THE MORAL HAZARD THEORY
OF CORPORATE FINANCIAL STRUCTURE:
EMPIRICAL TESTS

by

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Submitted in Partial Fulfillment of the Requirements for the Degree of
DOCTOR OF PHILOSOPHY
at the
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November 18, 1981

() Scott Howard Williamson 1981

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ABSTRACT

This thesis tests several theories of optimal corporate capital structure to identify the determinants of corporate borrowing. First, the theories are examined to develop testable hypotheses. The hypotheses lead to a regression equation which is estimated using several econometric techniques.

The thesis begins with a review of models of optimal capital structure, including the moral hazard theory. The models are grouped on the basis of their assumptions into several, more general theories. The empirical implications of each theory are reviewed.

A critical review of empirical work on the determinants of borrowing classifies tests into several basic categories. The implications of the tests' results are discussed.

Three capital structure theories are modeled in a single-period context to identify the variables which are related to the firm's debt ratio under each theory. Under the moral hazard theory, borrowing is negatively related to the value of the firm's growth opportunities. The variables are constructed for the 170 firms comprising the sample. In a cross-section regression equation, ordinary least squares with dummy variables and generalized least squares with a variance components model produce similar estimates. Possible errors in variables and simultaneity problems suggest a simultaneous equations approach to the estimation. A two-stage least squares model gives estimates similar to the single-equation results.

The results reject the hypothesis that, after controlling for other variables, the debt ratio is related to the firm's growth rate and variance of the growth rate. Also rejected is the common hypothesis that firm size has a positive impact on the debt ratio. The idea that non-interest tax shields reduce borrowing is also rejected. Two hypotheses cannot be rejected. First, asset risk has a negative impact on firm borrowing. Second, as suggested by the moral hazard theory, the proportion of firm value comprised by growth opportunities is negatively related to the debt ratio.

Thesis Supervisor: Stewart C. Myers, Professor of Finance
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Finally, here's Donna. No one but a Sloan School graduate could understand what I was going through. No one but Donna could make and keep me so happy through these years of adversity.
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OF CORPORATE FINANCIAL STRUCTURE:
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CHAPTER I
THEORIES OF OPTIMAL CAPITAL STRUCTURE

The development of a theory of optimal capital structure has been one of the principal tasks facing finance theorists. Currently many theories exist. The purpose of the present work is to test empirically the relatively recent "moral hazard theory" against several alternative hypotheses to determine which best explains the capital structures actually adopted by firms in the United States. An optimal capital structure is defined as the relative proportions of the items on the balance sheet's right side which maximize the stock price. Under the assumptions made by many of the theories financing and investment decisions are separable. Thus it is important to hold investment constant while solving for an optimal capital structure. In several recent theories, particularly those which deal with agency problems, separation does not take place. In fact, it is precisely this interdependence of investment and financing which distinguishes these theories from others. Because of the lack of separation the capital structure which maximizes the firm's total market value does not necessarily maximize the per share equity value.

The remainder of Chapter I is devoted to outlining several of the theories of optimal capital structure. Chapter II reviews a number of empirical studies which attempt to identify the determinants of firms' capital structures. Chapter III reexamines several theories to determine which variables should affect firms's debt ratios. Chapter IV presents tests of the more plausible capital structure models. The ordinary least squares technique provides estimates of the impact of the
variables identified in Chapter III on the debt to total capital ratios of a sample of firms. Then a variance components model is estimated using a generalized least squares technique. This allows for coefficient variations within as well as between industries. The results of both models do not reject the moral hazard hypothesis and cast doubt on several aspects of the competing theories.

Chapter V presents a simultaneous equations model which corrects the earlier model for bias due to measurement errors and simultaneity between two right-hand side variables. The resulting estimates are close to the earlier ones, and again the moral hazard hypothesis cannot be rejected.

I. Theories of Capital Structure in Absence of Taxes

To simplify the exposition I first contrast the polar theories, then examine the "traditional" approach, and finally return to a thorough investigation of the Modigliani-Miller (henceforth abbreviated as MM) theorem.

The net-income approach. The first of these theories is usually identified as the "net-income approach."¹ Imagine a firm which annually reinvests an amount equal to its economic depreciation. Economic income $\bar{X}(t)$ in each year $t$ is expected to be $X$ annually to perpetuity. The market value of the equity equals expected net income $E$ divided by the equity capitalization rate $k_e$. If the firm issues perpetual debt in face amount $B$ with coupon rate $r$ the promised annual payments are $rB$.

¹ See Durand (1959).
Assume that \( rB \) is less than all possible levels of \( X(t) \) so that the debt is riskless. Let the debt capitalization rate \( k_d \) be equal to \( r \).\(^2\) The value of the equity is

\[
S = \frac{X}{k_e} = \frac{X - k_d B}{k_e} = \frac{X}{k_e} - B \frac{k_d}{k_e}
\]

Since by assumption the debt is riskless, but the stock is not, \( k_d < k_e \). Holding investment, or \( X(t) \), constant while raising \( B \), the expression above implies that \( S \) falls less than \( B \) rises. As a result \( V \) rises.

Denoting the overall capitalization rate by \( k_o \) where \( k_o = \frac{X}{V} \), \( k_o \) falls with increasing leverage.

The net-operating-income approach. The net-operating-income approach gives a different result. The assumption here is that \( k_o \) and \( V \) are unaffected by the financing decision. Then \( S = V - B \), and

\[
k_e = \frac{E}{S} = \frac{X - k_d B}{S}.
\]

The first derivative,

\[
\frac{dk_e}{dB} = \frac{X - k_d (B+S)}{S^2}
\]

shows that \( k_e \) rises as \( B \) rises. Since \( X = k_d B + k_e S \), and by an earlier argument \( k_d < k_e \), \( \frac{dk_a}{dB} > 0 \).

The traditional approach. The traditional approach combines both the NI and NOI approaches.\(^3\) For small to moderate amounts of debt the firm's market value and capitalization rate behave in a manner similar

\(^2\) This requires that bonds be sold at par.

\(^3\) See Van Horne (1977) pp. 235-238.
to that postulated by NI; V rises, k_e and k_d are constant or rise slightly, and k_o falls as the firm substitutes "cheaper" debt for equity. "Those who adhere strictly to this method contend: first that conservative increases in bonded debt do not increase the risk borne by the common stockholders; second, that a package of securities containing a conservative proportion of bonds will justifiably command a higher market price than a package of common stock alone."\(^4\) According to this view, when more than a moderate amount of debt is used, k_e and k_d rise rapidly, causing V to fall and k_o to rise. Thus, at some level of borrowing, call it B*, the firm's market value and its share price are simultaneously at their respective maximums.

Modigliani-Miller and variations. MM (1969) use an arbitrage proof to show that the value of the firm V and the weighted average cost of capital are unaffected by leverage. The following assumptions underlie the MM arbitrage proof:

(1) fixed firm investment strategies;
(2) perfect substitution between firm and individual securities;
(3) perfect securities markets;
(4) perfect information;
(5) other investment opportunities not affected by one firm's supply of securities;
(6) at least one perfect substitute for each firm's cash flows; and
(7) risk free debt.

MM's arbitrage proof is as follows: consider two firms A and B in the same risk class. Firm B is levered and sells at a premium to A

\(^4\)See Durand (1952).
under the NI and traditional approaches. Imagine an investor owning
100α percent of B's stock. He can realize an arbitrage profit by taking
the following steps:

(1) Sell B's stock;
(2) Borrow an amount equal to 100α percent of B's debt; and
(3) Buy 100α percent of A's stock.

Since for $B_B + S_B = V_B > V_A = S_A$, actions (1) and (2) yield cash equal
to 100α percent of $V_B$, which is greater than 100α percent of $S_A$. His
original investment yields a cash flow of $(α)E_B = (α)X_B - (α)rB_B$. His
new investment nets him a cash flow of $(α)E_A - (α)rB_A$ or $(α)X_A - (α)rB_B$.
Since $X_A$ and $X_B$ are perfect substitutes, his cash flow is the same in
both cases, but he realizes the one-time cash gain of $(α) (V_B - V_A)$.
Since this is an arbitrage profit, MM argue that investors will bid up
the price of A's stock and reduce the price of B's.

Since the original MM article in 1958 a number of papers
exploring the theory have appeared. Robichek and Myers (1966) drop the
riskless debt and risk class assumptions of MM. In their one-period
model next period's total dollar return on the firm's assets is $X(s)$
where $s$ is the random variable state of nature occurring at time one.
The cash flow is divided into payments to bondholders, $D(s)$, plus the
residual flow to stockholders, $E(s)$, and the current values of those
securities are $B$ and $S$, respectively. Let $B(1+r)$ be the promised
payment to the bondholders. $X(s^* ) = B(1+r)$ implicitly defines the state
$s^*$, below which default occurs. The value of an unlevered firm to
investor $i$ is given by $V_I = \sum X(s)q_i (s)$, where $q_i (s)$ is the marginal
value to investor $i$ of an additional dollar in state $s$. Myers (1968)
shows that a sufficient condition for $q_j (s) = q_i (s)$ for all $i, j$ is that
the number of securities be at least as large as the number of states. Under this condition \( V_i = V_j \) for all \( i, j \); in other words, even if different investors have different subjective probability distributions on \( s \), they agree on state prices and on values of securities. Now consider a levered firm which is otherwise identical to the unlevered one. Separating the payoff into default and non-default sets of states, the value of the bonds is given by

\[
B = \sum_{s < s^*} X(s)q(s) + \sum_{s \geq s^*} B(1+r)q(s)
\]

The equity value is \( S = \sum_{s \geq s^*} [X(s) - B(1+r)]q(s) \). Adding the expressions gives

\[
V = \sum_{s < s^*} X(s)q(s) + \sum_{s \geq s^*} X(s)q(s) = \sum_{s \geq s^*} X(s)q(s),
\]

which is identical to the unlevered case. Capital structure is irrelevant with respect to firm valuation, even though Robichek and Myers permit default. Also, Robichek and Myers' complete markets assumption produces agreement on valuation and prevents capital structure changes from changing the portfolio opportunities faced by the investors.

Stiglitz (1974) presents theorems in which he carefully differentiates between irrelevance with respect to firm value and irrelevance with respect to investor wealth (a stronger result). For the first he dispenses with the assumption that debt is riskless. To get the stronger result Stiglitz retains assumptions (1) (fixed investment strategy), (2) (equal access), (3) (perfect markets), and (7) (no default). In addition (4) is retained since he assumes all investors place the same value on any given security. Through an arbitrage proof he shows that using "homemade leverage" an investor can achieve identical consumption levels before and after a firm's capital structure change.
In order to get the weaker result of his second theorem, Stiglitz allows default and replaces the equal access assumption with the assumption that financial intermediaries can costlessly issue securities against the corporate securities they purchase. If the economy is initially in equilibrium and a firm alters its capital structure, intermediaries can buy the securities of the firm and issue debt and equity in the original, equilibrium proportions. Thus, considering the set of securities held by individuals, the new equilibrium is identical to the old one, implying no change in valuations. In the limit, intermediaries issue enough securities to result in a complete market. The result approximates that of Robichek and Myers. Note that where bankruptcy is possible Stiglitz’s stronger result does not hold since a firm may shift wealth between individual bond- and stockholders by changing the capital structure.

It is the wealth-transfer idea that Fama and Miller (1972) address when they introduce the term "me-first rule." Fama and Miller show that assumptions (1)-(5) are not sufficient to obtain the result that capital structure changes have no effect on investor wealth (and firm market value), since wealth transfers between bond- and stockholders may result. Security holder indifference obtains if there is no default or there exist me-first covenants prohibiting actions which transfer wealth between security holders.

Finally, Fama (1978) presents the strongest theorem. Given assumptions (1), (2), (3), and (4), then capital structure changes do not affect firm valuation or investor wealth positions, even in absence of me-first rules. If investors have equal access, they can create securities identical to those which firms issue and can repackage those
issued by firms. Investors are not forced to purchase securities whose values are vulnerable to capital structure changes. When vulnerable securities are purchased, their price reflects the probability of the occurrence of states in which a redistribution will take place. Since investors can choose the same positions regardless of firm financing decisions, those decisions affect neither firm value nor investor wealth.

Empirical implications. The empirical implication of the traditional theory is that each firm will use a "conservative" level of debt financing, which does not increase the risk borne by the stockholders. But it is straightforward to show that the variability of earnings per share and risk always increases directly with leverage. Thus one must look to the second contention mentioned earlier, that the use of a conservative amount of borrowing (however that is defined) raises the value of the firm's package of securities.

The traditional theory suggests looking at the market values of firms or their costs of capital while controlling for variables other than financing. Firms with optimal debt ratios should have higher values (per dollar of cash flow) and lower costs of capital than other firms. This test would not be very powerful, however, since in equilibrium all firms of a given risk class with identical costs of capital and debt ratios. This is different from the MM result that,

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5 Identicality here extends farther than with the previous theorems. Fama's theorem requires that owners of individual-issued securities face wealth expropriation as a result of future financing opportunities. The wealth shifts would be of the same magnitudes and occur in the same states as those induced by the corresponding corporate issues.

6 See, for example, Van Horne (1977) p. 265.
although costs of capital should be identical, firms of a risk class have no incentive to cluster around a given debt ratio.

II. Theories of Capital Structure With Corporate Taxes

The MM model. MM (1963) modify their original propositions to incorporate tax effects. Two assumptions are necessary to derive the MM results:

1. Debt pays interest to perpetuity.
2. Firms will never issue new debt in the future.

Let $k_u$ be the overall cost of capital for an unlevered firm in some given risk class. Then

$$k_u = \frac{X(1-\tau)}{V_u},$$

where $\tau$ is the corporate tax rate and $V_u = S$ is the unlevered firm market value. As before $k_d = \frac{R}{B}$, where $R$ is the periodic interest payment to the bondholders. The total cash flow paid to the security holders in this simple model is NOI less taxes: $Y = X - \tau(X-R)$ or $Y = (1-\tau)X + \tau R$. The capitalized value of the two streams gives the levered firm value,

$$V_l = \frac{(1-\tau)X}{k_u} + \frac{\tau R}{k_d}.$$ The first term is $V_u$. Since $k_d = \frac{R}{B}$, the second term can be written as $\tau B$. Thus $V_l = V_u + \tau B$. Since $\frac{dV_l}{dB} = \tau > 0$, for two firms of the same risk class the one using the larger proportion of debt financing sells at a higher price. MM provide an arbitrage proof that the pricing relationship must hold.

Shareholders are not indifferent to firm financing decisions if the MM pricing relationship holds. As long as the bonds sell for a fair price, the entire value of the additional tax shield generated when a

\[7\text{MM point out that the assumptions can be relaxed to get more general results.}\]
firm increases its financial leverage accrues to the shareholders, making them unambiguously better off.

**Empirical implications.** The MM tax shield theory has several empirical implications. Due to the contribution of borrowing to the value of the firm, if the firms' unlevered cash flows are capitalized at the appropriate rate given their risk, the difference between their value and the firm's market value is approximately equal to $\tau B$. Thus for a sample of firms whose operating cash flows are of the same risk (hence should be capitalized at the same rate) market value could be regressed on an estimate of perpetual operating cash flow and on the level of borrowing. If MM are correct, the coefficient on the former variable is an estimate of the inverse of the capitalization rate for the risk class, while the coefficient on the latter variable is an estimate of the tax rate. Since the tax rate is positive, these results would indicate a positive effect of borrowing on firm value.

Another test consists of identifying events where firms' capital structures have changed without a concurrent change in underlying investment policies (i.e., holding expected operating cash flows constant) and measuring the change in the firms' market values. This is similar to tests by Masulis (1980). If the MM model is correct, the replacement of one dollar of equity with a like amount of debt results in a rise in firm market value of $\tau$.

Finally, the MM model does not suggest limits to the benefits of leverage. This implies that all firms should be levered to the point where any further increase in leverage would no longer be recognized as debt eligible for tax purposes by the I.R.S. Thus if all firms are at
their optimums, they are clustered around a high debt ratio, a result similar to that expected from the NI theory.

III. Theories of Capital Structure With Bankruptcy Costs

With the publication of the MM tax correction article a search began to find factors which could reconcile the all-debt prescription of MM with the observed reality of debt ratios below one-hundred percent. A number of authors suggest that costs incurred as a result of the process of bankruptcy might explain the observed ratios.8

Types of costs. Three types of negative cash flows are typically grouped under the term "bankruptcy costs." First are the "direct" costs associated with a reorganization or liquidation. The direct costs include administrative expenses incurred directly as a result of the bankruptcy process, especially legal fees. Several studies investigate the magnitude of these costs. Stanley and Girth (1971) estimate that approximately twenty percent of the pre-bankruptcy value of the firm is absorbed by direct costs. Van Horne (1975) reports a similar estimate (23.4 percent). In a study of bankruptcies of firms which were in general much larger than those included in the former studies, Warner (1977a) finds direct costs to average 5.3 per cent of firm value and suggests that economies of scale may exist for bankruptcy costs. Gordon and Malkiel (1981) give evidence that the costs are larger. Both Warner and Miller (1977) insist that, given the small size of realized costs, it is difficult to believe that the expected present value of those

costs can be large enough to nudge a firm from what would otherwise be its optimal capital structure.

None of the empirical studies cited above attempt to measure the "indirect" costs of bankruptcy. These costs include lost sales due to the perception of the firm as an unreliable supplier, higher costs as management devotes more of its resources to avoiding bankruptcy, and difficulty in arranging short-term financing. These indirect costs may be much larger than the direct ones, but there are no empirical estimates of them.

The third type of cost stems from the loss of tax write-offs on losses incurred by the firm. Kim (1978) cites sections of the tax code which make it very difficult for the security holders of a bankrupt firm to realize the tax deductions. Firms are prohibited from merging solely for tax purposes. Furthermore the courts have not allowed reorganized firms to carry forward tax losses incurred prior to reorganization. Thus most bankrupt firms face an asymmetrical tax treatment of gains and losses.

Discrete-time models. Authors have used several types of models to illustrate the combined effects of corporate taxes and bankruptcy costs. Perhaps most straightforward is the single period state preference model of Kraus and Litzenberger (1973). Denoting the promised payment to the debt holders by $R$, the firm's earnings before interest and taxes in state $q$ by $X(q)^*$, the bankruptcy costs in $q$ by $C(q)$, and the price of a simple security with payoff $1$ in state $q$ by $P(q)$, the value of the firm's debt is

$$L(rB) = \sum_{q=0}^{q^*-1} [X(q)-C(q)]P(q) + rB \sum_{q=q^*}^{\infty} P(q).$$
q* is defined implicitly by rB = X(q*). The equityholders receive the residual X(q)(1-τ) + τrB -rB whenever q ≥ q*. τ is the corporate tax rate. The market value of the equity is

\[ S(B) = \sum_{q=q^*}^{\infty} [X(q)(1-\tau) + \tau rB - rB] P(q) . \]

Adding the values of the debt and equity gives the firm's total value

\[ V(rB) = \sum_{q=0}^{q^*-1} [X(q) - C(q)] P(q) + \sum_{q=q^*}^{\infty} [(1-\tau)X(q) + \tau rB] P(q) \]

\[ = V(0) + \sum_{q=0}^{q^*-1} [\tau X(q) - C(q)] P(q) + rB \sum_{q=q^*}^{\infty} \tau P(q) , \]

where V(0) is the value of an otherwise identical, unlevered firm. The optimal level of borrowing occurs where the derivatives with respect to B of the last two terms are equal, and may fall between \( \frac{rB}{V} = 0 \) and \( \frac{rB}{V} = 1 \).

