estimator is asymptotically normal for fixed S. Define $J \equiv \operatorname{plim}_{N\to\infty}(J_N)$. Then

$$\sqrt{N}\left(\hat{b} - b\right) \overset{d}{\longrightarrow} \mathcal{N}\left(0, \operatorname{avar}(\hat{b})\right)$$

where

$$\operatorname{avar}(\hat{b}) \equiv \left(1 + \frac{1}{S}\right)\left[\frac{\partial J}{\partial b \partial m'}\left(\frac{\partial J}{\partial m}\frac{\partial J'}{\partial m}\right)^{-1}\frac{\partial J}{\partial m \partial b'}\right]^{-1}. \tag{72}$$

Further, the technique provides a test of the overidentifying restrictions of the model, with

$$\frac{NS}{1+S}\hat{G}_N'\hat{W}_N\hat{G}_N$$

converging in distribution to a χ^2 with degrees of freedom equal to the dimension of M minus the dimension of b.

The success of this procedure relies on picking moments m that can identify the structural parameters b. In other words, the model must be identified. Global identification of a simulated moments estimator obtains when the expected value of the difference between the simulated moments and the data moments equal zero if and only if the structural parameters equal their true values. A sufficient condition for identification is a one-to-one

mapping between the structural parameters and a subset of the data moments of the same dimension. Although our model does not yield such a closed form mapping, we take care in choosing appropriate moments to match, and we use a minimization algorithm, simulated annealing, that avoids local minima. Finally, we perform an informal check of the numerical condition for local identification. Let $\hat{m}_{bN'}^s$ be a subvector of m with the same dimension as b. Local identification implies that the Jacobian determinant, $\det\left(\partial\hat{m}_{bN'}^s\left(b\right)/\partial b\right)$, is non-zero . This condition can be interpreted loosely as saying that the moments, m, are informative about the structural parameters, b; that is, the sensitivity of m to b is high. If this were not the case, not only would $\det\left(\partial\hat{m}_{bN'}^s\left(b\right)/\partial b\right)$ be near zero, but the sample counterpart to the term $\partial J/\partial b\partial m'$ in (72) would be as well—a condition that would cause the parameter standard errors to blow up.

To generate simulated data comparable to COMPUSTAT, we create $S = 6$ artificial panels, containing 10,000 $i.i.d.$ firms.[14] We simulate each firm for 50 time periods and then keep the last nine, where we pick the number "nine" to correspond to the time span of our COMPUSTAT sample. Dropping the first part of the series allows us to observe the firm after it has worked its way out of a possibly suboptimal starting point.

One final issue is unobserved heterogeneity in our data from COMPUSTAT. Recall that our simulations produce $i.i.d.$ firms. Therefore, in order to render our simulated data comparable to our actual data we can either add heterogeneity to the simulations, or take the heterogeneity out of the actual data. We opt for the latter approach, using fixed firm and year effects in the estimation of all of our data moments.

In sum, we need to solve for eight parameters $\left(\alpha, a, \delta, \rho, \sigma_\varepsilon^2, \mu_\tau, \sigma_\tau, \lambda\right)$ by matching at least eight simulated moments with corresponding data moments. We use nine data moments in order to have an overidentified model. We start with four simple means: the average ratio of investment to total assets, the average ratio of cash flow to total assets, the average ratio of net equity issuance to total assets, and the average ratio of net debt to total assets, where net debt is defined as total long-term debt less cash. These moments

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[14]Michaelides and Ng (2000) find that good finite sample performance of an indirect inference estimator requires a simulated sample that is approximately ten times as large as the actual data sample.

will help pin down α, δ, and λ. Our next two moments capture the important features of the driving process for z. Here, we estimate a first-order panel autoregression of operating income on lagged operating income using the technique in Holtz-Eakin, Newey, and Rosen (1988). Simulated operating income is defined simply as zk^α. The two moments that we match from this exercise are the autoregressive parameter and the shock variance.[15] To pin down the adjustment cost parameter, a, we use a simple regression of investment on Tobin's Q, where simulated Tobin's Q is constructed as described above and actual Tobin's Q is constructed following the appendix to Whited (1992). Our final two moments come from a regression of the debt to assets ratio on Tobin's Q and the ratio of cash flow to assets, where we define actual cash flow as in Erickson and Whited (2000) and simulated cash flow as described above.