Scott (1976) and Kim (1978) show that internal optimums may exist under assumptions different from those of Kraus and Litzenberger. Scott shows that under risk neutrality imperfect markets for physical assets may produce an internal optimum. Presumably that model applies most directly to liquidations. Kim uses the Sharpe (1964) - Lintner (1965) capital asset pricing model and introduces stochastic bankruptcy and bankruptcy costs to derive an optimal capital structure under risk aversion. He is very careful to point out that the optimum occurs at a level of borrowing below the maximum allowed by the market.
Continuous time models. Other bankruptcy cost models are the continuous time, contingent claims models that derive from the work of Black and Scholes (1973). Oldfield (1976) models the equity as a contingent claim on both the unlevered firm value and the interest tax shield on the debt payment. Since he assumes that the debt is in the form of a pure discount bond, the only point at which default can occur in Oldfield's model is at the bond maturity date. At that time if the unlevered firm value is less than the promised debt payment, the firm is in default and loses all interest tax shields and incurs additional direct bankruptcy costs. Under these conditions Oldfield derives the levered firm value as a function of the promised debt repayment. Where direct bankruptcy costs are assumed to be zero, firm value is less than in the MM tax correction case, but $V$ increases monotonically with the promised repayment.\textsuperscript{9} Thus a corner solution again obtains, where an all-debt capital structure is optimal. Positive bankruptcy costs produce an internal optimum in the Oldfield model.

The model of Brennan and Schwartz (1978) is similar except that they assume that periodic coupon payments must be made on the corporate debt, rather than treating it as a discount bond. A firm is bankrupt if at the date of any coupon payment the underlying unlevered firm value is less than the maturity value of the debt.\textsuperscript{10} At such a point the stockholders lose all future interest tax shields, and the value of the firm less any direct bankruptcy costs passes to the stockholders.

\textsuperscript{9} This is reasonable since with MM's perpetual debt bankruptcy and loss of tax shields never occur, whereas in the Oldfield model they may occur at the end of a finite period.

\textsuperscript{10} This is not an optimal arrangement for the stockholders.
debtholders. The levered firm's value is maximized at a debt ratio less than one, even when direct bankruptcy costs are assumed to be zero.

To summarize, under most conditions the existence of positive direct or indirect bankruptcy costs is sufficient to induce a positive optimal level of equity financing. There is some argument whether the magnitudes of those costs are sufficient to account for the degree of equity financing actually observed. Although in some models by itself it may not induce equity financing, the loss of tax shields in default when combined with the other types of bankruptcy costs serves as a further incentive for the use of a positive level of equity.

**Empirical implications.** Haugen and Senbet (1978) reason that, regardless of previous empirical and theoretical studies, expected bankruptcy costs cannot be large enough to significantly offset the tax shields generated by debt. They argue that bankruptcy costs should always be avoided simply by recapitalizing the firm. If the costs of bankruptcy are larger than the transactions costs incurred in issuing new securities, any group of security holders or outsiders can simply force the firm to issue additional equity and use the proceeds to retire a sufficient quantity of debt to avert an impending bankruptcy. They note, however, that agency problems could prevent recapitalizations from taking place in lieu of bankruptcies.

The Kim model suggests that a value maximizing firm adjusts its borrowing to maximize the algebraic sum of the values of its expected component cash flows where each component is valued according to the Sharp (1964) - Lintner (1965) capital asset pricing model. Expected bankruptcy costs and expected foregone interest tax shields being among the components, a firm having relatively risky (high beta)
bankruptcy costs selects a high debt level, ceteris paribus.

Although one cannot observe the risk of a firm's bankruptcy costs, surrogates may be found. If bankruptcy occurs when the value of the firm (or its cash flows) is less than the promised debt payment, then the bankruptcy event (and realized bankruptcy costs) is negatively correlated with firm value (or cash flow). In that case the present value of the expected costs is a positive function of the firm's asset (or cash flow) beta. Thus the firm's asset (or cash flow) beta is a surrogate for the bankruptcy cost beta but with the opposite sign. Borrowing is negatively related to asset (or cash flow) betas, controlling for other variables.

Since empirical work suggests that, given the bankruptcy event, costs are a positive concave function of firm size, measures of firm size may have interactive effects with bankruptcy risk. Controlling for other variables, a larger firm may borrow more against each dollar of assets than a smaller firm.

A final test of the bankruptcy cost effect involves observing the effect of capital structure changes on the value of the firm's equity, holding the firm's asset portfolio constant. Controlling for other effects leverage raises the present value of bankruptcy costs by raising the probability (and in Kim's one-period model the size) of the costs. Most firms reducing their leverage is evidence of the effect if one looks at a sample of firms in financial distress and controls for asset changes. By reversing this argument firms which have recently

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11 In his study, Masulis (1978) uses the following as a working definition of financial distress: Stating the possibility of imminent bankruptcy, experiencing large losses relative to the size of the firm, in technical defaults of indentures, and/or in arrears on preferred stock.
experienced increases in their assets' value should issue debt. Most of
the additional value accrues to the levered equity, resulting in the need
to replace some equity with debt to move back to the previous debt ratio.
The increment to the assets' value serves to widen the gap between
expected firm value and the previously promised debt payment, resulting
in a reduction in the present value of the firm's expected bankruptcy
costs. The firm should replace equity with debt until it has again
balanced the marginal expected bankruptcy costs against the marginal
benefits conferred by the borrowing.

IV. Tax Clienteles Theories of Capital Structure

 Clienteles theories. Farrar and Selwyn (1967) and Myers (1967) note
that MM deal only with before-personal-tax returns to investors on
corporate securities. Adding differential taxes on income and capital
gains, they find that investors in different tax brackets value a firm
differently and that the valuations are determined by the manner in which
the firm's operating cash flows are divided between debt payments,
dividends, and capital gains.

The cash flow available to the investors in an all-equity firm
is \( X(1-T_C)(1-T_{PE}) \). Here a number of simplifying assumptions are made.
Among them are that the operating cash flow \( X \) is a level perpetuity and
that the firm reinvests all flows owned by the equityholders to produce
a capital gain which is immediately realized for personal tax purposes.
The effective rate on equity income is \( T_{PE} \), while the personal income
rate is \( T_P \). \( T_C \) is the corporate tax rate. If \( k_o \) is the pre-tax
capitalization rate for the all-equity firm, the firm's value is
\[ V_o = \frac{X(1-\tau_c)(1-\tau_{pe})}{k_o(1-\tau_{pe})} = \frac{X(1-\tau_c)}{k_o} \]

For a levered firm the after-personal-tax cash flow to debt and equity investors is \([(X-rB_c)(1-\tau_c)(1-\tau_{pe})] + rB_c(1-\tau_p), \) where \(B_c\) is the level of corporate borrowing. Capitalizing the cash flows at the appropriate rates, gives the MM result

\[ V = V_o + B_c\tau_c \]

Imagine an investor holding equity in a levered firm and levering his position by personal borrowing \(B_p\) at the rate \(r\). His periodic cash flow is \([(X-rB_c)(1-\tau_c)(1-\tau_{pe}) - rB_p(1-\tau_p)]\). To find the value of the total flow capitalize each part at the appropriate rate to get

\[ V = V_o - \frac{r[B_c(1-\tau_c)(1-\tau_{pe}) + B_p(1-\tau_p)]}{r(1-\tau_p)} \]

If the investor wished to maintain a constant level of total borrowing (corporate plus personal), the degree of leverage chosen by the firm affects his valuation of the cash flow. \( \frac{dV}{dB_c} = 1 - \frac{(1-\tau_c)(1-\tau_{pe})}{(1-\tau_p)^2} \). If the personal tax rate is less than the corporate rate, the value rises with corporate borrowing. The interpretation is simple. If the tax shields created by corporate borrowing are greater than by personal borrowing, individuals prefer to own equity in highly levered firms rather than to own equity in low-debt firms and borrow on own account to reach their desired risk position.

Black (1971, 1973) and Miller (1977) develop the differential tax treatment of cash flows into a clientele theory. Black suggests
that, given the supplies of securities subject to different degrees of personal taxation, investors could be ordered by increasing tax brackets. Those in the lowest tax brackets hold the securities subject to the highest personal taxation. Individuals in successively higher tax brackets hold securities subject to successively lower personal taxation.

In Miller's general equilibrium model investors are permitted to hold corporate bonds, municipal bonds of equivalent risk, and corporate stock, the income from which is assumed not to be subject to personal tax. Imagine an initial equilibrium in which there are no corporate bonds outstanding. If a firm issues debt, the after-tax return on that debt must be at least as great as on a tax-free bond of equivalent risk. Thus the promised return must be "grossed up." With the return augmented to some degree, it is identical on an after-tax basis to that of a tax-free bond to investors in the lowest tax bracket. As long as the interest tax shield available to some firm by issuing taxable debt is greater than the premium over the tax-exempt return that must be paid to induce investors in the next higher tax bracket to purchase the debt, taxable debt is issued. Firms no longer find it desirable to sell debt when the premium is equal to the tax shield generated. Thus the tax bracket of the marginal taxable debtholder is equal to the marginal firm's tax bracket. Individuals in brackets below this level hold taxable bonds, while those above it hold tax-exempt ones. Since in this certainty model corporate shares produce untaxed returns, they are priced identically to and are perfect substitutes for tax-free bonds. If in this competitive equilibrium all firms are in the
same tax bracket, all pay the same premium over the tax-free return, and the value of any firm is independent of its capital structure.

DeAngelo and Masulis (1980b) use a state preference model in which markets are complete, and simple debt and equity having non-zero payoffs in only one state are sold. Investors can be divided into three groups on the basis of their tax brackets for debt income, $\tau_p$, and equity income, $\tau_{pe}$. Investors in Group I are those for whom $(1-\tau_p) > (1-\tau_{pe})(1-\tau_c)$, where $\tau_c$ is the corporate tax rate. In Group II $(1-\tau_p) = (1-\tau_{pe})(1-\tau_c)$. In Group III $(1-\tau_p) < (1-\tau_{pe})(1-\tau_c)$. DeAngelo and Masulis present three cases. Letting $P_B(s)$ and $P_E(s)$ denote the prices of debt and equity claims paying one dollar in state $s$, respectively, they show that when $P_B(s) < P_E(s)(1-\tau_c)$, investors in Groups I and II find that the after-tax yield on state $s$ debt $(1-\tau_p)/P_B(s)$ exceeds that on state $s$ equity $(1-\tau_{pe})/P_E(s)$. Those investors demand debt. Since equity is priced at an after-corporate-tax premium, however, firms prefer to issue only equity. When debt is priced at a premium, Groups II and III find the after-tax yield on equity to be higher and demand equity. Firms prefer to supply debt at a premium. Finally when securities are priced such that $P_B(s) = P_E(s)(1-\tau_c)$ Group I demands debt, Group III equity, and Group II is indifferent, since the after-tax yields are identical for investors in that bracket. Since no security is priced at a premium, firms are willing to supply securities in the relative proportions demanded by the investors. Thus, even without

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12 This premium is necessarily equal to that required by the marginal investor. Infra-marginal investors earn a surplus.
municipals and with uncertainty, a Miller-type general equilibrium obtains, where the capital structure decisions of an individual firm does not affect its valuation, but the aggregate supplies of securities affect investor wealth. DeAngelo and Masulis point out that if complex debt and equity claims exist, rather than the simple ones considered above, the results do not in general hold, since securities supplied by firms cannot in general eliminate the price premiums associated with all states.

Taggart (1979) also shows that the nature of the equilibrium under uncertainty with conventional securities is different from that of Miller's model. Since risky shares are no longer perfect substitutes for riskless tax-free bonds, an individual may hold either tax-free bonds, taxable bonds, or stock alone, or he may hold a combination of either type of bond and stock. The individual's tax bracket influences the proportions of taxable and tax-exempt securities, while his risk aversion influences the proportions of riskless debt and risky equity. In Taggart's equilibrium all firms assume extreme capital structures, with low-bracket individuals forming a clientele for the highly levered firms, and high-bracket investors owning the unlevered firms. Capital structure does not affect value in the general equilibrium as long as the set of feasible capital structures is limited to the two extremes. At equilibrium investors in any given firm agree on the capital structure decision since they are all from the same clientele.

Finally DeAngelo and Masulis (1980a) find that by introducing "tax shelter substitutes" into their uncertainty version of the Miller model firms' equilibrium capital structures have determinate, internal optimums. Imagine a firm with depreciation and other deductions and/or
tax credits. The expected value of these tax shelters falls as the probability of their utilization is reduced by higher levels of leverage. In order to compensate for the loss the owners demand an increasing price as they issue more debt.\textsuperscript{13} This produces an upward-sloping supply curve for debt. As before the firm supply curves sum to produce an aggregate supply curve. Its intersection with the downward-sloping aggregate demand curve produces the equilibrium aggregate demand and supply. But in this case, since firm supply curves are not perfectly elastic, determinate, interior solutions result. The empirical manifestation should be a negative correspondence between the level of firms' tax-shelter substitutes and their use of debt financing.

\textbf{Empirical implications.} The various versions of the clientele theory yield different empirical predictions. Miller's model implies that there exist no systematic, cross-sectional patterns in debt usage. It does suggest that in a time series of tax-exempt yields and yields of corporate debt of identical risk there is a constant, proportional relationship, where the constant of proportionality is \((1-\tau_C)\).

The implications of the DeAngelo-Masulis and Taggart papers are somewhat different from Miller's. The most salient feature is the bimodal distribution of debt ratios. One group of firms uses no leverage, and the other group is highly levered. The theory does not suggest that the firms within either of the groups have common attributes. Because in equilibrium the firms within each group maximize their values, there is no dependence of levered firm value on the debt

\textsuperscript{13} This reduces the bonds' cost below \(R(1-\tau_C)\).
ratio. If some firms' debt ratios fall between those of the two groups, the levered firm value is a convex function of borrowing.

Both versions of the theory suggest something about the behavior of the time series of aggregate corporate borrowing. When legislated tax changes took effect where personal tax rates fell (rose) while corporate rates remained fixed, firms should have behaved according to the postulated wishes of investors by issuing (retiring) debt and retiring (issuing) equity.

Introducing tax-shelter substitutes changes the implications. First, each firm has a determinate interior optimal debt-ratio. These ratios may form a continuum. Thus, although they are not ruled out by the theory, there is no reason to expect either a unimodal or bimodal debt ratio distribution. Instead a negative relationship exists between the ratios of firms' tax-shelter substitutes to operating earnings and their debt ratios. DeAngelo and Masulis (1980b) suggest that the availability of substitutes is a function of the firms' industry. This might explain the industry dependence of debt ratios observed by Scott and Martín (1975) and others. On the individual firm level, a change in capital structure produces a change in market valuation, ceteris paribus. On the aggregate level tax rate changes affect corporate

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14 See also Scott (1972) and Schwartz and Aronson (1967).

15 Note that the theory indicates that each firm has an optimal debt ratio and that these optimal ratios may vary cross-sectionally. Unless all firms are at or below their optimal ratios we should not expect to observe a positive relationship between firms' borrowing their market valuations. Yet DeAngelo and Masulis (1980, p. 23) suggest that Miller and Modigliani's (1966) finding of such a positive relationship is evidence supporting the tax-shelter substitute theory.
borrowing in the same way as in the simple clientele theories. DeAngelo and Masulis suggest that corporate borrowing rises as firms attempt to replace the real value of their tax deductions based on historical cost lost due to inflation. Whenever the tax code changes to allow a higher level of tax-shelter substitutes, borrowing falls.

V. Agency Cost Theories of Capital Structure

Problems of agency arise whenever those managing an entity are not the sole financial beneficiaries of the operation. The corporation is one example. Jensen and Meckling (1976) analyze the effects of agency problems on the corporation.

Consider a firm in which the managers have supplied all the capital and have received equity claims. Under this arrangement the managers extract nonpecuniary benefits from the firm up to the point where the marginal value of those benefits to the managers equals the marginal cost. The latter is reflected in the value of the equity owned by the managers.

The situation changes, though, if some equity has been sold to outsiders who can't share the insiders' appropriated benefits. Now the insiders realize a level of benefits such that the marginal value is equal not to the marginal cost reflected in the total equity value, but to the fraction of the marginal cost reflected in the insiders' portion of the equity. If markets are efficient, this higher level of benefits is reflected in a reduction in the price the outside owners are willing to pay for the stock. Thus the insiders bear the full cost of their new, higher level of benefits. Since at the previous level of benefits
the total marginal cost is equal to the marginal benefit, the insiders find the new level suboptimal.

There are methods to reduce the loss of value by limiting the level of benefits consumed by the insiders. Jensen and Meckling discuss the monitoring of insiders' activities by the outsiders and the bonding of the insiders. Both involve costs which are reflected in the equity value and borne by the insiders. Thus the optimal level of monitoring and bonding occurs where the marginal cost of increasing those activities is equal to the marginal increment to equity value due to the reduced level of insider benefits.

Why would the insiders be willing to incur the agency costs mentioned? If the insiders have limited financial resources, and the value increment due to growth is greater than the agency costs incurred in selling external securities, the original owners will elect an issue.

Agency costs and debt. Similar agency problems exist when risky debt is issued. The owner-managers have opportunities to make decisions which effect wealth transfers between the equity owners and the debtholders and reduce total firm value. Chen and Kim (1979) point out that by consuming nonpecuniary benefits the managers also reduce the value of the debt, since they reduce the value of the firm on which the bondholders have claims if default occurs. Once again the price investors pay for the bonds reflects the value of the expected wealth expropriation. If, indeed, total firm value falls, then the equity owners lose more when they sell the bonds than the value of the wealth transfers they can obtain. As in the case with outside equity, in spite of the cost it may be desirable to issue debt if the insiders' resources
are limited. Through monitoring and bonding it may be possible to reduce the total agency costs below their level without these activities.

For a firm of a given size agency problems should play a role in determining the capital structure. Three factors which should affect the debt-equity choice have been identified:

1. Opportunities for wealth transfer from bondholders to equityholders.

2. Opportunities for wealth expropriation in the form of non-pecuniary benefits by the managers and its relative effects on the value of debt and equity.

3. Relative monitoring and bonding costs for debt- and equityholders.

Since the bondholders have a legal priority claim to periodic cash flows, the wealth transfers in (1) and (2) above do not affect their cash flows except in default. Thus the higher the probability of default (e.g. when the firm is very highly levered), the larger the negative effects of (1) and (2) on the value of the bonds. Since equity is a claim on the residual cash flow of the firm, (2) affects equity cash flows more directly. At some point the marginal agency costs for an additional dollar of debt and for one of equity are equal.

Agency costs and investment. Methods of transferring wealth between debt- and equityholders have received some attention in the literature. Galai and Masulis (1976) show how the transfer can be accomplished when the equityholders (or their agent) make the investment decision. One can view the equity S as a call option on the assets V of the firm with exercise price B, the promised payment on the debt. The value of an option is positively related to the variance rate of the underlying asset value. Thus by replacing the original assets with ones of equal value but higher risk, the owners can raise the value of the equity claim.
Since \( V = B+S \), \( B \) must fall. Even if the new asset acquisition has a negative net present value (\( \Delta V < 0 \)), if there is a sufficient increase in asset risk the equity value can still rise. In this latter case \( -\Delta B > \Delta S \).

A second method of effecting a wealth transfer is demonstrated by Myers (1977). He shows that future investment opportunities can be viewed as options. At the time the investment decision must be made the value of the underlying asset is the present value of the cash flows to the equity resulting from the investment. The exercise price is the required investment. If, by exercising, the equityholders receive an asset whose value is greater than the exercise price, they choose to exercise. The existence of corporate debt maturing after the expiration date reduces the value of the underlying asset to the stockholders since some of the cash flows accrue to the bondholders. Equityholders, seeking to maximize the value of their claim, choose to exercise only if the net present value of the equity cash flows is positive and thus may reject opportunities whose net present value of gross cash flows is positive. The possibility of rejecting firm-value maximizing opportunities reduces the value of a levered firm when compared to its unlevered counterpart.

The similarity of the latter two wealth transfer problems to the moral hazard problem in the insurance literature suggests the use of the term "moral hazard" to apply to this capital structure effect. Arrow writes (1971, p. 220) that a moral hazard exists "if the amount of the insurance payment is in any way dependent on a decision of the insured as well as on a state of nature." The idea fits quite well if the levered equity is viewed as a call option. Part of the value of a call option results from the insurance of the owner against large declines in the value of the underlying asset. Thus the equityholders are motivated to
act in a manner which allows them to collect on the insurance aspect.