A. Results

The results from this estimation exercise are in Tables II and III. Table II compares the actual with the simulated moments. Note here that the estimation procedure does a good job of matching all of the moments but the sensitivity of debt to Q. We conjecture that the noticeably lower sensitivity in the data is a result of measurement error in Q, which produces a downward biased slope coefficient on the mismeasured regressor. This attenuation bias problem is also evident in the discrepancy between observed and simulated investment-Q sensitivities. On the other hand, we match the observed negative sensitivity of debt to cash flow in the data quite well. This result implies that the widely observed negative relationship between profitability and debt is no anomaly. Rather, in our model, firms that have experienced high profits have lower equity regime switch points and therefore tend to issue less debt. Finally note that our simulated moments are quite close to their counterparts in Table I—a result not surprising in light of the similarity between our estimated parameters

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[15]As required by the Holtz-Eakin, Newey, and Rosen (1988) technique, we account for fixed effects via differencing our autoregression. For our other regressions we simply remove firm-level means from the data. We opt for this method simply because it is the method most used in the empirical literature we are trying to understand.

and those that we have chosen from previous studies.

Table III contains the point estimates for the structural parameters. Our estimate of δ appears reasonable, and our estimates of ρ and σ_ε^2 are close to the corresponding parameters generated by our estimation of the autoregressive process for operating income. Our estimate of α of 0.763 is consistent with decreasing returns to scale and is comparable to the estimate of 0.689 in Cooper and Ejarque (2000). μ_τ and σ_τ are difficult to interpret in that they depend on the state spaces for k and p. However, our estimated values imply that the firm hits the upper statutory rate of 0.35 84 percent of the time. In comparison, in 2001, 90.1 percent of the firms in our COMPUSTAT sample had incomes high enough to qualify them for the highest marginal tax rate.[16] The estimate of a is slightly smaller than the figures found by studies that estimate investment Euler equations, such as Bond and Meghir (1994) and Whited (1992). We conjecture that this discrepancy arises because Euler equation studies only have one source of sluggish capital stock adjustment: physical adjustment costs. In our model, however, we also have external finance costs, which can account for some of the observed sluggishness in investment and therefore allow for lower estimated physical adjustment costs.

Our most interesting parameter estimate is the 0.162 figure we find for λ. As emphasized above, the estimates of flotation costs of 0.028 used by Gomes are likely to be a lower bound on actual costs, and this estimate is consistent with the notion that informational costs are substantial. Recall that Titman and Wessels (1988), Rajan and Zingales (1995), and Fama and French (2002) have interpreted the negative relationship between debt and liquidity as evidence in favor of the Myers (1984) information based pecking order. Recall as well that Baker and Wurgler interpret the significance of lagged weighted Q as evidence in favor of market timing. However, the previous section shows that the tax system in conjunction with small floatation costs are sufficient to generate these stylized facts. Therefore, their

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[16]Specifically, the 2001 corporate income tax code stipulates that a firm with an income of between \$75,000 and \$100,000 had a marginal tax rate of 0.34. Although this rate is not quite at the highest statutory level, this tax schedule is almost flat after this tax bracket, and quite steep before this tax bracket. We therefore choose \$75,000 as the cutoff for the purposes of comparison with our simulated schedule.

evidence in insufficient to establish the existence of an adverse selection premium. On the other hand, our structural estimate is directly informative about the existence of asymmetric information costs.

B. Model Comparative Statics

We now explore the implications of our high estimate of λ, of setting $\lambda = 0$, and of changing the tax environment. Along this line we first simulate the model with the parameters set to their estimated values in Table III. Because the results are quite similar, for brevity we do not table them. We note, however, that we once again generate regression coefficients that have been interpreted as evidence in favor of market timing, finding a coefficient on lagged weighted Q of -0.879. The value is somewhat lower than the corresponding value in Table I because, with a higher λ, the firm does not issue as much equity.