Although a detailed discussion of empirical tests of the moral hazard model are presented in subsequent chapters, some of the general empirical manifestations of the moral hazard theory are considered here. First, if the monitoring and bonding costs necessary to enforce firm-value maximizing investment behavior are sufficiently high, a management finds that stock price is maximized at a lower debt ratio than would be the case if the moral hazard were eliminated. Thus firms whose values have a large growth opportunity content (resulting in a "large" moral hazard) have a lower debt ratio ceteris paribus. In a time series firms whose values have risen without a corresponding rise in tangible assets rebalance their financing mix by issuing equity. Note that most competing theories of capital structure predict that a rise in firm market value, which would ordinarily be reflected primarily in the value of the outstanding equity, motivates a debt issue to return the firm to its optimal debt ratio.

Finally, Myers points out several ways the firm can reduce the moral hazard problem. Relatively short-term borrowing means that debt repayment or recontracting occurs before the exercise date of the investment option. High-growth firms should be heavier users of convertible debt since the use of convertibles has been shown to reduce the moral hazard problem in some circumstances. 16

VI. Categorization of the Models

Four of the models can be dismissed as being unrealistic in their assumptions or results. The NI and MM-tax models suggest all

16 See Bodie and Taggart (1978).
firms in equilibrium are completely levered. The Taggart generalization of the Miller general equilibrium model predicts that all firms cluster around zero and 100 percent leverage. Since many firms have moderate, e.g. 30 percent, ratios of debt to total capital, these models are not considered further. The original MM model, since it ignores taxes, is dropped.

Four classes of models remain. The MM-type model with taxes and bankruptcy costs (MUTB) yields a unique interior optimal debt ratio for each firm. Tax-shelter substitutes can be added to the MMIB model. The resulting MMTBS model also produces a unique interior optimum for each firm, but the optimum is a function of the level of the firm's tax-shelter substitutes. Moral hazards also produce an optimal debt ratio. The optimal debt ratio for a firm under MMTBS changes if moral hazard problems exist. The underinvestment problem created by debt and growth opportunities (MII) will be studied. Finally, the Miller general equilibrium model suggests firms adopt various debt ratios, although no optimal debt ratio exists for any firm. The Miller model forms an alternative hypothesis against which the three null hypotheses are tested in Chapters IV and V.

Chapter II reviews previous empirical tests of capital structure hypotheses.
CHAPTER II

REVIEW OF EMPIRICAL LITERATURE
ON CAPITAL STRUCTURE

I. Considerations in Testing Capital Structure Hypotheses

The diverse theories of the determinants of corporate capital structures have spawned a large number of empirical tests. This section reviews the techniques employed in a number of those tests, summarizes the results, and analyzes the significance of the results for the capital structure theories.

From an empirical standpoint, the tests fall fairly neatly into two categories. The first consists of studies which attempt to test whether the data is consistent with a given capital structure theory versus the null hypothesis that the theory can be rejected. In such studies the theory being tested often yields a functional specification. If, in reality, a number of effects combine to determine actual capital structures, however, attempts to test a single theory are misspecified due to omitted variables.

The second category consists of attempts to test the hypothesis that several theoretical determinants are jointly supported by the data. Because the theories to be tested are often developed from very different models, specification of an appropriate structural relationship becomes more difficult. The need to be able to use the results to distinguish precisely between the theories being simultaneously tested makes the empirical design even more critical. Most of the studies to be reviewed fall into this second category.

This review groups the studies primarily according to the types
of theories they test. The first are those which concentrate on the interest tax shield advantage to debt financing. These studies test hypothesized functional relationships between firm borrowing and either firm value or cost of capital. Second are the tests which attempt to identify the factors which reduce the marginal benefits of financial leverage. Third are the studies attempting to verify some of the implications of the theory of agency and conflict between different classes of security holder. Fourth is a test of the general equilibrium, tax-clientele theory of corporate borrowing. Finally, work which studies the adjustment of firm borrowing to the target level of borrowing is reviewed.

II. Cost of Capital, Value, and Borrowing

Early studies. These studies focus on determining the slope of the relationship between the return on equity and the debt-equity ratio. The reported results are conflicting. Two studies\(^1\) report mildly negative dependence of the return on equity on the debt-equity ratio. Beranek (1965) finds evidence that the equity rate first rises, then falls. Barges (1963) finds evidence that the firm's capitalization rate is a U-shaped function of leverage. He interprets his results as support for the traditional view. Finally, if the widely divergent results were not enough cause for lack of confidence in these studies, Carleton and Silberman (1977) suggest that expected return and degree of financial leverage are both functions of earnings variability. The early studies, then, may be subject to bias due to the omission of the earnings variability and to the failure to acknowledge the simultaneous nature of

\(^1\)See Arditti (1965) and White (1963).
the determination of the level of borrowing and the equity rate of return.

**Value-based studies.** Miller and Modigliani (1966) use a different methodology in an attempt to control for previous empirical problems. In testing their hypothesis about corporate valuation, they derive a specific structural equation for firm value. The hypothesized determinants of firm value are (1) the capitalized value of the perpetual stream of expected, current, tax-adjusted earnings, (2) the present value of future growth opportunities, and (3) the present value of the interest tax shields realized by maintaining the current level of borrowing.

In their cross section of 63 electric utilities, MM employ an instrumental variables approach in an attempt to reduce the errors-in-variables problem stemming from the inability to measure expected earnings. In the first stage they regress actual earnings on the instruments. The latter include the levels of debt and preferred stock, common stock dividends, asset growth rate, and level of total assets. The first three instruments proxy for the earnings components flowing to each class of security.

For the growth variable in the second-stage regression, MM derive an expression for the present value of growth opportunities assuming constant reinvestment rate and profitability and assuming that the availability of new growth opportunities expires after a given number of years. In their regression equation the historical asset growth rate proxies for the magnitude of investment opportunities. MM suggest that the coefficient on the growth variable subsumes the profitability and time horizon effects.
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For the growth variable in the second-stage regression, MM derive an expression for the present value of growth opportunities assuming constant reinvestment rate and profitability and assuming that the availability of new growth opportunities expires after a given number of years. In their regression equation the historical asset growth rate proxies for the magnitude of investment opportunities. MM suggest that the coefficient on the growth variable subsumes the profitability and time horizon effects.
To capture the value of the interest tax shield, MM include as an explanatory variable the product of the corporate tax rate and the firm's outstanding debt obligations. This follows from the simplifying assumption that the firm will pay the same level of interest to perpetuity. Rather than include the value of the tax shield as an independent variable, MM in effect constrain its coefficient to unity by subtracting it from the firm's market value, the dependent variable.

The results of the test support the MM valuation model. The coefficient on the earnings variable is an estimate of the reciprocal of the equity cost of capital for tax-adjusted earnings. The derived cost of capital estimates for the years included in the study (1954, 1956, and 1957) are centered around 0.06. The growth variable's coefficient is positive, indicating its contribution to the value of the firm's securities. Finally, inclusion of a constant and a firm size variable produce some evidence that the marginal capitalization rate for each additional dollar of earnings falls and that, ceteris paribus, firms with more assets are valued more highly than those with less.

To test the relationship between debt and value, MM rerun their tests, including the value of the firm's debt as an independent variable. The estimated coefficient does not differ significantly from zero, indicating that the constrained tax shield variable captures the entire effect of firm borrowing.

The MM electric utility study is subject to a number of problems. One general problem derives from the nature of the sample.

That the results are open to question can be seen from the number of comments that followed the publication of the 1966 article. See Brigham and Gordon (1968), Crockett and Friend (1967), Gordon (1967), Higgins (1974), Litzenberger and Kao (1971), McDonald (1971), and Robichak, McDonald, and Higgins (1967), among others.
MM select firms in the electric utility industry in an attempt to control for firm "risk class" differences. Yet, since regulated firms are not subject to the same market forces affecting unregulated firms, these results may not be general. To make matters worse, Boness and Frankfurter (1977) question MM's assumption that the sample firms are, in fact, homogeneous with respect to risk. Using a random coefficients, time-series-cross-section technique on a subset of the MM sample, Boness and Frankfurter are able to reject the hypothesis that the set of coefficients is the same for all firms.\(^3\) In addition to the homogeneous risk class assumption, it is difficult to imagine that the variables collected into the growth coefficient are identical for all firms, as MM assume.\(^4\)

The behavior of the estimates for different years raises questions about the specification. For the three years reported by MM there is some variation in the estimated coefficients. Robichek, McDonald, and Higgins (1967) reestimate the equation for each year 1954-1964. They find that the earnings coefficient rises to a level in 1961 that implies an unreasonably low cost of equity. The $R^2$ changes significantly between years.

For the purposes of the present study it is important to note that the firms in the MM sample span a small range of debt ratios.\(^5\)

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\(^3\) Boness and Frankfurter use ordinary least squares, rather than the two-stage technique of MM, so their results are not directly comparable.

\(^4\) Another explanation for their results, not mentioned by Boness and Frankfurter, is the inconsistent behavior of the MM equation's estimates through time. See the discussion of the results of Robichek et al. below.

\(^5\) The means and standard deviations (in parentheses) of the ratios of debt to total firm value are .504(.051), .488(.049), and .548(.050), respectively. (MM (1966) p. 388)
Without much variation in debt ratios the power of a test of the effect of the debt ratio on value is likely to be low.

To determine whether the returns to the firm from issuing debt diminish due to expected bankruptcy costs, Bower, Bower, and Oldfield (1977) utilize the Oldfield (1976) contingent claims model of equity valuation. Recall that Oldfield assumes that bankruptcy is declared, and the costs paid out of firm value, when the value of the firm falls below the face value of the outstanding debt. Thus the variance rate of the value of the assets of the firm is an argument of the value of the equity of the levered firm.

Bower, Bower, and Oldfield perform two tests. First, the authors attempt to determine whether firms' capital structures are related to expected bankruptcy costs through the volatilities of their assets. For a cross section of 129 firms they regress a five-year average of the market ratio of equity to total assets on a constant, the standard deviation of the annual rate of change of the asset value, and industry dummy variables. Bower et al. find a positive relationship between the equity ratio and the asset variance rate and interpret the finding as support for a bankruptcy cost effect. Note that this conclusion does not directly conflict with MM, who predict that firm value is equal to the unlevered value of the assets plus a linear function of the level of borrowing. One should not put too much faith in the estimated relationship with the standard deviation, anyway, since, with the latter being the only firm-specific independent variable, the estimates are likely to suffer from misspecification bias.

In their second test Bower et al. indirectly test the MM hypothesis that the level of borrowing contributes linearly to firm value.
Call this the null hypothesis. Hamada (1972) shows that, using the relationship between levered value $V$, unlevered value $V_u$, and perpetual debt $B$, $V_u = V - \tau B$, the firm's equity $V_u$ beta can be written as a function of its asset beta: $\beta = \frac{V_u}{S} \beta_u$. If the marginal effect of debt does not change over the range of borrowing, then the Hamada relationship should hold for all $\frac{V_u}{S}$. Bower, et al. run the following regression equation on their cross section: 

$$[\beta_u \frac{V_u}{S} - \beta] = a_0 + a_1 \frac{V_u}{S} + e.$$ 

If $V$ is a concave function of $B$, then for high $B$, $\frac{V_u}{S} = \frac{V - \tau B}{S}$ will be biased downward. The LHS of the regression equation assumes negative values when $B$ (hence, $\frac{V_u}{S}$) is high. This makes $a_1 < 0$. The null hypothesis is accepted if and only if $a_0 = 0$ and $a_1 = 0$.

Bower, et al. do find a small but statistically significant negative coefficient on $\frac{V_u}{S}$. The independent variable explains only six percent of the variance of the dependent variable. Under the alternative hypothesis the equation suffers from errors-in-variables bias. The error in measuring $\frac{V_u}{S}$ biases $a_1$ downward in absolute value, raising the probability of a type II error. The dependent variable also suffers a measurement error under the alternative hypothesis. This error leads to a negative correlation between the error term and the independent variable. The effect is to bias $a_1$ downward algebraically. \(^6\) This raises the probability of a type I

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\(^6\)Let the general regression model be given by

$$y = X\beta + e$$

where $y$, $X$, $\beta$, and $e$ are matrices. The OLS estimator of is

$$\hat{\beta} = \hat{\beta} + (X'X)^{-1}X'e.$$ 

Taking probability limits gives

$$\text{plim} \hat{\beta} = \beta + \text{plim}(\frac{1}{n} X'X)^{-1} \text{plim}(\frac{1}{n} X'e)$$

By the usual assumptions $(X'X)$ converges to a positive definite matrix. Since in this problem $\text{plim}(\frac{1}{n} X'e) < 0$, \(\text{plim} \hat{\beta} < \beta.\)
error. The conflicting errors make interpretation of the results very
difficult, although they are suggestive that highly leveraged firms are
not valued in the same way as others.

III. Debt Ratios and Firm Operating Characteristics

A large body of research examines the empirical relationships
between debt ratios and firm characteristics which reduce borrowing
incentives. They seek to determine what, if anything, causes a deviation
from the linear relationship $V = V_u + \tau B$ at higher levels of $B$. Unlike
the studies in the previous section, these do not examine the functional
relationship between $V$ and $B$. Instead, they (usually tacitly) assume
that a firm on average sets its actual level of borrowing equal to a
target level $B^*$ which maximizes $V$. Thus they attempt to relate $B^*$ to
operating characteristics in order to discover the sources of the devia-
tion of $\frac{B^*}{V^*}$ from one. Since $B^*$ and $V^*$ are not directly observable, an
actual debt ratio is used under the assumption that it is an unbiased, if
noisy, measure of the target ratio.

This section covers two types of tests. The first type is a
cross-sectional model in which the hypothesized relationship between the
level of the debt ratio and its determinants is tested. The preceding
comments about target and actual levels apply directly here. The second
type of test consists of a probability model. The probability of
issuance of a given class of security, conditional on the issuance of any
type of security, is related to the target debt ratio and the size of the
firm's existing deviation from the target. Most of these studies don't
address the target ratio explicitly.
Tests based on debt ratios. The work of Schwartz and Aronson (1967) forms the basis for several early studies. In the studies the various authors try to determine whether book debt ratios differ significantly across industries. The use of industry as the sole independent variable is rationalized by Scott (1972, p. 46): "First, the financial structures of firms are influenced by the basic business risk to which the firms are exposed. Second, different degrees of business risk can be approximated by different industry groupings." Using analysis of variance techniques on their samples, both Schwartz and Aronson and Scott find evidence that the mean debt ratios of industries differ significantly. Scott and Martin (1975) provide further support. Using an analysis of covariance technique, they find that firm size is positively related to the firm's debt ratio but that, even after removing the size effect, the industry effect remains. ⁷

Ferri and Jones (1979), using a novel cluster analysis technique, test industry, size, and direct measures of business risk and operating leverage. They use a statistical clustering algorithm to partition the 233 firms in their sample into groups such that the within-group financial structures are most similar and the between group structures are most dissimilar. They then determine the degree to which each of the independent variables provides information allowing one to predict to which leverage group each firm belongs. The tests are run on the same set of firms using book data from 1974 and 1976.

The Ferri-Jones results differ substantially from those of most other studies. Industry is very weakly related to leverage group, with

⁷Contrary evidence on the industry effect is produced using international data by Remmers, Stonehill, Wright, and Beekhuisen (1974).
nearly all of the association due to one particular industry's lack of debt financing. Size is nearly unrelated to leverage class. There is practically no systematic association between operating cash flow volatility and leverage group. They find a strong, negative dependence of borrowing on operating leverage as measured by the proportion of a firm's assets represented by fixed assets.

Finally, Martin, Petty, and Scott (1979) attempt to simultaneously test three theories of capital structure: (1) the bankruptcy cost-tax shield theory, (2) the tax clientele theory, and (3) the moral hazard theory. They construct variables which they claim proxy for the effects limiting borrowing under the respective theories. The variables are as follows: For (1), (a) the ratio of operating income before depreciation minus fixed finance charges to the standard deviation of the time series of that quantity, and (b) the ratio of net working capital to total assets. For (2), the dividend payout ratio. For (3), (a) the ratio of plant and equipment to total assets (a measure of capital intensity), (b) the ratio of earnings before interest and taxes to total assets (a measure of profitability), and (c) the average of the rates of growth of total assets and operating income.

Martin et al. choose to examine simultaneously the relationship of the six explanatory variables to two measures of leverage, the ratios of finance charges to total assets and common equity to total assets.

8The authors' reasoning appears to be as follows: In the tax clientele model the present value of the interest tax shield is inversely related to the ratio (1−τ_p) / (1−τ_e), where τ_e and τ_p are the personal tax rates on returns from stock and bonds, respectively. By raising τ_p by paying out a larger share of the equity return in the form of dividends, a firm can raise the after-tax value of the interest tax shield on each dollar of debt.
Using the technique of canonical analysis, they find statistically significant relationships between the dependent variables and the net working capital, plant and equipment, and EBIT ratios. Industry appears to add no information. Unfortunately, their technique does not yield interpretable information on the magnitudes or directions of these relationships.

Although the results seem to lend some support for the bankruptcy cost and moral hazard theories, their proxy variables could be picking up effects other than the intended ones. The net working capital ratio may pick up size effects. In the economic order quantity model for inventory control, net working capital relates to the square root of total assets. Thus the ratio should be inversely related to size. The plant and equipment ratio is not a good proxy for the value of growth opportunities since the book value of total assets in the denominator does not adequately include the value of those opportunities. Finally, it is not clear that historical growth rates are adequate proxies for the value of future, profitable growth opportunities requiring discretionary outlays.

Tests based on securities issues. A number of studies using a variety of econometric techniques seek to explain the class of security issued, given that securities are issued. Some of these studies are "kitchen sink" models where every conceivable explanatory variable is

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9 There is evidence (see Taggart (1977) and discussion below) that firms initially meet long-term financing requirements by drawing down their working capital. When securities are eventually issued, the actual target may be overshot (due to fixed issue costs and an expectation of a rise in the target level) with the unneeded funds going into the working capital account. If this is true with debt issues, one should expect that many firms with relatively large working capital balances will also be above their long-term debt targets.
included. (Baxter and Cragg (1970) used approximately 90 variables.)

Martin and Scott's (1974) study is unique in employing discriminant analysis. Using a sample of 58 firms issuing either straight debt or common stock, they measure the ability of 23 independent variables to discriminate between the two classes of issues. The variables fall into categories measuring (1) leverage, (2) liquidity, (3) profitability, (4) dividend policy, (5) stock price, (6) firm size, and (7) sales growth and variability. The six specific variables they find to jointly have the most power (with the direction of influence on the probability of a debt issue in parentheses) are total assets (+), price earnings ratio (-), current-to-total asset ratio relative to industry mean (-), dividend payout ratio (+), cash flow to net worth relative to industry mean (-), and total debt to total assets (-).

The authors interpret the results in specific terms without relating them to any formal theories. They claim that large firms tend to issue debt. A firm whose stock price is "high" (indicated by the P/E ratio) and one which already has considerable debt in its capital structure is likely to issue equity. The authors admit they have no priors on the association with the dividend payout.\textsuperscript{10} The direction of the profitability and liquidity effects is opposite to that expected by the authors.\textsuperscript{11} Without a theory to be tested one does not know whether

\textsuperscript{10} Martin and Scott (1974) p. 73.

\textsuperscript{11} They try to explain the negative sign on the current asset ratio by suggesting that firms with high net working capital balances may have low operating leverage, implying a low level of fixed and total assets. If they compensate for their low operating leverage by employing higher financial leverage, then their debt ratios will be high, and they will be inclined to issue equity. This reasoning is difficult to follow. If such firms desire high financial leverage, they should be no more likely to issue equity than a firm desiring a lower level of financial leverage, ceteris paribus.
the relationships are peculiar to this sample or are representative of certain causal relationships. Martin and Scott claim that because the statistical relationships in the sample are significant their model should have predictive power. This is by no means proven. Finally, they arbitrarily select six for the number of discriminators. No explanation is given for the exclusion of other variables, especially a growth term which they report as having considerable discriminatory power.

Like several other studies\textsuperscript{12} that by Marsh (1979) uses logit and probit analysis to determine the magnitudes and directions of the effects of a number of factors on the probability of a firm issuing equity, given it issues either equity or debt. His hypothesis and test is more carefully constructed than those of similar studies. Marsh delineates three general factors which should affect the conditional probability of an equity issue. First are the deviations of the firm's long- and short-term debt ratios from their historical averages. Second are factors which may affect the target long-term debt ratio, changing it from its historical value. Size measured by total book assets, asset composition, measured by the ratio of fixed to total assets, and bankruptcy risk, measured by the ratio of fixed charges minus EBIT to the standard deviation of the time series of the variable, are the factors tested under the debt target hypothesis. Third are variables which attempt to capture debt and equity market conditions under the hypothesis that firms tend to issue a given type of security when market conditions "favor" that type. The variables measuring this effect are the difference between the firm's recent stock return and the market return, the

\textsuperscript{12} Baxter and Cragg (1970) and Taub (1975).
aggregate level of equity issues forecast from an autoregressive model, and the aggregate level of debt issues forecast in an analogous manner.

Marsh's results, using data on British firms, are strong both for his complete sample and for two subsamples. The coefficients on all variables are of the expected signs and statistically significant. Equity issue is more likely in small, risky firms with low fixed asset ratios.\textsuperscript{13}

\textbf{Review of cross-section debt ratio and issues tests.} Table II-1 summarizes the findings of the studies reviewed in this section. Two factors are consistently shown to be related to financing policy. Firm size is positively correlated with debt financing. Most studies attribute this finding to the comparative ease of access to public debt markets enjoyed by large firms. Since most of the studies used samples consisting of N.Y.S.E. firms, it is surprising that the effect should be pronounced. There is also strong evidence that the firms favoring equity financing are those having high P/E ratios and those whose stock prices are high by historical standards. This is surprising for two reasons. First, since stock is a levered security, if the firm's asset value has risen, the percentage rise of the value of the firm's stock is greater than the increase in the value of its debt. Thus, if the firm was initially at its target debt ratio, after the increase it will be below, and it should issue \textit{debt}. Second, the correlation between P/E and recent

\textsuperscript{13}Marsh (p. 3) states that finding long-term debt financing associated with a high proportion of fixed assets is consistent with the MH theory because the maturity of the assets and liabilities is matched. It is also consistent because the theory shows that the disincentives to debt financing are reduced if the firm's assets do not require a high level of future discretionary expenditures.
price performance is not likely to be strong, since it is due primarily to selection bias. Instead, it is likely that P/E proxies for the growth character of the firm. The MH theory predicts that a high level of growth opportunities is related to equity financing.

There is weaker evidence on the importance of several other variables. Support for the bankruptcy cost theory comes from the negative association between earnings variability and debt financing found in three studies. That firms with highly profitable assets use equity financing is consistent with the MH idea. This result is entirely incompatible with the intuition presented in the works cited. Finally, as suggested earlier, the net working capital ratio may be a proxy for a size variable.

IV. **Measurement of Dynamic Effects of Capital Structure Changes**

This section reviews studies of the effects of capital structure changes on security holders. Most of the effects recently studied are the results of agency problems and produce agency costs borne by the owners. From the measured effects one can work backward to deduce a financing strategy which, given the firm's operating characteristics, is optimal for its owners. One can then ask how changes in the operating characteristics affect agency and other financing costs and the optimal financing strategy.

The incentives for the equity holders to take an action which transfers wealth from senior security holders to themselves are a positive function of the debt ratio. This is because the potential transfer per dollar of equity is related to firm leverage. The likelihood of such an action by the equity holders raises the cost of unprotected debt.
Thus the incentives for the use of costly covenants and limited debt ratios are increased.

**Effects of bondholder claim dilution.** Smith and Warner (1979) identify senior security claim dilution as an area of security holder conflict. From their analysis of debt covenants restricting, in part, claim dilution opportunities, they conclude that the costs of writing and enforcing the covenants are determinants of firms' debt ratios. Furthermore, since firms agree to costly covenants rather than avoid borrowing, there are advantages to borrowing which combine with the costs of debt covenants to produce an optimal debt ratio for each firm.

Kim, McConnell, and Greenwood (1977) examine a situation in which bondholder claims are diluted by the formation of captive finance subsidiaries by firms. In each of the 24 cases they examine, indenture loopholes enabled the parent firm to sell its receivable to a subsidiary and to guarantee the subsidiary's debt. In effect, the claims of the parent's bondholders became subordinated to those of the subsidiary's bondholders.  

To measure the wealth transfer the authors first apply the two-factor capital asset pricing model to the monthly rates of return on the stocks of their sample firms, using the Fama-MacBeth (1973) technique. The residuals give the firm-specific returns not attributable to the effects of the market or the zero-beta security. The expectation of the residual is zero. The time series of residuals for the 24 firms is arranged in event time such that for each firm month zero is the month in

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14 Although not mentioned by the authors, the equity holders also stand to gain from the additional interest tax shields generated by the new debt.
which its subsidiary was formed. The 24 residuals in each month are averaged. The previous monthly averages are cumulated each month to form a series of cumulative average residuals (CARs). E(CAR) = 0 for all months. The authors find large positive CARs in months -5 to 0, indicating that stockholders in these firms earned unusually large returns in the months immediately preceding the formation of a finance subsidiary. The CAR amounts to about 0.18 by month zero.

Kim et al. analyze the returns on the bonds of these firms in a similar manner. Instead of washing market influences from the bond returns using the two-factor model, they find another bond of similar characteristics to pair with each bond in the sample. They use the difference between the monthly rates of return on the two bonds to measure the firm-specific return of the bond in their sample. As with the stock sample, the authors arrange the differences in event time, then form cumulative average differences (CADs) for the portfolio consisting of the entire sample. They find a large negative CAD (about 0.09) between months -7 and +2.

The evidence of significant wealth redistribution in the event of a finance subsidiary formation suggests some debt covenants are imperfect with respect to the protection they afford bondholders against dilution of their claims. The wealth transfers, when they occur, are large and measurable. The possibility of such a transfer should raise the cost of imperfectly protected debt and reduce the optimal debt ratio.

Kim et al. did not isolate the dilution effect. Some of the measured abnormal returns may be due to other phenomena. The formation of a captive finance subsidiary is essentially a means of debt financing. The consolidated firm's debt ratio rises, as do its assets. Thus one
might reasonably expect both expected bankruptcy costs and the present value of tax shields to rise. Since the firm's assets also rise, the opportunity to shift asset risk presents itself.

Effects of recapitalizations. In his work Masulis (1978 and 1980) controls for investment changes by constructing a sample of 163 recapitalizations and exchange offers. In these events one outstanding class of security is exchanged by the company for another class (either a new class or additional units of a class already outstanding). This represents a capital structure change, but since new funds are not raised by the firm, it does not imply new investment.\textsuperscript{15} Masulis' sample includes exchanges between each pair of securities (debt, preferred, and common stock).

To analyze the effects of capital structure changes, Masulis partitions his sample into events corresponding to each of the three pairs of securities. Take the set of debt-equity exchanges, for example. The stock of firms in this set is collected in an event-time portfolio, where day 0 corresponds to the announcement date of the offer. He then calculates the daily portfolio rates of return. In order to determine whether any of the daily rates are unusually large, Masulis calculates the mean daily portfolio return and its variance during a 60-day comparison period and tests for significant differences from this mean. He finds positive abnormal returns on the junior security when the exchange increases leverage and a negative effect when leverage is reduced. The effect on the senior securities involved is exactly opposite.

\textsuperscript{15}Masulis controls for other investment changes near the date of the offer. See Masulis (1980) p. 151.
In order to get an idea of the relative magnitude of the wealth transfer, interest tax shield, and bankruptcy cost effects, Masulis compares the announcement returns for exchanges between different classes of securities. He argues that in exchanges where preferred stock replaces common, the 0.0334 announcement return to common stockholders should be due entirely to a redistribution from existing holders of preferred to holders of common.\textsuperscript{16} The 0.0463 return to common when debt replaces preferred should be due to a positive tax effect and a negative bankruptcy cost effect. Since the tax effect net of the bankruptcy effect is larger than the redistribution effect, it appears that on average in this sample the tax effect is greater than the redistribution effect.\textsuperscript{17} Furthermore, when the set of events corresponding to exchanges of debt for equity is divided into a set where the debt is protected against issues of equal and senior standing and a set where the covenants do not prohibit senior or equal issues, the negative announcement effect is much greater for the incompletely protected set than for the protected one.

In order to obtain more information on the significance of the hypothesized bankruptcy cost effect, Masulis (1978) isolates the events where firms reduced their leverage. Most of these events correspond to firms in financial distress. The announcement effects of these events are very small. Since both tax and dilution effects should produce negative

\textsuperscript{16} If bankruptcy cost effects are economically significant, part of the return may be due to the interpretation of the announcement as a signal of management's increased earnings expectations.

\textsuperscript{17} Note that this information cannot be deduced by looking directly at debt-for-common exchanges.
shareholder returns, one can deduce that the bankruptcy cost effect must be positive in order for the net return on the stock to be close to zero.

The work by Masulis provides support for theories of tax shield, bankruptcy cost, and potential dilution effects on corporate capital structure. Thus it seems reasonable that firms should consider these factors when determining their financing policies. The evidence on dilution suggests that similar redistribution effects should be present for dividend, asset substitution, and underinvestment situations since all four are facets of the general agency problem.

V. A Test of the Tax Clientele Theory

Tests of the Miller model. Gordon and Malkiel (1981) and Skelton (1980) present evidence on Miller's (1977) tax clientele model. In the model the marginal investor, who is different between holding taxable corporate bonds and tax-free municipals or corporate stock is in a tax bracket $\tau_p$ equal to the corporate tax rate $\tau_c$. Thus in equilibrium the ratio of the yield on a municipal to the pretax yield on an equivalent corporate bond must be equal to $1 - \tau_c$. Gordon and Malkiel find that the tax exempt yield has been approximately 75 percent of the taxable long-term bond yield, implying that no one with $\tau_p > .25$ should pay tax on investment income. They note that since in the Miller model only those for whom $\tau_p > .46$ on investment income purchase equity, no one should purchase equity. While Skelton arrives at a similar figure for the ratio of long-term bond yields, he finds that the ratio is only .54 for one-year bonds. The implied marginal $\tau_p = .46$ is very close to the Miller model's prediction. Skelton's explanation of the ratios does not
support the model, however. His habitat theory argues that institutional restrictions effectively force banks (for whom $r_c = .46$) to dominate the short-term market. If this is true, then one should look at the long-term ratio to test the Miller model.

**Tests of the Miller model with risky securities.** The extension of Miller's model to include risky securities\textsuperscript{18} produces two salient empirical predictions. First, firms should cluster at the high and low ends of the leverage spectrum in order to provide low- and high-bracket investors with the types of equity securities they desire. Second, high-bracket investors should hold the equity of the low-leverage firms, while low-bracket investors should hold the equity of firms in the high-leverage group. Kim, Lewellen, and McConnell (1979) subject both of these implications to testing.

In order to test the first hypothesis, Kim et al. construct a frequency distribution of book debt ratios for 1970 for the 1140 firms in their sample. The distribution is, indeed, mildly bimodal, with the lower mode at zero and the upper one in the 30-35 percent debt range. Most ratios fall in the 20-60 percent range. These results are not strongly supportive of a theory predicting modes at the extremes.

Kim et al. make three attempts to test the clientele effect directly. They divide their company sample into two leverage classes and determine the tax brackets of the investors in each firm's equity.\textsuperscript{19}

\textsuperscript{18}DeAngelo and Masulis (1980b), Kim, Lewellen, and McConnell (1979), and Taggart (1980).

\textsuperscript{19}Investor information is from investor profiles of the customers of a major brokerage firm.
They find that the mean investor tax brackets of the two groups differs by only two percent. The authors divide the firms into leverage deciles and identify the tax brackets of investors in each of the firms. Even with the finer resolution of this test they find little systematic investor tax bracket variation across the deciles. Finally, they analyze information on each investor position in each of the firms. By regressing the firm leverage ratio on the tax bracket of the investor in that position, they do find a significant, negative relationship, but its magnitude is extremely small.

In spite of a very large sample, Kim et al. were able to produce only very weak evidence to support the tax clientele theory. The weak results could be due in part to desertion of the clienteles by investors in search of better diversification. Since the study does not control for other capital structure determinants, it is possible that bankruptcy cost and agency cost considerations deter firms in the upper mode from employing more leverage.

VI. Evidence on the Adjustment of Debt Levels

The theories of corporate capital structure reviewed earlier give optimal target levels for debt, but it may be important for the purposes of empirical testing to know how the adjustment to the target level takes place. One must know the determinants of the size of the adjustment and of its timing. Factors which could be expected to play roles are adjustment costs, costs of being off target, the predictability of the determinants of the target, and the predictability of automatic financing items, especially earnings and dividends. Several empirical studies look at these factors.
A normative model of adjustment. Lev and Pekelman (1975) utilize the theory of optimal control to develop a model of adjustment. The book values of long-term debt and common stock are the state variables. The four control variables are equity issues, long-term debt issues, short-term debt issues, and dividends (they affect retained earnings financing). All cost functions are assumed to be quadratic. Costs are incurred due to deviations from a deterministic debt ratio target, a stochastic new capital requirements target, deterministic dividend target, and due to adjustment costs for the control variables corresponding to securities issues. The quadratic cost assumption leads to a simple solution where the optimal control variables depend on the current state variables, the (constant) cost parameters, and the deterministic path of the debt target. The second and higher moments of the stochastic variables play no role.

Lev and Pekelman test the descriptive power of their model on a sample of 388 firms. Each of their four regression equations tests the dependence of one of the control variables on the two state variables. The equations are run as cross sections on the firms within each industry, implying the assumption that the cost structures and debt target paths are identical for all firms within a given industry. These and the strong assumptions in the simple model probably cause the exceptionally weak results (very low R²) of the tests.

Empirical studies of the adjustment process. Taggart (1974 and 1977) uses aggregate data to test a model of balance sheet adjustment. Assuming that dividend and investment policies are independent of financing, changes in the long-term asset and retained earnings accounts are
exogenous. Permanent capital changes, consisting of long-term debt and equity issues, and temporary capital changes, consisting of short-term debt issues and liquid asset account changes, can be used to finance changes in the long-term asset account not financed automatically by retained earnings. Taggart assumes that the permanent capital target is equal to the level of long-term assets plus a given fraction of working assets. Furthermore, the actual permanent capital level adjusts to the target level according to a partial adjustment process. Temporary capital serves to take up the slack and to finance the fraction of working assets not financed by permanent capital. The changes in permanent capital not financed by retained earnings are made up of changes in the book amounts of bonds and stock outstanding. The book debt target is the level needed to keep the market debt-equity ratio at the constant, target level.

Taggart fits the model to 62 quarters of aggregate data for non-financial corporations. He finds that long-term external financing needs due to asset acquisition are met by slow adjustment through debt and equity issues, with the slack being taken up by the short-term items. The higher are interest rates, the slower is the adjustment, and more of the slack is likely to be absorbed by drawing down the liquid asset account. Changes in the book debt-equity target resulting from changes in the market value of the stock prompt very slow rebalancing response. Taggart finds that market and book target ratios have roughly equivalent power in the model. He does find evidence that stock issues are more likely to be used than debt issues to meet a rising permanent capital target in times of rising stock prices.

Several important points are brought out by the Taggart papers.
First, the adjustment of long-term financing sources to their target levels is quite slow. Second, because of the slow adjustment, short-term debt and liquid assets should be considered a financing source (albeit temporary) for fixed assets. Finally, as in other studies, this one finds that firms tend to move away from debt targets when equity prices change. Imagine a firm initially at its target debt-equity ratio. If its equity price rises, its debt-equity ratio will fall below target. It would seem the firm should retire equity and issue debt. Yet Taggart finds the opposite behavior. The true effect is even stronger than Taggart's results indicate. In calculating the debt-equity ratio Taggart uses the average equity price over the previous 12 quarters. Thus his ratio does not reflect the true magnitude of the rebalancing incentive to issue debt in a rising equity market.

Finally, Taggart's results are supported by Ang (1976), using time series data on individual firms. Ang models the target as a constant fraction of the firm's book assets and finds slow adjustment to the target.

VII. A Summing Up

Support for some theories. This review uncovers fairly strong empirical support for several hypotheses. Although I know of no direct empirical support for the view that taxes help determine firms' debt ratios, MM and Masulis provide indirect evidence by showing that interest tax shields do have a positive effect on firm value.

There is evidence that bankruptcy costs play a role in limiting corporate leverage. Several studies show that the riskiness of the firm's income flow is negatively related to leverage measures. Masulis presents
evidence that capital structure changes affect the present value of bankruptcy costs.

Finally, studies support the hypothesis that agency costs are related to capital structure. Reasoning that firms attempt to control such costs leads to two predictions. First, firms limit the amount of debt financing they use, in order to reduce the size of potential wealth transfers and the incentive to effect them. Second, firms submit themselves to costly indenture arrangements.

**Empirical loose ends.** Several empirical results are difficult to explain satisfactorily without resorting to an agency argument. For example, there is a mass of evidence indicating that firms with high P/Es or whose stock prices have recently risen are more likely to issue equity and to have low debt ratios than other firms. This conflicts with the idea of a reasonably constant target debt ratio. It may imply that firms consider their market timing ability good enough to outweigh the costs of being off target.20 In a market where investors are rational, however, the announcement of an issue depresses the security price if the investors believe the issuer has superior timing ability. The result is an approximately zero-sum game where the issuer earns no extraordinary returns by timing issues. An alternative to the timing explanation can be offered, however. If P/E is positively related to valuable growth opportunities and if stock price increases reflect, in part, revaluations of these growth opportunities, then the empirical results may be the

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20 The P/E effect might be explained if the owners wish to maintain tight control. In order to raise a given amount of money the managers of high P/E firms may not need to issue as many shares as their counterparts in other firms.
manifestations of a rise in the level of growth opportunities. This worsens the moral hazard problem and provides an incentive for a reduction of the target ratio.

There is some evidence that firms with high working capital ratios are more likely to issue stock than other firms. If the working capital ratio is negatively related to the present value of bankruptcy costs, then the empirical result does not support the bankruptcy cost theory. If, instead, one thinks of working capital as assets which can easily be transformed into assets of greater risk, the theory of agency provides a motivation for equity financing.

It appears that highly profitable firms are biased toward equity financing. This runs counter to the "intuitive" idea that the high profits encourage the commitment to a high debt service level. If, however, future discretionary investment is required to defend existing opportunities and to develop new ones, then an underinvestment problem encourages the use of equity rather than debt in order to minimize agency costs.

Finally, high dividend payout ratios may be associated with firms using debt financing. The high payout may be associated with the absence of significant growth opportunities demanding internal financing. Without a high level of discretionary investment, one of the incentives for limiting debt financing is absent.
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The symbols +, 0, - indicate the correlation of the variable with the debt ratio or the probability of issuing debt. X indicates an association without specification of direction.
CHAPTER III

IMPLICATIONS OF SEVERAL CAPITAL STRUCTURE MODELS

This chapter examines three theories of corporate capital structure to demonstrate which variables affect firm borrowing. The first is the Modigliani-Miller theory with corporate taxes and bankruptcy costs, or costs of financial distress. The pure MM (1958) theory is not relevant by itself since it ignores the corporate income tax. It is difficult to construct a test of the MM theory as the null hypothesis because the theory does not suggest any relationships between borrowing and any firm-specific characteristics. Instead, it can be an alternative hypothesis against which various null hypotheses, specifying relationships between borrowing and other variables, may be tested. The addition of the corporate income tax to the MM model results in the prediction that all firms maximize financial leverage.\(^1\) This MM-tax model must be looked upon as a "straw man," since even casual empiricism reveals that few firms have debt ratios approaching one. Finally, the inclusion of bankruptcy costs does yield a model whose predictions seem realistic; the rising present value of expected bankruptcy costs provides a limit to the financial advantages of borrowing. The MM-tax-bankruptcy cost (MMTB) model is the first hypothesis to be tested.

The second hypothesis is the MMTB model with the provision of additional tax shields from depreciation, depletion, and the investment

\(^1\)In addition to the factors limiting the optimal level of borrowing discussed below, the I.R.S. will disallow the deduction of interest expenses for firms which are so highly levered that the I.R.S. considers the debt to be equity in disguise. Such a ruling is most likely in a case in which the holders of the equity claims also own a substantial amount of the firm's debt.
tax credit. This model is denoted by MMTBS. An earlier chapter showed that these tax shields provide a limit to the benefits from borrowing in addition to the limit imposed by bankruptcy costs. The relevant trade-off is the tax shields provided by debt and other tax shelters against the present value of the expected bankruptcy costs.