To flesh out the intuition behind this result, and to gain a better understanding of the behavior of our model, we next present in Table IV summary statistics from this simulation, categorized by the firm's financing regime. The table is divided into two panels: the top corresponds to a value of λ equal to 0.162, and the bottom to a value of λ equal to zero. Eliminating the cost of external equity is particularly interesting in that it can tell us the extent to which any of our previous results are driven by this aspect of our model.

Several features of Table IV are noteworthy. Savers never issue equity and debtors never make distributions. This fits with the intermediate MC scenario. Also, as noted above, the firm only hits its debt constraint a small fraction of the time. Further, cash-cow savers have lower values of Q and disinvest, whereas equity issuers are the most highly indebted, invest the most, and have the highest Qs. This last result is what generates a negative coefficient on lagged weighted Q, despite the lack of market timing in our model. In other words, high productivity shocks produce both high Qs and equity issuance. This phenomenon, combined with sluggish adjustment of debt, produces the observed negative correlation between current leverage and lagged weighted Q. As seen in the bottom panel, when we set $\lambda = 0$, we find strikingly similar results, suggesting that the tax environment is a more important determinant of the firm's optimal policies than the existence of costly

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external equity. The two major differences we do find occur in savings behavior and equity issuance. As the external finance premium goes to zero, equity issuance naturally rises. Further, savings falls as the corporation's precautionary motive diminishes. It does not disappear, however, because the firm still has a motive to save in order to avoid bumping up against its debt constraint.

Note that our firm behaves in rough accordance with the rules of thumb of the static pecking order theory. However, changes in the tax regime faced by the corporation can lead to departures. We explore these possibilities via a variety of scenarios. First, we lower the maximal statutory corporate income tax rate until it is just above the tax rate on interest income. When we do this, we find that the firm will finance solely with equity approximately two percent of the time. This violation of the static pecking order occurs for firms who are current savers and who anticipate needing equity in the future. Second, when we lower the maximal corporate tax rate below the tax rate on interest income, we find, as predicted by the model in the high MC scenario, that the firm always holds cash and only finances with equity. In other words, we find a tax-based rationale for corporate liquidity holdings. This sort of phenomenon can also occur in a firm that has, for example, high non-debt tax shields. Third, when we raise the maximal corporate income tax rate, the tax benefit of debt is sufficiently great that firms occasionally find it optimal to have issue debt and make distributions at the same time. This high corporate tax rate simulation also generates some observations in which the firm has enough internal funds to finance optimal investment, but nonetheless chooses to issue debt—a result consistent with the low MC scenario.

VII. Conclusion

In recent years, the empirical literature has documented a number of stylized facts viewed as inconsistent with the traditional tradeoff theory of capital structure: profitable firms appear to be underlevered; leverage is declining in lagged liquidity; and leverage is declining in the external finance weighted average Q ratio. Such evidence has been interpreted as being a sufficient basis for concluding that "taxes are second order," and that capital structure

reflects either market timing or Myers' (1984) asymmetric information-based pecking order. However, this paper has shown that these stylized facts are entirely consistent with the behavior of a rational maximizing firm responding to the incentives implicit in the tax code. We do so by writing down, simulating, and estimating a fully specified dynamic model of optimal investment and financial policy in the presence of corporate and individual income taxes.

The underlying message of this paper is that meaningful empirical work in corporate finance demands a tighter link between theory and data than is currently the norm. To those inclined to dismiss the importance of model-building in generating null hypotheses, we note that this paper has demonstrated that the empirical literature has incorrectly interpreted the regression coefficients generated by a firm responding to the violation of Modigliani-Miller Assumption Number One: No Taxes. We view this as a sufficient basis for questioning the commonplace empirical tests based upon verbal argumentation or inferences drawn from the first-order conditions of static models. "To avoid reopening old wounds, no names will be mentioned here. References can be supplied upon request, however," Miller (1977).