Finally, the last section examines the moral hazard theory (MH) to determine whether the predictions of the MMTBS model change when the MH theory is imposed.

I. The Modigliani-Miller Theory With Taxes and Bankruptcy Costs

This section uses a two-period model to examine the implications of the MMT3 theory. While it cannot be an accurate representation of the continuous-time world, the two-period model is useful to examine the model's qualitative predictions.

In the pure MM model the level of debt is indeterminate. With the corporate income tax, however, debt provides a tax shield, which is an incentive for a positive amount of borrowing. Thus under MMTB one should observe a positive relationship between debt and total assets in a cross section.

The model. A two-period model illustrates the dependence of the expected tax shield on borrowing. Let X be the value of the firm next period (t+1), at which time the firm will liquidate. X is a random variable. The level of borrowing at t results in a liability of B which must be paid at t+1. Assume for simplicity that all of B is deductible for tax purposes as long as X>B. For X<B the firm pays no tax. X is distributed lognormally with E(logX)=μ and Var(logX)=σ^2. The distribution makes more sense than the normal distribution because
security holders' limited liability precludes negative values of X. 

Firm value next period and μ are functions only of the rate of return on the firm's present assets. In a multiperiod framework they are also related to investment between the beginning and end points. The expected tax shield is the sum of two terms. The first is the tax shield realized when X falls between zero and B. The firm can shelter all its earnings with B. Thus the shield is equal to τX, where τ is the corporate tax rate. The bondholders get all of X in this case. For X>B the entire $B shelter is utilized, the shield being τB. The expected tax shield is given by²,³

\[ E(TS) = \tau \int \frac{1}{\sqrt{2\pi}} e^{\frac{1}{2\sigma^2} \left( \log X - \mu \right)^2} \sigma X + \tau B \frac{1}{\sqrt{2\pi}} e^{\frac{1}{2\sigma^2} \left( \log X - \mu \right)^2} dX. \]  

(1)

To make the expressions below more tractable, let \( Z = \log(X) - \mu \). This changes the lognormally distributed variable X to the normally distributed variable Z.

\[ E(TS) = \tau \int \frac{1}{\sqrt{2\pi}} e^{\frac{1}{2\sigma^2} \left( Z - \mu \right)^2} \sigma Z + \tau B \frac{1}{\sqrt{2\pi}} e^{\frac{1}{2\sigma^2} \left( Z - \mu \right)^2} dZ. \]  

(1a)

²To simplify the exposition I will work with the expected tax shield and bankruptcy cost, rather than their present values. Later, I shall discuss the capitalization rates to be applied to the expected tax shield and bankruptcy cost.

³Two alternative tax shield assumptions for X<B are (a) the firm loses all tax shields, and (b) the firm retains the value of all tax shields. In case (a) the derivative in equation (2) is smaller than shown in the text, with the largest change occurring where \( \log(B) = \mu \). This reduces the optimal level of B. In case (b) \( E(TS) = \tau B \). The optimal level of B is greater than in the case shown in the text. A corner solution (all debt) obtains in case (b) if the slope of the bankruptcy cost function (described below) is sufficiently low.

The results of the model remain essentially unchanged if X is defined as the random level of earnings from which tax deductible interest payments τB are made. Three different tax shield regions result. For X<0 the shield is zero; for 0<X<τB the shield equals X; and for X≥τB the shield equals τB.
The derivative of \( E(TS) \) shows the relationship between \( E(TS) \) and \( B \):

\[
\frac{dE(TS)}{dB} = \tau \int_{-\infty}^{\log(B) - \mu} \phi(z) \, dz,
\]

where \( \phi(z) \) is the normal density function for \( z \) distributed as \( N(0, \sigma^2) \). Equation (2) is just the tax rate times \( \text{Prob}(Z > \log(B) - \mu) \), or \( \tau \) times \( \text{Prob}(X > B) \). Thus the derivative is positive. The second derivative is negative:

\[
\frac{d^2E(TS)}{dB^2} = -\frac{1}{B} \tau \phi\left(\log(B) - \mu\right)^2.
\]

The exponential, hence the second derivative, approaches zero as \( B \) approaches zero and as \( B \) becomes very large relative to \( \mu \). The \( E(TS) \) function takes on the shape illustrated in Figure III-1 below.

According to the MMNB theory positive bankruptcy costs induce firms to limit borrowing. A firm substitutes debt for equity financing until the present value of the marginal expected tax shield from a further increment to debt equals the marginal increment in the expected bankruptcy cost's present value. The optimal financing mix occurs where the present values of the marginal expected tax shield and bankruptcy cost are equal.

As in the Kim model (1978), the expected bankruptcy cost can be written as \( \bar{b}^*(BC|b=1) \). The bankruptcy operator, \( b \), is one if \( X < B \) and zero otherwise. The expected value is \( \bar{b} \). The bankruptcy cost, \( BC \), is a function of the magnitude of the claims against the firm and the complexity of its capital structure. The capital structure is determined prior to bankruptcy. Since larger firms generally have more complex
capital structures, it is reasonable to assume that firms with high values at \( t \) will incur higher bankruptcy costs if they go bankrupt at \( t+1 \). The previous chapter noted some empirical evidence that the realized bankruptcy cost is a positive, concave function of prior firm value because of economies of scale in reorganization and liquidation.

The expected value of the bankruptcy operator is

\[
\bar{b} = \int_0^B \frac{1}{\sqrt{2\pi}\sigma} \exp \left[ -\frac{1}{2\sigma^2} \left( \log(y(x)) - \mu \right)^2 \right] dX.
\] (4)

Using the change of variables applied earlier converts the density function to a normal, \( N(0,\sigma^2) \):

\[
\bar{b} = \int_{-\infty}^{\log(b)} \frac{1}{\sqrt{2\pi}\sigma} \exp \left[ -\frac{1}{2\sigma^2} z^2 \right] dz.
\] (4a)

The derivative of \( E(BC) = \bar{b} \cdot (BC|b=1) \) gives the marginal expected bankruptcy cost, which can be set equal to the expression in equation (2) to find the optimal point:

\[
\frac{dE(BC)}{dB} = BC \cdot \frac{1}{B} \cdot \bar{b} \left[ \log(B) - \mu \right].
\] (5)

The derivative is positive, indicating that additional borrowing always raises the probability of bankruptcy and the expected bankruptcy cost.

The second derivative reveals the shape of the function:

\[
\frac{d^2E(BC)}{dB^2} = -BC \cdot \frac{1}{B^2} \left[ \log(B)^2 - \mu^2 \right] \cdot \frac{1}{\sigma^2} \left[ \log(B) - \mu \right].
\] (6)

The second derivative is positive for \( B < \exp(\mu - \sigma^2) \) and negative for \( B > \exp(\mu - \sigma^2) \). The inflection point occurs where \( B = E(X) \).

\[ \text{With } X \text{ distributed lognormally, } E(X) = \exp\left(\mu + \frac{1}{2}\sigma^2\right) \text{ and } \text{Var}(X) = (\exp(\sigma^2) - 1)\exp(2\mu + \sigma^2). \text{ At the inflection point } B = \exp(\mu - \sigma^2). \text{ This is equivalent to } B = E(X) \cdot \exp\left(-\frac{3}{2}\sigma^2\right). \]
Figure III-1: Tax Shield and Bankruptcy Cost Curves

Figure III-2: Shifts of Tax Shield and Bankruptcy Cost Curves, Raising $B^*$

Figure III-3: Shifts of Tax Shield and Bankruptcy Cost Curves, Reducing $B^*$
Figure III-1 above illustrates the determination of the optimal level of borrowing B*. As B approaches zero, $\frac{dE(BC)}{dB}$ goes to zero while $\frac{dE(TS)}{dB}$ is positive. The initially positive $\frac{d^2E(BC)}{dB^2}$ and the negative $\frac{d^2E(TS)}{dB^2}$ allow the slope of the E(BC) curve to "catch up" to the E(TS) curve's slope, yielding the optimum. B* occurs below the inflection point of the E(BC) curve. Imagine that $\frac{dE(TS)}{dB} > \frac{dE(BC)}{dB}$ for all B below and at the inflection point. Since as B goes to infinity both slopes approach zero from above, the smoothness properties of the second derivatives prevent the slopes from being equal anywhere to the right of the inflection point.

The determination of B* is similar to the Scott (1976) and Kim (1978) models. Scott uses a multiperiod model where bankruptcy costs are introduced by assuming the firm's assets are liquidated at less than market value if bankruptcy occurs. He maximizes firm value by adjusting borrowing. Kim uses a two-period model and the mean-variance CAPM to price risky cash flows. With positive bankruptcy costsKim demonstrates (1) that the market may limit firm borrowing (set debt capacity) to less than 100 percent, and (2) that the firm value maximizing level of borrowing is below the market imposed debt capacity. The model of this chapter shows that to produce the interior optimal debt ratio results of Scott and Kim it is unnecessary to use a complicated multiperiod model or a specific asset pricing model.

The effects of $\mu$ and $\sigma$ on B*. In the NMTB theory the expected firm value at t+1 and the variability of that value affect B*. Since it is determined by the equality of $\frac{dE(TS)}{dB}$ and $\frac{dE(BC)}{dB}$, B* shifts when the slopes change. The derivatives of the slopes with respect to $\mu$ and
σ are consequently of interest.

The differential of the slope of the E(TS) curve is

\[
d\left( \frac{dE(TS)}{dB} \right) = \int \phi(z)dz \int d\mu + \tau \int \frac{1}{\sigma} \int \int \phi(z)dz \int d\mu.
\]

(7)

For \( du > 0 \) and \( d\sigma = 0 \), the slope at each level of B rises, as in Figure III-2. This moves B* further to the right. For \( d\sigma > 0 \) and \( du = 0 \), the slope at each level of B below B=exp(μ) falls, moving B* to the left (Figure III-3).\(^5\)

Since X is assumed distributed lognormally, the parameters of the distribution of X are \( E(X) = \exp(\mu + 1/2\sigma^2) \) and \( \text{Var}(X) = \{\exp(\sigma^2) - 1\} \{\exp(2\mu + \sigma^2)\} \). Thus each of the changes in \( \mu \) and \( \sigma \) analyzed above is actually a change in both parameters of the distribution of X. In analyzing the \( du \) effect in equation (7), \( d\sigma \) must be set such that \( d\{\text{Var}(X)\}/du = 0 \):

\[
\frac{d\sigma}{du} \bigg|_{\frac{d\{\text{Var}(X)\}}{du} = 0} = \frac{1 - \exp(\sigma^2)}{\sigma^2 \exp(\sigma^2) - 1}.
\]

Similarly, when analyzing the effects of \( d\sigma \), \( E(X) \) cannot be permitted to change:

\[
\frac{d\mu}{d\sigma} \bigg|_{\frac{dE(X)}{d\sigma} = 0} = -\sigma < 0.
\]

\(^5\)For \( B < \exp(\mu) \) the second term in equation (7) becomes

\[
\tau \frac{1}{\sigma} \left[ \frac{1}{2} \int z^2 \phi(z)dz + \int \int \phi(z)dz \right] d\sigma.
\]

From the properties of the normal distribution \( \frac{1}{\sigma} \int z^2 \phi(z)dz < \int \phi(z)dz \). Thus the term is negative.
The effect of a change in E(X), shown by dividing (7) by dμ and substituting for $\frac{d\sigma}{d\mu}$ is to raise the slope of the E(TS) curve for $B < \exp(\mu)$ and to raise $B^*$. An increase in Var(X), shown by dividing (7) by dσ and substituting for $\frac{d\mu}{d\sigma}$, reduces the slope and $B^*$.

μ and σ also influence $B^*$ through the slope of the E(BC) curve.

The differential of the slope is

$$d \left( \frac{dE(BC)}{dB} \right) = -\frac{1}{8} \left\{ l_2(\log(B) - \mu) \right\} \cdot \left\{ l_3(\log(B) - \mu) \right\} d\lambda - \frac{1}{8} \left[ -\frac{1}{c_1} \left\{ l_3(\log(B) - \mu) \right\} \cdot \frac{d\lambda}{\sigma} \right\} \left\{ l_2(\log(B) - \mu) \right\} d\sigma. \quad (8)$$

The pure dμ effect, setting dσ = 0, unambiguously raises $B^*$ by reducing the slope of the E(BC) curve left of the inflection point (Figure III-2). Since the dμ effect on the E(TS) curve also moves $B^*$ to the right, the total effect, dB*/dμ, is positive. Dividing (8) by dμ and substituting for dσ/dμ shows the effect of changing E(X) while holding Var(X) constant. The factor multiplying dσ in (8) is nonpositive for log(B) $\mu < \sigma$, of which the interval from $-\infty$ to the inflection point is a subset. Thus the slope of the E(BC) curve falls, raising $B^*$. In the same interval an increase in σ, setting dμ = 0 raises the slope of the curve, reinforcing the negative impact of dσ on $B^*$ through the E(TS) curve (Figure III-3). Finally, dividing (8) by dσ and substituting $-\sigma$

---

6The tax shield is like an option to the firm. The underlying asset on which the value of the option depends is X. When the option is far out of the money, i.e. when log(B) $\mu$, a small increases in σ has a large positive effect on the probability of exercise, hence the value, of the option. This means that $-\frac{d}{d\mu} \left( \frac{dE(TS)}{dB} \right)$ can be negative for B $\exp(\mu)$ when one sets $\frac{d\sigma}{d\mu} < 0$. Note that when B $\exp(\mu)$ the value of the tax shield does not rise with σ, i.e. $\frac{dE(TS)}{d\sigma} < 0$, as one would expect with an option. The limiting value of τB of the tax shield is responsible for this phenomenon.
for \(du/d\sigma\) gives the effect of changing \(\text{Var}(X)\), holding \(E(X)\) constant. In the relevant range for \(\log(B)-\mu\) both of the two terms in (8) are positive, again reinforcing the effect of \(d\sigma\) on \(B^*\) through the \(E(TS)\) curve. Thus \(\frac{dB^*}{d\sigma} < 0\).

**The effect of systematic risk on \(B^*\).** The model can be used to illustrate the hypothesis that systematic risk (beta) and the optimal level of borrowing, \(B^*\), are negatively related. \(B^*\) is determined by the point at which the marginal present values with respect to \(B\) of \(E(TS)\) and \(E(BC)\) are equal. The present values, henceforth denoted by \(PV(E(TS))\) and \(PV(E(BC))\), are \(E(TS)/(1+k_{TS})\) and \(E(BC)/(1+k_{BC})\), respectively, where \(k_{TS}\) and \(k_{BC}\) are the capitalization rates for the corresponding cash flows. Thus at \(B^*

\[
\frac{dE(TS)}{dB} \cdot \frac{1}{1+k_{TS}} = B^* \frac{dB}{dB} \cdot \frac{1}{1+k_{BC}} \quad (9)
\]

\(B^*\) may change with systematic risk if either capitalization rate, or both, changes.

Consider first the tax shields. Since the tax shield is tied to \(X\), the tax shield and asset betas are positively related. Denoting the asset beta by \(\beta_X\),

\[
\frac{d}{d\beta_X} \left[ \frac{dE(TS)}{d\beta} \cdot \frac{1}{1+k_{TS}} \right] = -\frac{dE(TS)}{dB} \cdot \frac{1}{1+k_{TS}} \cdot \frac{dk_{TS}}{d\beta_X} + \frac{1}{1+k_{TS}} \cdot \frac{dE(TS)}{dB} \cdot \frac{d\sigma}{d\beta_X} \quad (10)
\]

The second term on the right of equation (10) permits \(\frac{d\sigma}{d\beta_X} > 0\). Substituting for \(\frac{d\sigma}{d\beta_X}\) from equation (7) (with \(du=0\)) and assuming investors are risk averse with respect to systematic risk \(\frac{dk_{TS}}{d\beta_X} > 0\), the derivative in (10) is negative for \(B^* \exp(\mu)\). This reduces the slope of the \(PV[E(TS)]\) curve at each value of \(B\). The point \(B^*\) at which
\[
\frac{d\left[PV(E(TS))\right]}{dB} = \frac{d\left[PV(E(BC))\right]}{dB}
\]
falls. Thus, acting through the \(PV(E(TS))\) curve, \(B^*\) is negatively related to \(\beta_X\).

The systematic risk of the bankruptcy cost cash flows \(\beta_{BC}\) affects the slope of the \(PV(E(BC))\) curve:

\[
\frac{d}{d\beta_X} \left[ BC \cdot \frac{\bar{b}}{1 + \bar{k}_{BC}} \right] = -\frac{BC}{(1 + \bar{k}_{BC})^2} \cdot \frac{d\bar{b}}{d\beta} \cdot \frac{d\bar{k}_{BC}}{d\beta_X}.
\]  \(11\)

From the viewpoint of one who would receive these cash flows, the derivative in (10) is negative. The slope of the \(PV(E(BC))\) curve falls at each relevant point \(B\), raising \(B^*\) ceteris paribus. The cash flows are zero when \(X > B\) and positive when \(X < B\), thus are negatively correlated with \(X\). Consequently, \(\beta_{BC}\) and \(\beta_X\) will likely be of opposite sign. If this is true, then

\[
\frac{d}{d\beta_X} \left[ \frac{d[PV(E(BC))]}{dB} \right] > 0.
\]

The slope of the \(PV(E(BC))\) curve rises with \(\beta_X\), reducing \(B^*\) ceteris paribus. Since \(\beta_X\) acts in the same direction through both curves, \(\frac{dB^*}{dB_X} < 0\).

**Summary of empirical implications.** Several implications of the MMTB theory are frequently cited. The level of borrowing is

1. positively related to the expected asset value;
2. negatively related to the variance of the future asset value; and
3. negatively related to the beta of the asset value.

A cross-section regression model to test MMTB as a null hypothesis would regress the level of borrowing on the three factors. The first can be broken into two variables, the current asset value and the expected growth rate of that value. In a multiperiod or continuous-time world, the present value of the firm's debt and its assets should
be approximately the same if the asset variance and beta are zero. Borrowing should be positively related to the asset growth rate since the rate reflects additional investment. Finally, equation (9) reveals that the level of bankruptcy cost affects $B^*$. If $BC$ is a positive, concave function of asset value, $B$ will be a negative, concave function of asset value.

II. The Model With Tax Shelter Substitutes

The MMTBS model is identical to the MMTB model except that MMTBS recognizes that a firm may possess tax shields in addition to those generated by debt. These shields arise from depreciation, depletion, and the investment tax credit. Like the interest tax shield, their value is directly related to the probability that the firm will be able to utilize them. The expected level of operating income net of interest expense determines, at least in part, the likelihood the tax shields will be utilized. Since the financing decision affects the value of these corporate assets, the financing decision affects the value of the firm. Even without bankruptcy costs there may be an interior optimal capital structure.

Expected tax shields in the MMTBS model. The qualitative features of MMTBS can be illustrated using the two-period model of the previous section. The firm adjusts borrowing, $B$, until the present value of the marginal expected tax shields is equal to the present value of the marginal expected bankruptcy cost. Since bankruptcy costs are the same as in MMTB, it is not necessary to reexamine that equation.\(^7\) The tax

\(^7\)Of course, the result would be identical if lost tax shields were grouped with other bankruptcy costs.
shields are assumed realized in the following order as operating income
rises: debt, depreciation, depletion, then the investment credit. The
ordering of the first three is immaterial since they produce equal tax
shields, dollar-for-dollar. The investment credit cannot be used unless
there is a positive tax liability after the deduction of the first three
shelters. Finally, depletion will be grouped together with depreciation
since their treatments are similar.8

\[
E(TS) = \int x \psi(x) dx + \tau B \int \psi(x) dx + \Delta \int \psi(x) dx + ITC \int \psi(x) dx, \quad (12)
\]

where \( \Delta \) is the sum of depreciation and depletion; ITC is the investment
tax credit; \( \theta \) is the maximum fraction of taxable income which is per-
mitted by law to be sheltered by ITC;9 and \( \psi(x) \) is the density function
for the lognormally distributed level of firm value \( X \). Instead of two
different positive ranges of realized tax shields, \( \tau X \) and \( \tau B \), as in
MMTB, Table III-1 shows five ranges for \( X \) and the total and marginal tax
shields in each range. In equation (12) there are three consecutive
pairs of integrals. The first integral of each pair represents the tax
shield derived from the particular source, \( B, \Delta, \) or ITC, when \( X \) is not
great enough to permit utilization of the entire shield. The second
integral added to the first gives the shield when the entire shield can
be utilized.

Equation (12) can be made more manageable by setting \( z = \log X - \mu \)
and changing variables. The new equation has terms involving the normal

8The manufacturing firms comprising my sample have negligible
amounts of depletion. Consequently, the distinction between deprecia-
tion and depletion will not matter from a practical standpoint.

9\( \theta \) ranged from 0.5 to 0.9 during the 1970's.
variate Z distributed as \( N(0, \sigma^2) \):

\[
E(TS) = r \int_{-\infty}^{\infty} 
\left( \int_{-\infty}^{t} e^{\exp(z-t)}dz \right)dz + 2 \int_{-\infty}^{\infty} \int_{-\infty}^{t} e^{\exp(z-t)}dz + r \int_{-\infty}^{\infty} \int_{-\infty}^{t} e^{\exp(z-t)}dz - B \int_{-\infty}^{t} \exp(z-t)dz.
\]

(13)

The limits of integration are \( a = \log(B) - \mu \), \( b = \log(B+\Delta) - \mu \), and \( c = \log(B+\Delta + \frac{ITC}{\sigma_t}) - \mu \).

The derivatives of the \( E(TS) \) curve reveal its shape. The marginal expected tax shield is

\[
\frac{dE(TS)}{dB} = \tau \int_{-\infty}^{\infty} \phi(z)dz + (1-\theta)\tau \int_{b}^{c} \phi(z)dz.
\]

(14)

Since \( 0 < \theta < 1 \), \( dE(TS)/dB > 0 \). The second derivative is

\[
\frac{d^2E(TS)}{dB^2} = -\theta \frac{1}{\sigma_t^2} \phi \left\{ \log(B+\Delta + \frac{ITC}{\sigma_t}) - \mu \right\} + (1-\theta)\tau \frac{1}{\sigma_t^2} \phi \left\{ \log(B+\Delta + \frac{ITC}{\sigma_t}) - \mu \right\}.
\]

(15)

The second derivative is negative over the entire range of \( B \). Thus the MMTBS \( E(TS) \) curve retains the same shape as the MMTB \( E(TS) \) curve illustrated in Figure III-1. The curve is shifted up since even at \( B=0 \) tax shields are available as long as \( \Delta > 0 \) or \( ITC > 0 \). Also, differentiation of equation (14) with respect to \( \Delta \) and ITC shows that the slope of the curve at each point is reduced by the substitutes:

\[
\frac{d}{d\Delta} \left[ \frac{dE(TS)}{dB} \right] = \frac{d^2E(TS)}{dB^2} < 0,
\]

(16)

\[
\frac{d}{dITC} \left[ \frac{dE(TS)}{dB} \right] = -\frac{1}{\sigma_t^2} \phi \left\{ \log(B+\Delta + \frac{ITC}{\sigma_t}) - \mu \right\} < 0.
\]

(17)

The negative relationship between the \( E(TS) \) curve's slope and \( \Delta \) and ITC produces a negative relationship between these substitutes and the level
of B at which the E(TS) and E(BC) slopes are equal. (See Figure III-3.) Thus B* is negatively related to Δ and to ITC. While adding Δ and ITC raises E(TS), it reduces the marginal E(TS), \( \frac{dE(TS)}{dB} \). Reducing B reduces marginal E(BC) and raises marginal E(TS). At the lower B*, E(TS) and E(BC) are again equal.

The effects of Δ and ITC are not identical. ITC is a credit, rather than a deduction; it reduces B* more than an equal amount of Δ, at least at low levels of \( \log(B+\Delta+\frac{ITC}{\theta t})-\mu \). At higher levels of the braced quantity the \( \theta \) constraint on the use of ITC reduces the ability of ITC to substitute for B or Δ.

**The effects of \( \mu \) and \( \sigma \) on B*.** The partial effects of changes in the distribution of X are illustrated by the differential of the expected tax shields:

\[
\frac{d}{dB} \left[ \frac{dE(TS)}{d\mu} \right] = \left[ \theta \tau \phi \left( \log \left( B + \Delta + \frac{ITC}{\theta t} \right) - \mu \right) + (1 - \theta) \tau \phi \left( \log \left( B + \Delta + \frac{ITC}{\theta t} \right) - \mu \right) \right] \frac{d\mu}{\sigma} 
+ \left[ \frac{1}{\sigma^2} \int \frac{1}{2} \left( \frac{1}{\sigma^2} - 1 \right) \phi(z) \frac{d^2}{dz^2} \left( \frac{1}{\sigma^2} - 1 \right) \phi(z) dz \right] d\sigma.
\]

(18)
The du effect is clearly positive, raising the slope of E(TS) at every point B, and raising B*. A sufficient condition for \( d[E(TS)/dB]/d\sigma < 0 \) is \( \log(B+\Delta+\frac{ITC}{\theta t})-\mu \), or equivalently \( B+\Delta+\frac{ITC}{\theta t} < E(X)\exp(-\frac{1}{2} \sigma^2) \). The dσ effect reduces the slope and reduces B*.

To investigate the effects of changes in the distribution of X, rather than \( \log(X) \), the substitutions of the previous section must be made. The effect of a change in E(X) is isolated by dividing equation (18) by du. To hold Var(X) constant substitute

\[
\left. \frac{d\sigma}{d\mu} \right|_{d\mu = 0} = \frac{1 - \exp(\sigma^2)}{\sigma \left[ 2 \exp(\sigma^2) - 1 \right]} < 0.
\]

\( \log(B+\Delta+\frac{ITC}{\theta t}) \) is a sufficient condition for
\[ \frac{d}{d\sigma} \left( \frac{dE(TS)}{dB} \right) \bigg| \frac{dE(X)}{d\mu} = 0 > 0. \]

The effect of a change of \( \text{Var}(X) \) is isolated by dividing (18) by \( d\sigma \). The substitution

\[ \frac{d\mu}{d\sigma} \left( \frac{dE(X)}{d\sigma} \right) = 0 \]

holds \( E(X) \) constant. Again, \( \log(\beta + \Delta + \frac{\text{ITC}}{\theta T}) \mu \) is a sufficient condition for

\[ \frac{d}{d\sigma} \left( \frac{dE(TS)}{dB} \right) \bigg| \frac{dE(X)}{d\sigma} = 0 < 0. \]

**Summary of empirical implications.** The empirical implications of MMTB remain. Across firms borrowing should be directly related to the expected value of the firm's assets, ceteris paribus. Empirically, the coefficient of borrowing on the level of assets at \( t \) should be approximately one. Borrowing should be positively related to the expected growth rate of the assets. The variance about the expected growth rate should be negatively related to borrowing. The negative effect of systematic risk on firm borrowing is not changed by the addition of tax shelter substitutes.

The level of tax shelter substitutes, depreciation and investment credits, should be negatively related to borrowing. Because of the different tax treatment of the two, depreciation and investment credits effects may differ in magnitude.

**III. The Moral Hazard Theory**

Myers (1977) shows that debt financing creates a moral hazard.

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\[ ^{10} \text{See footnote 6.} \]
If the shareholders or their agents must make an investment decision before the firm's outstanding debt matures, the optimal investment strategy may differ from the optimal strategy with no debt. The altered investment strategy reduces the market value of the firm and its debt. "Moral hazard theory" (MH) describes the idea that the debt may alter the optimal decision to the detriment of the debtholders.\footnote{The term "moral hazard" has been applied primarily in the theoretical literature on insurance. Arrow has written (1971, p. 220), "If the amount of the insurance payment is in any way dependent on a decision of the insured as well as on a state of nature, then the effect is very much the same as that of any excise tax and optimality will not be achieved either by the competitive system or be [sic] an attempt by the government to simulate a perfectly competitive system." When a firm has debt outstanding, its investment decisions may no longer depend only on the state of nature but also on the level of debt. Equity is essentially a call option on the value of the firm. A call option is equivalent to the purchase of the underlying security combined with borrowing and the purchase of insurance against a fall in the value of the underlying asset. The moral hazard idea in insurance thus carries over directly to levered equity.}

The MH theory's implications are quite different from those of MM and its derivatives. Modern finance theory typically makes the assumptions necessary for the separation of investment and financing decisions. The two are then treated independently. The MH theory implies that the separation may not obtain; the investment and financing decisions must be made simultaneously since their optimality is mutually dependent.

\textbf{A model of the MH theory.} A simple model can illustrate the agency problem created by the moral hazard. The appendix to this chapter presents a more complete model. Imagine that a firm has pure discount bonds outstanding with total face amount $B$. The current market value of the debt is $D$. The value of the firm is defined by

\begin{equation}
V = D + S
\end{equation}
where $S$ is the value of the firm's equity. A crucial difference between agency and most other theories is that the former recognizes that decisions which maximize $V$ do not necessarily maximize $S$. The derivative of (19) shows the level of investment which maximizes the equity value

$$\frac{3S}{3I} = \frac{3V}{3I} - \frac{3D}{3I} = 1$$  (20)

where $I$ is the level of investment. Assume that all new investment is financed by issuing new equity.\(^{12}\) The chain rule and regrouping gives

$$\frac{3S}{3I} = \frac{3V}{3I}(1 - \frac{3D}{3V}) = 1.$$  (20a)

With no debt outstanding ($D = B = 0$), the first-order condition (20a) is satisfied when $\frac{3V}{3I} = 1$ for the marginal investment. This is equivalent to the common criterion that the net present value of the marginal project be zero.

The optimal investment condition changes, however, with risky debt outstanding. Merton (1974) shows that $\frac{3D}{3V} > 0$ for risky debt. Thus in (20a) $1 - \frac{3D}{3V} < 1$. The first-order condition implies that $\frac{3V}{3I} > 1$ for the marginal investment, and $\frac{3D}{3V}$ is an increasing function of the face amount $B$ outstanding.\(^{13}\) Thus leverage and the difference $\left(\frac{3V}{3I} - 1\right)$ are directly related. Of two similar firms facing identical investment opportunities, the levered firm accepts fewer or the same projects as the unlevered firm. When the levered firm rejects projects having

\(^{12}\)Other cases are explored in the appendix.

\(^{13}\)Using Merton's notation, the partial of the debt value with respect to firm asset value equals one minus the partial of the equity with respect to firm asset value:

$$F_V = 1 - f_V = 1 - \Phi(x_1).$$

If we now take the partial of this quantity with respect to $B$, we get

$$F_{VB} = \frac{1}{B \sigma \sqrt{2\pi}} \exp\left(-\frac{1}{2} x_1^2\right) > 0.$$
positive net present values (but \( \frac{\Delta S}{\Delta I} < 1 \)), its value \( V_L \) rises less than its unlevered counterpart's \( V_U \).

**Direct effects on security values.** The market value, \( V_L \) or \( V_U \), is comprised of two types of assets, assets in place, AIP, and the present value of growth opportunities, PVGO. PVGO is the difference between the present values of the growth opportunities' expected cash flows and the expected investment. The critical difference between AIP and PVGO is that growth opportunities require future (discretionary) investment to provide positive cash flows, whereas AIP do not. The distinction between the asset classes is not precise. Many cash-flow-producing tangible assets require discretionary future investment to extend their revenue-generating lives. Thus part of the value of a tangible asset may be classified as AIP, while part is labeled PVGO.

The reduced expected level of investment resulting from the levered firm's moral hazard problem leads to smaller expected cash flows, hence a smaller value of PVGO vis-à-vis a similar, unlevered firm. \( V_L \) is less than \( V_U \) if both firms have identical AIP and face identical investment opportunities.

Both the equity and the debt of the levered firm reflect its reduced market value. Imagine that the per share equity prices \( S_U \) and \( S_L \) of the unlevered and levered firms were the same. With the discovery of a growth opportunity \( S_U \) rises while \( S_L \) does not if the levered firm's moral hazard forces the rejection of the project. Since debt and underlying firm asset values are directly related, \( B_L \) is smaller than it would be if the levered firm accepted the opportunity. Note that the stockholders transfer part of the loss \( (V_U - V_L) \) to the bondholders.

The bondholders can "charge" the stockholders for the antici-
pated losses in advance. With perfect knowledge of the firm's growth opportunities the bondholders can calculate the present value of the expected wealth expropriation due to underinvestment by the firm's owners. The bondholders can transfer an amount equal to this expected loss back to the shareholders by requiring a higher promised return on the bonds than they would without the moral hazard. The cost incurred by the stockholders exactly matches the present value of their expropriation opportunities. The stockholders bear the full amount \((V_U - V_L)\), the agency cost due to the underinvestment problem, while the bondholders' wealth is the same it would be if the agency problem did not exist.

**Remedies for the underinvestment problem.** Jensen and Meckling (1976), Myers (1977), and Smith and Warner (1979) point out that, in theory, restrictive covenants can reduce or eliminate the underinvestment problem. But it is difficult and costly to write enforceable covenants. Moreover, it is probably extremely costly, if not impossible, for the bondholders to monitor the investment decisions of the firm to insure that it accepts all positive net present value opportunities.\(^{14}\) Jensen and Meckling (1976) show that although the bondholders pay the monitoring costs directly, they ultimately shift the costs to the stockholders. The stockholders may choose to bear either the direct costs of underinvestment (by electing not to enter into covenants prohibiting underinvestment) or the monitoring costs of the covenants.

The firm's owners have another strategy available to them. They can use less financial leverage, reducing the potential

\(^{14}\)See Myers (1977) for a detailed discussion on the problem of monitoring firm investment decisions.
underinvestment and the size of the bondholder wealth expropriation.\textsuperscript{15}

The agency costs transferred to the stockholders fall, but the firm loses
the interest tax shields. The owners must identify the degree of
leverage at which the marginal reduction in agency costs of debt equals
the marginal reduction in tax shields net of bankruptcy cost.

\textbf{Summary of empirical implications.} MH suggests that assets be
classified into AIP and PVGO categories. No moral hazard is created
when an all-AIP firm borrows; the amount borrowed is equal to the
optimal borrowing under MMTBS. For a firm consisting of both AIP and
PVGO the optimal level of borrowing is less than the optimal amount
under MMTBS, as the firm minimizes the sum of debt agency costs and lost
tax shields.

To test MH as the null hypothesis, a cross-section regression
model like the one for the MMTBS hypothesis is useful. Under MH,
however, $B$ is no longer equal to $V$ when risk and tax shield substitutes
are zero. Instead, $V$ must be broken into AIP and PVGO.\textsuperscript{16} For given $V$
firm borrowing falls as PVGO rises (and AIP falls). A test of MH
involves testing whether the coefficient of borrowing on PVGO is less
than the coefficient on AIP, while controlling for risk and the level of
tax shelter substitutes. An equivalent test is for a negative
coefficient of borrowing on PVGO, holding $V$, risk, and tax shelter

\textsuperscript{15}They may, of course, elect to incur some combination of the
direct cost of underinvestment and the monitoring cost by agreeing to
covenants which only partially restrict their investment decisions.

\textsuperscript{16}As noted above, the distinction between AIP and PVGO is not
precise. The value of PVGO derives from discretionary future
investment. With many tangible assets there are opportunities for
discretionary future expenditure, e.g. in maintenance. Thus part of the
value of many tangible assets may be due to PVGO. The implications for
empirical testing are discussed in the following chapter.
substitutes constant.

Other cross-section tests correlate the level of PVGO with various strategies, in addition to leverage reduction, which reduce the MH problem. First, the MH problem disappears if the investment decision follows repayment of debt. Thus firms with high levels of PVGO may have shorter average debt maturities. Second, since convenants can reduce the underinvestment problem, the severity of convenants should be related to PVGO. Finally, Bodie and Taggart (1978) show that debt call provisions can partially remedy the problem by allowing the firm to reduce its leverage when it faces an investment decision. Thus the use of call provisions may be associated with the level of PVGO.

Time-series effects may be tested. An increase in the value of the firm's assets should be reflected primarily in a rise in the value of its equity since equity is a levered security. Under MNTBS the firm should rebalance its capital structure by issuing debt and retiring equity. Curiously, this was not detected in any of the empirical work reviewed in the previous chapter. Firms seem to issue equity after equity price increases. This finding may be consistent with the MH result that the debt ratio is negatively related to \( \frac{\text{PVGO}}{V_L} \). If most of the rise in asset value is due to an upward revision in PVGO, then the firm should further reduce its financial leverage. Equity issues should follow rises in PVGO rather than declines.
APPENDIX

In the MM Model the investment and financing decisions are assumed to be independent, the investment decision, once made, is immutable, and the financing decision is based on the announced level of investment. The MH model contrasts with MM in that the investment is assumed to depend on financing and vice versa. The dependence can arise due to a number of costs which may move an equilibrium to a new point as firms and individuals attempt to reduce such costs. (See Jensen and Meckling (1976)).

The following detailed model of the MH theory shows one of the many possible ways in which agency costs (due in this case to a moral hazard) can arise and how optimizing behavior differs from behavior in a model, such as MM, with agency costs.

Imagine a firm whose sole asset consists of a growth opportunity to which it is about to commit funds. Imagine further that the firm may borrow and issue additional equity to finance the realization of the idea. All income, $G$, is to be received next period and is a function of the total investment, $D+S$ (debt plus equity), and the state of nature next period, $q$. Call the state in which the firm's net income is zero, $q^*$. Then letting pretax income from the opportunity be given by $G$, $q^*$ is defined by

$$G(D+S, q^*)(1-T) = B - (B-D)T = B(1-T) + DT,$$

where $B$ is the promised debt repayment, and $T$ the corporate tax rate. There are no taxes in states below $q^*$.

The shareholders' objective function is given by the difference between the present value of the equity cash flow from the growth
opportunity and the equity investment, \( S \), i.e. the net present value of the equity:

\[
F = \frac{1}{1+p} \int_{q}^{\infty} \{G(D+S, \ q)(1-T) - (B-(B-D)T)\}dF(q) - S. 
\]  
(A-2)

Note that to simplify the exposition I have assumed risk neutral behavior of investors.

For any level of borrowing, the original shareholders maximize \( F \) by setting total equity, \( S \), and investment, \( (D+S) \), such that

\[
\frac{\partial F}{\partial S} = 0 = \frac{1}{1+p} \int_{q^*}^{\infty} G_1^*(1-T)dF(q) - 1, 
\]  
(A-3)

where the subscript on \( G \) indicates the partial derivative. The effect of changes in borrowing on \( (A-3) \) is given by

\[
\frac{d}{dD} \frac{\partial F}{\partial S} = 0 \frac{1}{1+p} \left[ \int_{q^*}^{\infty} G_{11}^*(1-T)(1 - \frac{dS}{dD})dF(q) - \frac{dq^*}{dD} G_1(D+S, q^*)(1-T) \right]. 
\]  
(A-4)

Solving for \( \frac{dS^*}{dD} \) shows how the optimal equity investment \( S^* \) changes with the level of borrowing:

\[
\frac{dS^*}{dD} = -1 + \frac{\frac{dq^*}{dD} G_1(D+S, q^*)}{\int_{q^*}^{\infty} G_{11}^*dF(q)}. 
\]  
(A-5)

It will be shown below that \( \frac{dS^*}{dD} < -1 \), i.e. that additional borrowing always reduces total optimal investment in the growth opportunity.