Appendix

For the purpose of brevity, we adopt the following notational conventions:

$$
\begin{aligned}
X &\equiv K \times P \\
Y &\equiv K \times P \\
x &\equiv (k, p) \\
y &\equiv (k', p') \\
\beta &\equiv \frac{1}{1 + r(1 - \tau_i)}
\end{aligned}
$$

Proof of Proposition 1

Let F represent the space of all continuous, and hence bounded, functions on the compact set $X \times Z$. Letting d_∞ be the sup metric, consider the complete metric space (F, d_∞). The Bellman T with domain F is:

$$
(Tv)(x, z) \equiv \max_{y \in Y} \; e(x, y, z) + \beta \sum_{z'} v(y, z') \Gamma(z', z). \tag{A1}
$$

Lemma: The Bellman is an operator on (F, d_∞):

$$
T : F \to F.
$$

Proof:

Consider an arbitrary $v \in F$. From Stokey and Lucas (1989) Lemma 9.5 we know that:

$$
\sum_{z'} v(y, z') \Gamma(z', z) \in F.
$$

Since: e is continuous; the expectation is continuous; and Y is compact, the Maximum Theorem implies that (Tv) is continuous and hence bounded on $X \times Z$.

Lemma (Monotonicity): $(v, \widehat{v}) \in F \times F$ and

$$
\begin{aligned}
\forall \; (x, z) \;&\in\; X \times Z, \;\; v(x, z) \le \widehat{v}(x, z) \Longrightarrow \\
(Tv)(x, z) \;&\le\; (T\widehat{v})(x, z) \; \forall \; (x, z) \in X \times Z.
\end{aligned}
$$

Proof:

Define y^* to be the solution to (A1) for the function v. Existence follows from the Maximum Theorem. Then:

$$
\begin{aligned}
(Tv)(x,z) &\equiv e(x,y^*,z) + \beta \sum_{z'} v(y^*,z')\Gamma(z',z) & \text{(A4)} \\
&\leq e(x,y^*,z) + \beta \sum_{z'} \widehat{v}(y^*,z')\Gamma(z',z) \\
&\leq (T\widehat{v})(x,z).
\end{aligned}
$$

Lemma (Discounting): For an arbitrary $v \in F$ and scalar $a \geq 0$, there exists a constant $\beta \in (0,1)$ such that $\forall (x,z) \in X \times Z$:

$$
(T(v+a))(x,z) \leq (Tv)(x,z) + \beta a.
$$

Proof:

$$
\begin{aligned}
(T(v+a))(x,z) &\equiv \max_{y \in Y} \; e(x,y,z) + \beta \sum_{z'} [v(y,z') + a]\Gamma(z',z) & \text{(A5)} \\
&= \max_{y \in Y} \; e(x,y,z) + \beta \sum_{z'} v(y,z')\Gamma(z',z) + \beta a \\
&\equiv (Tv)(x,z) + \beta a.
\end{aligned}
$$

Since the Bellman satisfies Blackwell's sufficient conditions for a contraction mapping, existence and uniqueness of the fixed point $(TV) = V$ follows from the Contraction Mapping Theorem.

Proof of Proposition 2

The proof follows Theorem 9.8 in Stokey and Lucas (1989), and we here verify that the necessary conditions are met. The only non-trivial conditions that need to be proven are that: 1) e is weakly concave and strictly so in its first two arguments; and 2) the constraint set $K \times P$ is convex.

Lemma (Concavity of e): Define the function u as follows:

$$
u(k,p,k',p',z) \equiv \pi(k,z) - p - g[\theta(k,p,z)] + \frac{p'}{1+r} - \Psi(k',k).
$$

We may express e as follows:

$$e(u) \equiv [1 + \Phi_i \lambda - \Phi_d \tau_d] u.$$

Since e is weakly concave in u, we need only establish that u is concave. To do so, we verify that the Hessian of e is negative semi-definite. The Hessian (H) of u is as follows:

$$\begin{bmatrix} u_{kk} & u_{kp} & u_{kk'} & u_{kp'} \\ u_{pk} & u_{pp} & u_{pk'} & u_{pp'} \\ u_{k'k} & u_{k'p} & u_{k'k'} & u_{k'p'} \\ u_{p'k} & u_{p'p} & u_{p'k'} & u_{p'p'} \end{bmatrix} \tag{A6}$$

Checking the sign of the determinants:

$$|H_1| = \pi_{11}(1 - \tau_c) - g''(\theta)(\pi_1 - \delta)^2 - \Psi_{22} < 0 \tag{A7}$$

$$|H_2| = -g''(\theta)\left(\frac{r}{1+r}\right)^2 [\pi_{11}(1 - \tau_c) - \Psi_{22}] > 0$$

$$|H_3| = -(\Psi_{22})^2 g''(\theta)\left(\frac{r}{1+r}\right)^2 - \Psi_{11} * |H_2| < 0$$

$$|H_4| = 0.$$

Lemma (Convexity of $K \times P$): Application of the implicit theorem to the credit rationing condition implies that:

$$\frac{\partial \overline{p}}{\partial k} = \frac{\pi_1 - \tau_c(\theta)(\pi_1 - \delta)}{1 - \left(\frac{r}{1+r}\right)\tau_c(\theta)}. \tag{A8}$$

From the concavity of π and convexity of g it follows that $\overline{p}(\cdot)$ is concave. Hence $P \times K$ is a convex set.

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Table I: Simple Model Simulation

Average Debt-Assets Ratio (Net of Cash)	0.108
Fraction of Observations with Positive Cash	0.310
Average Investment/Assets	0.129
Standard Deviation of Investment/Assets	0.147
Average Equity Issuance/Assets	0.067
a_1	-0.031
a_2	-0.593
b_1	-0.037
b_2	-0.267
c_1	0.039
c_2	-1.170
c_3	-0.154

$(a_1, a_2, b_1, b_2, c_1, c_2, c_3)$ are estimated slope coefficients in the following regressions:

$$\frac{\text{Debt}}{\text{Market Assets}} = a_0 + a_1(\text{Tobin's Q}) + a_2\left(\frac{\text{Cash Flow}}{\text{Book Assets}}\right) + u_a$$

$$\frac{\text{Debt}}{\text{Market Assets}} = b_0 + b_1(\text{Tobin's Q}) + b_2\left(\frac{\text{EBITDA}}{\text{Book Assets}}\right) + u_b$$

$$\frac{\text{Debt}}{\text{Market Assets}} = c_0 + c_1(\text{Tobin's Q}) + c_2(\text{Weighted Q}) + c_3\left(\frac{\text{Cash Flow}}{\text{Book Assets}}\right) + u_c$$

Table II: Simulated Moments Estimation: Moment Estimates

	Actual Moments	Simulated Moments
Average Investment/Assets	0.079	0.118
Average Cash Flow/Assets	0.097	0.139
Average Debt-Assets Ratio (Net of Cash)	0.075	0.095
Average Equity Issuance/Assets	0.024	0.021
Investment-q sensitivity	0.019	0.036
Debt-q sensitivity	-0.073	-0.142
Debt-cash flow sensitivity	-0.235	-0.211
Serial Correlation of Income/Assets	0.583	0.524
Standard Deviation of the shock to Incomes/Assets	0.117	0.130

Calculations are based on a sample of nonfinancial firms from the annual 2002 COMPUSTAT industrial files. The sample period is 1993 to 2001. Estimation is done with the simulated moments estimator in Gourieroux, Monfort, and Renault (1993).

Table III: Simulated Moments Estimation: Structural Parameter Estimates

a	δ	λ	α	σ_e	ρ	μ_τ	σ_τ	χ^2
0.763	0.108	0.162	0.721	0.158	0.580	-6.936	12.159	1.549
(0.211)	(0.041)	(0.036)	(0.732)	(0.220)	(0.223)	(2.297)	(4.285)	(0.213)

Calculations are based on a sample of nonfinancial firms from the annual 2002 COMPUSTAT industrial files. The sample period is 1993 to 2001. Estimation is done with the simulated moments estimator in Gourieroux, Monfort, and Renault (1993). δ is the rate of capital stock depreciation; a is an adjustment-cost parameter; λ is the proportional cost of external equity; α captures decreasing returns to scale; ρ is the serial correlation of $\ln(z)$; σ_e is the standard deviation of the innovation to $\ln(z)$; and μ_τ and σ_τ are parameters that define the shape of the marginal corporate tax schedule. χ^2 is a chi-squared statistic for the test of the overidentifying restrictions. In parentheses is its p-value.