Now consider the firm's debt. If the bonds are fairly priced their value is the present value of the expected payoff:

\[
D = \frac{1}{1+p} \left[ \int_{q^*}^{\infty} G(D+S, \ q)dF(q) + \int_{q^*}^{\infty} BdF(q) \right], 
\]  
(A-6)

Rearranging \( (A-6) \) and differentiating gives the amount by which
the promised payment to bondholders, B, must rise to induce investors to lend an additional dollar:

\[
\frac{dB}{dD} = \frac{(1+p)-(1+\frac{dS}{dD}) \int q^* G_1^* dF(q) - \frac{dG(d+S, q^*)}{dD}}{\int q^* dF(q)} - B \cdot \frac{T}{1-T}. 
\]  

(A-7)

The definition of q* in equation (A-1) can be rearranged for substitution into (A-7):

\[G(d+S, q^*) = \frac{B(1-T)+DT}{1-T} = B + D \cdot \frac{T}{1-T}. \]

Substituting this into (A-7) gives

\[
\frac{dB}{dD} = \frac{(1+p)-(1+\frac{dS}{dD}) \int q^* G_1^* dF(q) - \frac{dG(d+S, q^*)}{dD}}{\int q^* dF(q)} - B \cdot \frac{T}{1-T}. 
\]  

(A-8)

Differentiating the stockholders' objective function and setting it to zero (below) gives the optimal level of borrowing:

\[
\frac{dF}{dD} = \frac{1}{1+p} \int q^* (G_1^* (1+\frac{dS^*}{dD})(1-T) - \frac{dB}{dD} (1-T)+T) dF(q)
\]

\[- \frac{dG(d+S, q^*)}{dD} \cdot (1-T)-(B(B-D)T) - \frac{dS}{dD}. \]

(A-9)

Substitute the expression for \(\frac{dF}{dS} \) (A-3) into (A-9) to simplify the expression for \(\frac{dF}{dD} \):

\[
\frac{dF}{dD} = 1 - \frac{1}{1+p} \left\{ (1-T) \frac{dB}{dD} + T \right\} \int q^* dF(q). \]

(A-10)

Now substitute for \(\frac{dB}{dD} \) from (A-8):

\[
\frac{dF}{dD} = 1 - \frac{1}{1+p} T \int q^* dF(q) - (1-T) + \frac{1}{1+p} (1-T)(1-\frac{dS}{dD}) \int G_1^* dF(q)
\]

\[+ \frac{1}{1+p} DT \frac{dG(d+S, q^*)}{dD}. \]

(A-11)
Finally, substitute the expression (A-5) for \( \frac{dS^*}{dD} \):

\[
\frac{dF}{dD} = 1 - \frac{1}{1+p} T \int_q^\infty dF(q) - (1-T) + \frac{1}{1+p} (1-T) \int_q^\infty \frac{dF(q)}{q^* G_{11} dq} \]

\( + \frac{1}{1+p} DT \frac{dq^*}{dD} \) \hspace{1cm} (A-12)

Setting \( \frac{dF}{dD} = 0 \) and solving for \( D \) gives the optimal level of borrowing, \( D^* \). At \( D = 0 \), \( \frac{dF}{dD} = T \frac{p}{1+p} > 0 \). Thus the value of the stockholders' objective function rises as \( D \) rises from zero. At the opposite extreme, consider \( \frac{dF}{dD} \) when \( D \) is large. Look at the next-to-last term in (A-12). With the usual assumptions that \( G_1 > 0 \), and \( G_{11} < 0 \), this is negative for large \( D \). Note that as \( D \) becomes large the possibility of default approaches one, i.e., \( q^* \to \infty \). Thus the denominator approaches zero while the numerator approaches infinity. The term, then, goes to negative infinity. Thus for large \( D \), \( \frac{dF}{dD} < 0 \). This shows that the maximum of the stockholders' objective function, if one exists, must occur for a debt ratio between zero and one; unlike MM, there is an optimal debt ratio which is not a corner solution.

Lastly, consider \( \frac{dS^*}{dD} \), which determines the optimal investment \( (D+s^*) \) at each \( D \). We can break \( \frac{dq^*}{dD} \) up as \( \frac{dq^*}{dD} = \frac{2q^*}{3S} \frac{3S}{3D} + \frac{3q^*}{3D} \). Substituting this for \( \frac{dq^*}{dD} \) in (A-5) gives

\[
\frac{dS^*}{dD} = - \frac{\frac{3q^*}{3D} G_1(D+S, q^*)(1-T)}{\frac{3q^*}{3S} G_1(D+S, q^*)(1+T)} \int_q^\infty \frac{G_{11}^*(1-T)dF(q)}{q^*} \]

\( \int_q^\infty \frac{G_{11}^*(1-T)dF(q)}{q^*} \)
or
\[
\frac{dS^*}{dD} = - \frac{\frac{\partial q^*}{\partial D} \int_{Q}^{Q^*} G_{11} dF(q)}{\frac{\partial q^*}{\partial S} \int_{Q}^{Q^*} G_{1} (D+S, q^*)}
\]  \hspace{1cm} (A-13)

The critical question is whether \( \frac{dS^*}{dD} < -1 \), i.e. whether borrowing actually reduces total investment, \( D+S^* \), and firm value. Recasting equation (A-13), investment falls if
\[
\frac{dS^*}{dD} = - \frac{\frac{\partial q^*}{\partial D}}{\frac{\partial q^*}{\partial S} - \alpha} < -1.
\]  \hspace{1cm} (A-14)

If \( \frac{\partial q^*}{\partial S} > \alpha > 0 \), (A-14) simplifies to
\[
\frac{\partial q^*}{\partial D} > \frac{\partial q^*}{\partial S},
\]  \hspace{1cm} (A-14a)
i.e. for borrowing to reduce total investment, the break-even state \( q^* \) must rise more (or fall less) with a change in \( D \) than with a like change in \( S \).

To determine whether \( \frac{\partial q^*}{\partial S} - \alpha > 0 \) so that (A-14a) is relevant, consider the second order condition on the objective function:
\[
\frac{\partial^2 F}{\partial S^2} = \frac{1}{1+\tau} \left[ \int_{Q}^{Q^*} G_{11} \cdot (1-T) dF(q) - \frac{\partial q^*}{\partial S} G_{1} (D+S, q^*) \cdot (1-T) \right] < 0.
\]

This shows that
\[
\frac{\partial q^*}{\partial S} > \frac{\int_{Q}^{Q^*} G_{11} \cdot (1-T) dF(q)}{G_{1} (D+S, q^*) \cdot (1-T)}.
\]

Thus the denominators in (A-13) and (A-14) are positive, and (A-14a) can be used.
The definition (A-1) of \( q^* \) determines whether condition (A-14a) holds. The partial of (A-1) with respect to \( S \) is

\[
\frac{\partial q^*}{\partial S} = -\frac{G_1}{G_2},
\]

while the partial with respect to \( D \) is

\[
\frac{\partial q^*}{\partial D} = -\frac{G_1}{G_2} + \frac{1}{G_2} \left[ \frac{\partial B}{\partial D} + \frac{T}{1-T} \right].
\]

From the positive second term of (A-16), \( \frac{\partial q^*}{\partial D} > \frac{\partial q^*}{\partial S} \), and conditions (A-14) and (A-14a) hold. This proves that \( \frac{dS^*}{dD} < -1 \); borrowing reduces total investment and firm value.

The detailed moral hazard model in this Appendix shows explicitly the equilibrating process, whereas the simple model of Chapter III does not. The detailed model shows the reaction process by which bondholders adjust their required promised payoff, \( B \), according to the level of firm borrowing, \( D \). The equity owners' adjustment of the total investment in response to the level of borrowing is also shown clearly. The combination of bond- and stockholder behavior simultaneously determines the optimal level of debt and investment.
CHAPTER IV
SINGLE-EQUATION REGRESSION TESTS

This chapter presents empirical tests of theories of optimal corporate capital structure. First is a review of the variables important in each theory of the preceding chapter. Next, to test the theories cross-section regression models are proposed. Then the use of available data to construct the required variables for a sample of corporations is discussed. Finally, the results and shortcomings of the single-equation tests are considered.

I. The Independent Variables

The MMTB model. In the MMTB model the expected tax shield and bankruptcy cost determine the optimal level of borrowing, \( B^* \). These expected values are functions of the \textit{ex ante} distribution of the firm's value on the date on which the debt matures. A larger expected stock of assets on the debt maturity date supports a higher level of borrowing, \textit{ceteris paribus}. The expected firm value is the product of the current value, \( V \), and one plus the expected growth rate, \( \mu \).\(^1\) Thus \( \mu \) reflects primarily the firm's investment rate; firms investing heavily display high values of \( \mu \). MMTB implies that a firm with no risk of bankruptcy should borrow against the entire asset value, \( B^* = V \). The previous chapter demonstrates the rationale for the MMTB prediction that the variance of firm value at the debt's maturity is negatively related to \( B^* \). The negative relationship also exists between the \textit{ex ante} variance,

\(^1\)Note that \( \mu \) is now defined as one plus the growth rate of \( V \), rather than as the expected value of \( V \).
$\sigma^2$, of the growth rate and B*.

In the MMTB model the present value of the expected bankruptcy cost and B* are functions of the asset systematic risk, $\beta$. B* is negatively related to $\beta$, ceteris paribus. Estimation problems may result from the collinearity of $\beta$ with $\sigma^2$.

Finally, if the marginal cost of bankruptcy falls with increasing firm size, $V$, then B* may not be related linearly to $V$. Large firms find B* a larger fraction of $V$, ceteris paribus.

The MMTB theory can be tested by estimating the following cross-section, multiple regression equation

$$\hat{\sigma}_i = a_0 \cdot V_1 + a_1 \cdot \mu_1 + a_2 \cdot \sigma^2_1 + a_3 \cdot \beta_1 + a_4 \cdot \hat{V}_1 + e_i,$$

where the subscript $i$ indexes the firm, and $e_i$ is a random error term. MMTB predicts $a_0 = 1$, $a_1 > 0$, $a_2 < 0$, $a_3 < 0$, and $a_4 > 0$.

The MMTBS model. The MMTBS differs from MMTB by recognizing that the firm has sources of tax shields in addition to borrowing and that the size of the substitute shields affects the borrowing decision. Equation (1) is misspecified, under MMTBS; the least squares (OLS) coefficient estimates are biased since (1) lacks a variable measuring the exogenously determined level of tax shield substitutes. Neither the size of the shelters (dollars of depreciation, dollars of depletion, etc.) nor the size of the shields provided gives a good indication of the marginal tax benefit provided by borrowing. Borrowing is directly

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2 Henceforth the subscript $i$ will be omitted where the omission will cause no confusion.

3 Without controlling for taxable income, the size of the tax shields has little meaning. Although two firms have the same level of tax shields, the firm with the larger remaining unshielded income will have the greater need for additional shields.
related to the level of unsheltered income, *ceteris paribus*. Operating income before depreciation, OI, minus the amount of income sheltered by depreciation, Δ, and the Investment tax credit, ITC, gives the unsheltered income variable. Each dollar of depreciation shelters one dollar of OI. Each investment credit dollar shelters \( \frac{1}{\tau} \) dollars of OI. In the MMTBS model the tax shelters also have different impacts on borrowing because ITC cannot be used to shelter all of OI. Since depreciation and investment credit differ by more than \( \frac{1}{\tau} \), two separate variables are added to equation (1).

\[
B = a_0 + a_1 \mu + a_2 \sigma + a_3 \beta + a_4 V + a_5 (OI-\Delta) + a_6 ITC + e. \tag{2}
\]

The coefficient on ITC incorporates the factor \( \frac{1}{\tau} \). \( V \) and \( (OI-\Delta) \) are likely to be highly correlated through firm scale. The size and depreciation shelter effects estimates, \( \hat{a}_0 \) and \( \hat{a}_5 \), may consequently be confounded. \( \hat{a} > 0 \) and \( \hat{a} < 0 \) rejects the MMTB hypothesis in favor of MMTBS.

The MH model. The important determinant of corporate borrowing in the MH model is the level of options for future investment in projects having positive expected net present values. The components of the firm's market value, \( V \), must be identified before developing a technique to measure the present value of a firm's growth opportunities, \( PVGO \). Let \( V = V_T + V_I \), where \( V_T \) represents the value of the firm's tangible assets. \( V_T \) is the present value of the expected cash flows which would be generated by the firm's physical assets regardless of who owned and

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4No firms in my sample of industrial companies have depletion.

5This section owes a lot to both Stewart Myers and James Paddock. See Paddock (1978).
operated them. In defining $V_T$ this way, cash flows are not included if they are not produced directly by the firm's tangible assets but result instead from the specific firm's employment of the assets.

$V_I$ denotes the value of the firm's intangible assets. The intangibles are firm-specific and represent the increment added to the tangible assets' competitive market value by the way the specific firm employs the tangible assets.

$V_I$ may be broken into $V_{IT}$, the value of intangibles requiring no future discretionary investment but associated with certain tangible assets, and $V_{IG}$, the value of growth opportunities requiring future discretionary investment. $V_I = V_{IT} + V_{IG}$.

The dividing line between the assets in $V_{IT}$ and those in $V_{IG}$ is not distinct. The important difference, the one which is responsible for the moral hazard problem, is that growth opportunities require future investment to produce their cash flows, where as other intangibles do not. Two examples are the utility and semiconductor industries. A utility, granted a monopoly by a government, may reap monopoly rents from the use of its tangible assets. No future investment is required to produce the excess returns on the tangible assets. The present value of those returns falls into $V_{IT}$.6 For a semiconductor firm most of $V_I$

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6Even here things become somewhat fuzzy. If the utility's assets depreciate, then a positive level of (gross) investment is required to maintain the same level of excess returns. If that investment is discretionary (the firm's managers won't go to jail for failing to maintain service to the utility's customers) then $V_{IT}$ consists of the present value of the (declining) excess returns from the firm's present tangible assets if left to wear out. $V_{IG}$ consists of the present value of the difference between the excess cash with and without the investment. Since for any industry the excess returns from current tangible assets are received sooner than those from the future, discretionary investment, it is reasonable to assume that $V_{IT}$ is much larger than $V_{IG}$. The assumption is not reasonable if the assets' economic depreciation occurs very rapidly.
derives from the ability to identify and develop new technologies requiring future investment to implement and produce. Finally, note that $V_{IG} \geq 0$. Firms do not invest in projects whose ex ante net present values are negative.

Estimates of $V_{IG}$ are needed to test the MH theory. Only $V$ in the equation $V = V_T + V_{IT} + V_{IG}$ is directly measurable. The tests of the MH theory use an estimate of $V_{IG}$, called PVGO, obtained by subtracting an estimate of $(V_T + V_{IT})$ from $V$. In the aggregate, monopoly rents probably account for most of $V_{IT}$, but the sample contains no industries in which monopolies are ordinarily granted to firms. Thus, for most firms in the sample $V_{IT}$ is probably small compared to $V$. As an approximation assume $V_{IT} = 0$.

In 1976 the S.E.C. began requiring that large firms annually publish estimates of their tangible assets's replacement cost. If the markets for those assets are competitive, the replacement cost represents the market value and provides an estimate of $V_T$. Of course there are problems with the replacement cost numbers, but they do provide information. Care in modeling and testing can reduce the effects of noisy estimates of $V_T$ and $V_{IG}$ and the possible upward bias in the $V_{IG}$ estimate caused by the approximation $V_{IT} = 0$.

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7Patents, which provide legal monopolies in a sense, do contribute to $V_I$ for the semiconductor and other "growth" industries. It is interesting to ask executives in these industries what would happen to their stock prices if they were to discontinue all net investment in the future. Invariably the response contains the word "disaster". On the other hand, when asked how the loss of all current patent protection would affect the stock price, the response generally suggests some decline, but not of the same magnitude as that of the previous scenario. Thus casual empiricism suggests that although some high-growth firms may seem to possess considerable patent protection, their growth rate means that a much larger part of $V_I$ consists of $V_{IG}$ than $V_{IT}$. 
MH implies that equations (1) and (2) are misspecified. \( a_0 \) is not equal to one since firms borrow less as the ratio of PVGO to \( V \) rises. The misspecification leads to biased estimates of the coefficients. This suggests adding a variable, PVGO, to equation (2).

The MH idea suggests another modification to equation (2). The MH problem occurs only when debt matures after the investment decision is made. Myers (1977) points out the use of short-term debt is one way to reduce the problem. Thus the model is concerned only with the determinants of long-term borrowing. Readily marketable short-term assets against which there are offsetting short-term liabilities do not support long-term debt. A new short-term assets variable, STA, consists of all current assets, except inventories, minus current liabilities, except current maturities of long-term debt. Assets in place, AIP, consists of property, plant, and equipment plus inventories. These two transformations change the market value balance sheet from its normal configuration, shown in Figure IV-1a, to that shown in Figure IV-1b. This reduces the total market value by the sum of debt due plus payables. All tests performed use the variables from the transformed balance sheet.

Equation (2) can be rewritten to include the variables STA and PVGO, measuring the composition of \( V \):

\[
3 = a_0 V + a_1 u + a_2 \sigma^2 + a_3 \beta + a_4 V^2 + a_5 (OI-\Delta) + a_6 ITC + a_7 STA + a_8 PVGO + e. \tag{3}
\]

Each \( a_j \), \( j=1,2,3,5,6 \), can be treated as the partial derivative of \( B \) with respect to the \( j \)th variable. \( \frac{\partial B}{\partial AIP} = a_0 + 2Va_4; \frac{\partial B}{\partial STA} = a_0 + 2Va_4 + a_7; \) and \( \frac{\partial B}{\partial PVGO} = a_0 + 2Va_4 + a_8 \). Under NMTB and NMTBS equal amounts of each
<table>
<thead>
<tr>
<th>Cash and Short-Term Investments</th>
<th>Debt Due</th>
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<tr>
<td>Receivables</td>
<td>Long-Term Debt (Current Maturities)</td>
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<tr>
<td>Inventories</td>
<td>Payables</td>
</tr>
<tr>
<td>Property, Plant, Equipment</td>
<td>Long-Term Debt</td>
</tr>
<tr>
<td>Present Value of Growth Opportunities</td>
<td>Preferred Stock</td>
</tr>
<tr>
<td></td>
<td>Common Equity</td>
</tr>
<tr>
<td>Market Value</td>
<td>Market Value</td>
</tr>
</tbody>
</table>

**Figure IV-1a:** Market Value Balance Sheet

<table>
<thead>
<tr>
<th>STA</th>
<th>Long-Term Debt (Incl. Current Maturities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIP</td>
<td>Preferred Stock</td>
</tr>
<tr>
<td>PVGO</td>
<td>Common Equity</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>

**Figure IV-1b:** Transformed Market Value Balance Sheet
of the three asset classes support the same amount of debt, so 
\( a_7 = a_8 = 0 \). MH allows that the debt capacity of AIP and STA may
differ, so \( a_7 \) may not equal zero. \( a_8 < 0 \) in the MH model because PVGO
supports less debt than an equal amount of AIP. If \( a_8 > 0 \), the MH hypo-
thesis is rejected.

Under MMTB and MMTBS the current level of borrowing is deter-
mined by the future level of assets. If \( \mu > 1 \) the future level includes
assets to be acquired by future investment. Thus \( a_1 > 0 \), and \( a_2 < 0 \). The
uncertain investment creates a moral hazard problem, however; under MH
the expected present value of the assets supports less debt than a like
level of assets in place. If the debt capacity of PVGO is sufficiently
less than that of AIP, \( a_1 \) could be nonpositive. Thus the signs of \( a_1 \)
and \( a_2 \) are not determinate under MH.

Finally, the estimates from equation (3) are likely to be
inefficient due to heteroskedasticity. In order to reduce the
anticipated dispersion of the error term variances, (3) is estimated
after normalization by \( V \):

\[
\frac{B}{V} = a_0 + a_1 \mu + a_2 \sigma^2 + a_3 \beta + a_4 V + a_5 \left( \frac{OI-A}{V} \right) + a_6 \frac{LTC}{V} \\
+ a_7 \frac{STA}{V} + a_8 \frac{PVGO}{V} + e. 
\]  

(3a)

II. Construction of the Variables

The sample consists of 170 manufacturing firms falling into
fourteen two-digit S.I.C. industries and 24 three-digit industries. The
sample firms were selected according to the following criteria:

(1) N.Y.S.E.-listed stock in 1976;

(2) fiscal year ending between December 1, 1976 and
March 31, 1977;
(3) all required data available;⁸ and

(4) at least four firms in the three-digit industry meeting requirements (1), (2), and (3).

Although the sample is biased toward large companies, there is substantial size dispersion, with total book assets ranging from $37.6 million to $15.5 billion.

The data were collected from Compustat tapes, S.E.C. Form 10-K, corporate annual reports, Moody's Industrial Manual, Standard and Poor's Reports, and Moody's Bond Record. Stock variables use data for the last day of each firm's 1976 fiscal year. Flow data correspond to the same fiscal year.