Table IV: Simulation Summary Statistics

	Saving			Debt			Debt
	Distributions	Equity	Neither	Distributions	Equity	Neither	Constrained
$\lambda = 0.162$							
Fraction	0.208	0	0.230	0	0.099	0.463	0.053
Investment/Assets	-0.067	——	-0.046	——	0.435	0.165	0.112
Debt/Assets	-0.122	——	-0.071	——	0.389	0.262	0.026
Tobin's Q	1.600	——	1.577	——	2.520	1.421	1.378
Assets	62.034	——	41.897	——	33.410	40.058	32.712
Cash Flow/Assets	0.253	——	0.146	——	0.149	0.083	0.062
Equity/Assets	——	——	——	——	0.021	——	——
$\lambda = 0$							
Fraction	0.174	0	0.162	0	0.160	0.504	0.041
Investment/Assets	-0.059	——	-0.026	——	0.448	0.187	0.134
Debt/Assets	-0.105	——	-0.056	——	0.375	0.235	0.054
Tobin's Q	1.390	——	1.295	——	2.130	1.404	1.250
Assets	55.502	——	48.783	——	32.748	39.472	31.700
Cash Flow/Assets	0.264	——	0.166	——	0.152	0.093	0.058
Equity/Assets	——	——	——	——	0.081	——	0.032

Figure 1: Low Marginal Cost of Debt Service

$1+\lambda$

$1-\tau_d$

savings

0

L

H
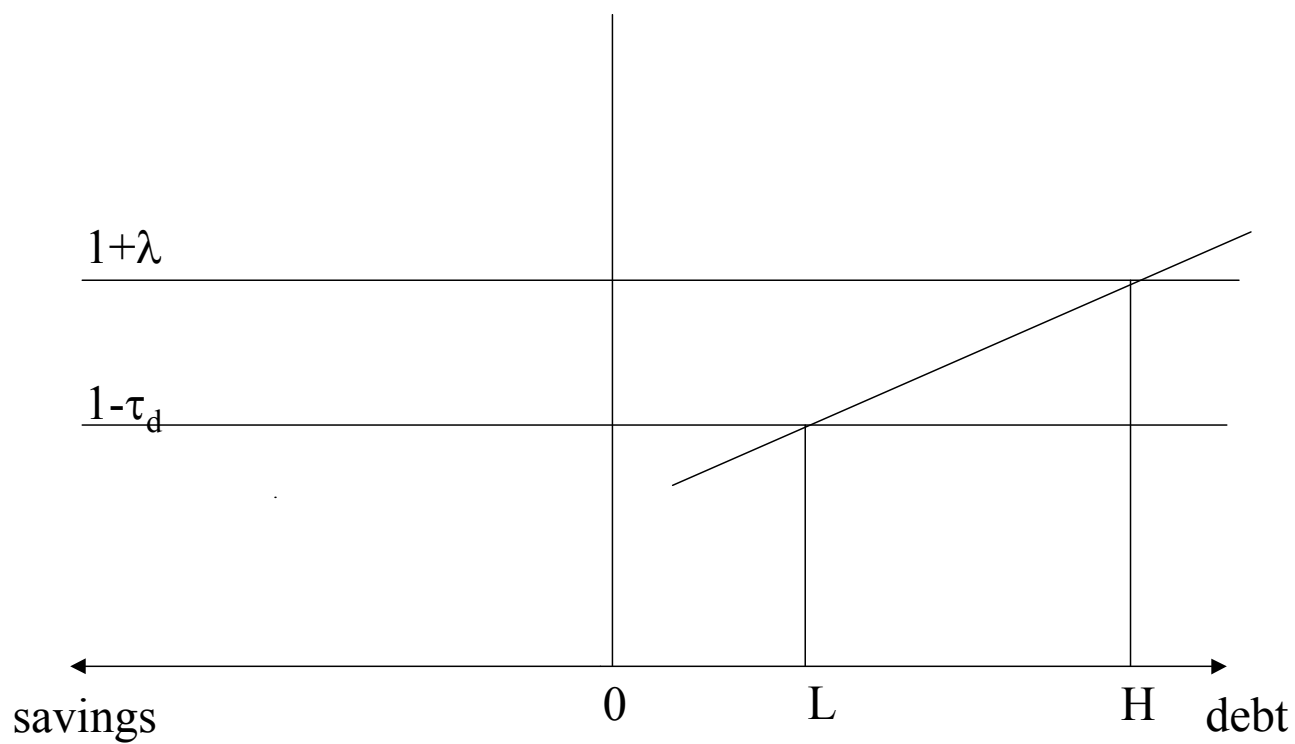
debt

Figure 2: High Marginal Cost of Debt Service

$1+\lambda$

$1-\tau_d$

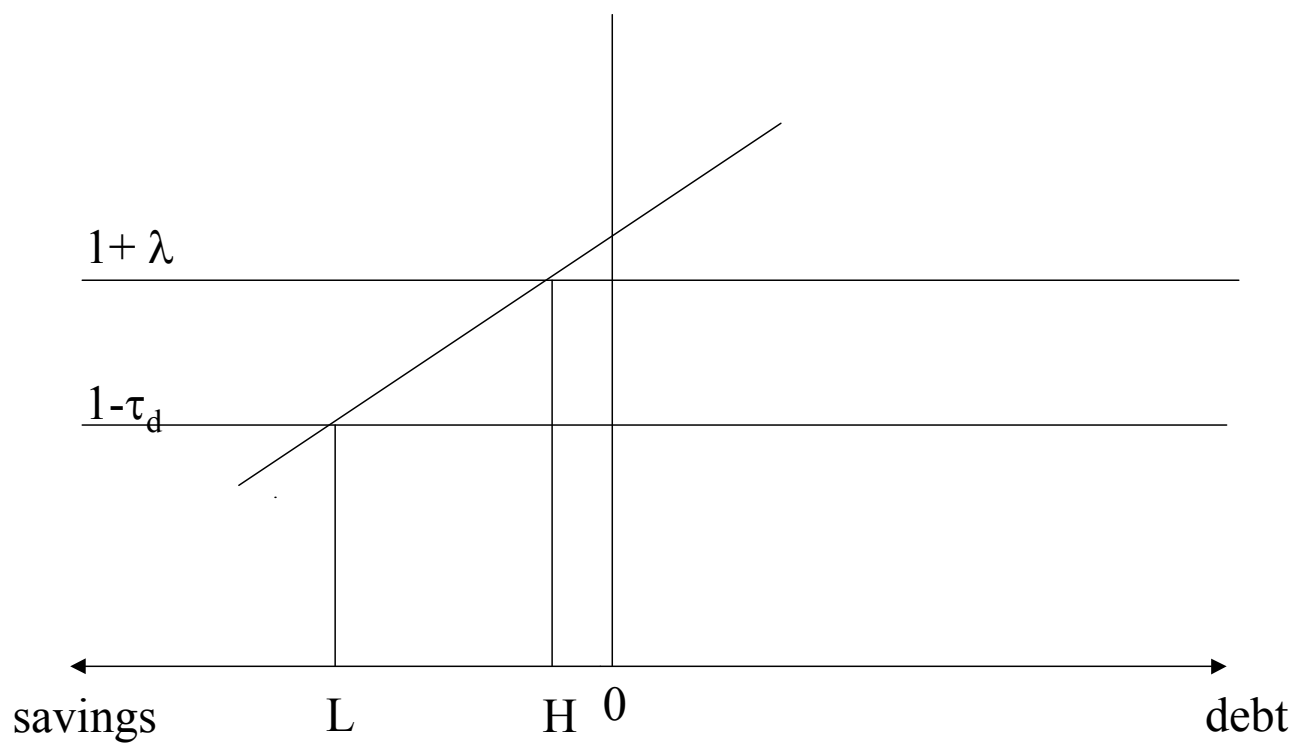savings   L   H   0   debt

Figure 3: Intermediate Marginal Cost of Debt Service

$1+\lambda$

$1-\tau_d$

savings L 0 H debt