The dependent variable. The numerator of the debt ratio in equation (3a) can be measured using either the debt's book or its market value. Most theories of corporate capital structure assume that firms use pure discount bonds. Since most long-term corporate borrowing is actually via coupon debt, market interest rate changes cause most of the difference between market and book values. Without substantial cross-sectional maturity differences, market and book values should be highly correlated.⁹

The choice of market or book ratios affects the probability of rejecting the MH hypothesis for four reasons. First, if high-PVGO firms issue debt with the same maturity but higher coupons than low-PVGO firms,¹⁰ the market value of the high-PVGO debt will be higher than that

⁸The third requirement eliminates a number of firms which were too small to be obliged to comply with the reporting of certain replacement cost information under the S.E.C.'s Accounting Series Release No. 190.

⁹In this sample the correlation coefficient is 0.97.

¹⁰See the previous section of this chapter.
of the low-PVGO debt. The shorter duration of the high-coupon debt combined with historically high interest rates in 1976 are responsible. The market debt ratio gives a more powerful test of the MH hypothesis since high-PVGO firms will appear to have relatively high debt ratios if firms do not immediately adjust back to their target market value ratios. This raises the probability of a Type I error, of rejecting the MH hypothesis when it is, in fact, true. Second, the more rapid growth of high-PVGO firms means that a larger proportion of their debt was issued recently, resulting in a shorter average duration. This results in a higher 1976 market value of B and a more powerful test of MH. Third, under MH high-PVGO firms may issue debt of shorter maturity, hence duration, giving a higher 1976 market value of B and a more powerful test of MH. Finally, with the high proportion of recently issued debt, the average duration is longer, ceteris paribus, for high-PVGO firms. This effect reduces the power of the market value test, but reduces the probability of a Type I error. The initial tests reported in this chapter are repeated using both debt ratio measures.  

The tests use an estimate of each firm's long-term debt equal to the sum of the market value of publicly traded issues, the present values of the estimated payments from untraded issues, plus the debt component of convertible issues. To remove the debt component from the market value of a convertible I subtract the stream of interest and

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11Taggart (1977) reports little evidence supporting the hypothesis that firms set target debt ratios in market, rather than in book terms.

12A bond's cash flows are discounted using an estimated yield curve. First the Moody's index for bonds of the same rating (Aaa, Aa, etc.) is selected. Then the issues comprising the index are categorized by maturity. Finally, a yield curve is fitted to the average of the yields on the bonds of each maturity.
principal payments capitalized at the market yield for bonds of similar rating and maturity. For all types of debt the book value is used in cases where lack of reported information precludes estimating the market value.

The sum of the market values of the debt, common stock (shares times per-share price), and preferred stock gives the denominator, $V$, of the dependent variable in (3a). Where preferred stock market values are not observable, they are estimated by capitalizing the assumed perpetual dividend stream at the rate given by the Moody's preferred index of the appropriate rating.

The value of the interest tax shield does not appear on the asset side of the balance sheet in Figure IV-1b, so it must be removed from the measured $V$. The tests use three different sets of variables reflecting different estimated tax shield corrections of the measured $V$. The MM (1958) model suggests subtracting an amount equal to the tax rate times the value of the debt. The set of variable names ending in "48" use the MM correction at the 1976 tax rate of .48. Farrar and Selwyn (1967) show the personal income - capital gains rate differential makes the MM correction larger than the effective tax shield. Miller (1977) and Miller and Scholes (1978) show that value of the shield falls to zero at the margin. The set of variable names ending in "U" use an effective rate of zero. Finally, MM assume that assets supporting debt do not

13The full market value of convertible debt is used.

14While not all firms face a .48 marginal tax rate, I have not developed a better technique for estimating the rate for each firm.

15If the interest tax shield is an asset which supports the same amount of debt as an equal amount of AIP, then $VU$ is the appropriate variable to relate to $B$ since it includes the value of the tax shield.
depreciate, permitting the firm to maintain a constant level of borrowing and tax shields to perpetuity. In reality, assets depreciate and may be replaced. In a competitive market for replacement assets, price reflects the value of the assets to the firm, including the tax shields generated by debt supportable by the assets. Only the remaining tax shields from debt supported by currently owned assets contribute to the measured \( v \).  

To approximate the series of remaining tax shields for a firm I assume a linear depreciation schedule for the firm's long-term assets. Year-end 1976 assets and 1977 depreciation provide information to calculate the weighted-average remaining asset life. The 1976 tax shield is estimated by the product of the tax rate and 1976 interest on long-term debt. Successive years' shields are estimated by letting the 1976 shield decline linearly to zero over the weighted-average asset life. The variables ending with "C" use the measured \( V \) corrected by this declining stream of tax shields discounted at the 1976 Moody's bond index yield.

**Adjustment to the target debt ratio.** The variables on the right-hand side of equation (3a) determine the firm's target debt ratio, \( \frac{B^*}{V} \). Since the target ratio is unobservable, the actual ratio \( \frac{B}{V} \) proxies for the target in the empirical tests. The actual ratio adjusts to the target through a partial adjustment process if firms incur both costs of adjusting to the target and costs of being off target.  

For example, imagine a firm where initially the actual target ratios were equal, \( \left( \frac{B}{V} \right)_t = \left( \frac{B^*}{V} \right)_t \). At \( t+1 \) the market revalues the firm's assets so that the...

\[ \text{Stewart Myers pointed this out to me.} \]

\[ \text{Taggart (1974) models this process.} \]
ratio \( \frac{PVGO}{V} \) changes such that \( \left( \frac{PVGO}{V} \right)_{t+1} > \left( \frac{PVGO}{V} \right)_{t} \). Note that the revalued assets may be AIP, STA, PVGO, or any combination of the three. Under the MH hypothesis \( a < 0 \) in equation (3a), and \( \left( \frac{B^*}{V} \right)_{t+1} < \left( \frac{B^*}{V} \right)_{t} = (\frac{B}{V})_{t} \). If \( \frac{B}{V} \) adjusts only partially, then \( \left( \frac{B^*}{V} \right)_{t+1} < \left( \frac{B}{V} \right)_{t+1} \), and the expected residual is positive. Conversely, if \( \left( \frac{B^*}{V} \right)_{t+1} < \left( \frac{B}{V} \right)_{t} = (\frac{B}{V})_{t} \), then \( \left( \frac{B^*}{V} \right)_{t+1} > (\frac{B}{V})_{t+1} \), and the expected residual is negative.

If, due to the adjustment process, firms' actual ratios differ from the targets, the dependent variable contains a measurement error equal to \( \frac{B}{V} - \frac{B^*}{V} \). Ordinarily, measurement errors in the regression's dependent variable reduce efficiency by raising the standard error of the regression but do not affect consistency. In this case, however, the measurement error, whose random component is absorbed by the residual, is likely to be correlated with the independent variables, particularly \( \frac{PVGO}{V} \) and \( \frac{STA}{V} \). The correlation leads to inconsistent OLS estimates. Thus the adjustment problem may produce inconsistent estimates of the equation (3a) coefficients.

The difficulties in testing a specific adjustment process model compound when the model and a capital structure hypothesis are tested jointly. Rather than specify and test a specific model of adjustment, I perform a more general test of the adjustment-induced error problem. The error would result either from a revaluation of \( V \), especially the PVGO component since it is probably more volatile than AIP and STA, or

\[18\] Lev and Pekelman (1975) develop a detailed, multi-equation model of adjustment to a target capital structure. To obtain a closed form solution they found it necessary to make assumptions restricting the model's generality. Their attempt to test the model gives disappointing results. It is difficult to tell whether this is due to the model or the assumptions made to get the solution. Ang (1976) tests a number of less detailed hypotheses about capital structure adjustment. Because of the absence of theory underlying his tests, it is difficult to draw conclusions from them.
from changes in unsheltered operating income. Under this hypothesis changes in these two variables have explanatory power in (3a). The first variable to be included is the change in \( V, \Delta V \). The second is the change in \((OI - \Delta - ITC)\). Both variables are normalized by \( V \). Both are formed for the periods 1975-1976 and 1971-1976. In the partial adjustment model \( \Delta V > 0 \) leads to \( \frac{B}{V} < \frac{B^*}{V} \). Thus \( \frac{B}{V} \) is negatively related to \( \Delta V \). Similarly, if unsheltered operating income rises, \( \frac{B}{V} < \frac{B^*}{V} \); \( \frac{B}{V} \) is negatively related to the change in \((OI - \Delta - ITC)\).

**The independent variables.** In the NMTB model the future value and the variance of the value are determinants of borrowing. Alternatively, the expected value and variance of the growth rate are determinants. Above it was noted that the growth rate is a function of firm investment. \( \mu \) proxies for the ex ante growth rate. It is the mean of one plus the annual rates of growth of firm market value from 1965 through 1976. Little stock price drift is likely to be picked up over this interval, so that most of \( \mu \) results from firm investment. \( \sigma^2 \) is the square of the standard error of a regression line fitted to the annual growth rates.\(^{19}\)

The model of Chapter III showed that the systematic risk of the firm's assets affects the capitalization rates applied to its cash flows and is a determinant of the optimal capital structure. A procedure similar to that of Hamada (1972) can be used to estimate the "unlevered" or asset beta from an estimate of the beta of the levered

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\(^{19}\)The use of a short observation period protects against the influence of observations from much earlier periods when the parameters may have been different. Efficiency is lost, however. For a number of the sample firms the required data is not available for years before 1965.
equity, $S_L$, to the unlevered firm value, $S_U$:

$$\beta_U = \beta \frac{S_L}{S_U}.$$  \hspace{1cm} (4)

$S_L$ and $\beta_L$ are measured directly. $S_U$ is estimated using the three previously described techniques of estimating the value of interest tax shields. The three estimates of $\beta_U$ are denoted by $\text{BETA}_48$, $\text{BETAU}$, and $\text{BETAC}$.

The investment tax credit variable measures the income sheltered by the credit. There are two standard methods of accounting for an investment credit earned in period $t$. The normalized treatment amortizes the credit over future periods even though the full shield is used at $t$. To reconstruct the credit earned at $t$, $\text{ITC}_t$, I use the change in the investment credit balance sheet entry from $t-1$ to $t$, $\frac{B}{\Delta \text{ITC}}$, and the income statement entry reflecting the amortized credits allocated to period $t$, $\text{ITC}^I_t$:

$$\Delta \text{ITC}^B_t = \text{ITC}^B_t - \text{ITC}^I_t.$$ \hspace{1cm} (5)

The actual credit earned at $t$ is

$$\text{ITC}^B_t = \Delta \text{ITC}^B_t + \text{ITC}^I_t.$$ \hspace{1cm} (5a)

The second, flow-through, accounting method shows the entire credit on the income statement when earned. Thus $\text{ITC}^B_t = \text{ITC}^I_t$, and $\Delta \text{ITC}^B_t = 0$. I

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\footnote{This procedure is accurate only if the debt has no systematic risk. For firms in or near financial distress the debt beta is likely to be significantly greater than zero, resulting in a poor estimate of $\beta_U$.}
use equation (5a) to reconstruct $ITC_t$ since it works for both accounting methods. Finally, to calculate the income sheltered by $ITC_t$, the credit should be divided by the effective tax rate. Rather than estimate this rate, $ITC_{1976}$ is used directly; the coefficient on $ITC$ impounds the reciprocal of the rate. This technique assumes all firms have identical marginal tax rates.

The actual tax shelter provided by depreciation differs from publicly reported depreciation because of the different schedules (accelerated and straight-line) used for tax and public financial statements. The tax account depreciation, $\Delta_T$, is reconstructed from the public statements using by $DT$, the change in the balance sheet deferred tax account, to measure the over- or under-reporting of taxes paid in the public statements:

$$DT = (\Delta_T - \Delta_B)\tau,$$

where $\Delta_B$ is publicly reported depreciation. Solving (6) for $\Delta_T$ gives

$$\Delta_T = \frac{DT}{\tau} + \Delta_B. \tag{6a}$$

Rather than estimate $\tau$ and form the variable $(OI - \Delta_T)/V$ shown in equation (3a), I break the variable in two. The first is $NOI = (OI - \Delta_B)/V$. The second is $DT/V$, whose coefficient is negative and impounds $1/\tau$ under MMTBS. Equation (3a) becomes

$$\frac{B}{V} = a_0 + a_1 \mu + a_2 \sigma^2 + a_3 \beta + a_4 V + a_5 \frac{OI - \Delta B}{V} + a_6 \frac{DT}{V} + a_7 \frac{ITC}{V}$$

$$+ a_8 \frac{STA}{V} + a_9 \frac{PVGO}{V} + e. \tag{3b}$$

$PVGO$ is estimated by subtracting $AIP + STA$ from $V$. $AIP$ is
estimated by the reported replacement cost of the firm's inventories and long-term assets. STA is measured using the book values of the balance sheet items which comprise the net short-term assets.

This method of estimating PVGO allows errors to enter the estimate from three sources:

1. errors in estimated \( V \) from the estimates of debt and preferred market values,
2. errors in estimated \( V \) from the estimates of the interest tax shields, and
3. errors in estimated AIP from the reported replacement cost.

The econometric problems created by errors in PVGO and solutions to these problems are discussed in the following chapter.

Measurement errors in PVGO may cause a collinearity problem. If \( V_{IT} > 0 \) for some sample firms, their estimated PVGOs and PVGO ratios may be biased upward. The firms' earnings-price and \((OI-A)/V\) ratios also reflect the monopoly rents. Thus the estimates of \( a_5 \) and \( a_8 \) in equation (3a) may be correlated.

Finally equation (3b) is estimated with thirteen dummy variables to allow for industry differences in the constant. \( a_0 \) provides an estimate of AIP's effect on borrowing for the first industry. The dummies pick up differences in borrowing against AIP between the first and remaining industries.\(^{21}\)

\(^{21}\)Fertuck (1975) shows higher inter-firm stock return correlation within three-digit industries than in the market as a whole. The correlation within two digit industries is about the same as in the market. Three-digit dummies do not, however, provide a significantly greater amount of information about borrowing against AIP than two-digit dummies. See Williamson (1979).
III. Sample Characteristics

Table IV-1 gives summary statistics for the variables in equation (3b). The A.S.R.-190 reporting requirement and the N.Y.S.E. listing requirement restrict the sample to large corporations. The average market value measured by VU, V48, or VC is about $1.7 billion, where VU is uncorrected for tax shields, V48 uses the NM tax correction with \( r = .48 \), and VC uses a declining schedule of borrowing against present long-term assets and \( r = .48 \). The variance of the market values is large, with firms ranging from less than $50 million to more than $42 billion.

The debt ratio with VU as the denominator, BU, can take values from zero to one. It ranges up to 0.883 in the sample. The debt ratios with V48 and VC in the denominators, B48 and BC, may assume values greater than one if BU is close to one. F. & M. Schaefer has the largest BU and B48 in the sample, while White Motor has the largest BC. White Motor's longer estimated asset life gives it larger estimated tax shields per dollar of borrowing and reduces the denominator in BC.

The book debt ratios BBOOKU, BBOOK48, and BBOOKC are very close to the corresponding market debt ratios. Due to the high long-term rates in 1976 the market ratios average almost two percent less than the book ratios.

The ten-year asset growth rates, MU, average about seven percent. Adjusted for major mergers and acquisitions, A-T-O experienced the greatest decrease in size, followed by Olin. NVF and Smith International had the largest growth.

The asset betas with 0, .48, and declining tax shield assumptions, BETAU, BETA48, and BETAC, center around 0.8. International
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Flavors and Fragrances followed by Avon have the greatest values of
BETAU and BETA48. White Motor's BETAC is highest due to the combination
of its high equity beta (1.35) and the large estimated tax shields
subtracted to form VC.

The short-term asset ratios average about 11.5 percent. The
ratios STAU, STA48, and STAC correspond to STA/VU, STA/V48, and STA/VC.
The outliers are readily explainable. Control Data has the highest
value of each of the three ratios. Commercial Credit Corporation
comprises a major portion of Control Data. Much of Commercial Credit's
assets are customer debt and lease obligations, falling into the current
asset account. White Motor has the smallest values of the STA vari-
able, all negative. White Motor had borrowed heavily in the short-term
market in an attempt to relieve cash flow problems. Of course, the cash
drain did not stop, and White Motor filed under Chapter 11.

The sample means of the PVGO ratios, PVGOU, PVGO48, and PVGOC are
negative. The sample distributions are skewed. The median of each is
slightly negative, while the mean is pulled down by a few large
negative observations. The negative values confirm measurement errors
in these variables and demonstrate the need to reduce the resulting bias
in the regression estimates. The following chapter employs a technique
to reduce the problem. Avon has the highest values of the PVGO ratios.
American Home Products and International Flavors and Fragrances closely
follow Avon. White Motor and Cyclops are at the other end of the
scale.

The U, 48, and C forms of each variable track one another very
closely. The pairwise correlation between the three forms of each
variable is greater than .89 in every case.
The highest pairwise correlation between the debt ratio variables and the independent variables is with the PVGO ratios (-.63 to -.72). (See Table IV-2.) Other variables highly correlated with the debt ratio variables are the short-term asset ratio STAC (-.32) and the one-year change in unsheltered net operating income, DNOIU, DNOI48, and DNOIC. Correlations between independent variables suggest regression collinearity problems. The PVGO ratios are strongly correlated with MU (.33 to .34), BETA (.36 to .60), and the deferred tax variables, DTU, DT48, and DTC, (-.38 to -.41). The STA ratios are linked to the variance SIGMA2, about the mean asset growth rate (.23 to .29). A network of relationships runs through the tax shelter substitutes ratios, with high correlations between the pair NOI and DT and the pair DT and ITC. The DNOI ratios are positively related to the NOI and ITC ratios. Finally, the DNOI ratio is related to the 1976 level of that ratio, NOI.

IV. Single Equation Regression Results

The results of estimating the MH equation (3b) including the industry dummies appear in Table IV-3. Within the individual columns of estimates all ratio variables plus BETA and V use the same tax shield correction, either \( \tau = 0 \), \( \tau = .48 \), or declining tax shields. The three sets of estimated coefficients are similar. The constant, corresponding to the effect of a change in AIP on borrowing, is consistently less than one but greater than the average debt ratio. MU and SIGMA2, also MMTB variables, have estimated coefficients whose signs do not support the hypothesis that the debt ratio is a positive function of the asset growth rate and a negative function of the variance around that rate.
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<td>(.0132)</td>
<td>(.0182)</td>
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| Adjusted \( R^2 \)    | .7952       | .6709       | .6406       |
| Standard error \((y|X)\) | .0762       | .1401       | .1577       |

\(^a\)Standard errors in parentheses.
Finally, BETA has the expected significant negative coefficient in all three regressions. The debt ratios fall by .04 to .08 for a 0.1 increase in the asset beta.

The asset value variables, V, allowing for nonlinearity in the bankruptcy cost effect, is significantly different from zero at the .10 level only in the third regression. The sign of the estimated coefficient is negative in all regressions. This result rejects the commonly suggested hypothesis that large firms have higher debt ratios than small firms, ceteris paribus. This statement is qualified by the fact that all firms in this sample are fairly large.

The tax shelter substitutes variables do not perform well. Except in one regression the operating income and deferred-tax variables have signs which reject the MMTBS hypothesis. The sign on the investment credit variable is "correct," but the estimated coefficient changes by an order of magnitude between equations and has large standard errors.

The MH variables explain much of the debt ratio's variability. The PVGO variable has the expected negative coefficient, which is statistically significantly different from zero at the .05 level in all three runs. The estimated coefficient varies considerably between regressions, ranging from -0.03 in the t = 0 equation to -0.16 in the declining-tax-shield equation. The disparity is due partly to the imprecision of the estimates resulting from the strong collinearity between the PVGO variables and the MU, BETA, and ITC variables. The disparity between the PVGO coefficients is also due to the fact that the three regressions estimate relationships between different sets of variables.

---

22See Table IV-2.
The outliers. Table IV-4 lists the firms whose residual in any of the three regression is greater than the standard error of the regression. The adjusted residuals\textsuperscript{23} from the three regressions are shown. F. & M. Schaefer and White Motor have large positive residuals; both were clearly in financial distress. Their high debt ratios are products of maximal borrowing in reaction to cash flow problems and depressed equity values. BETA understates their asset betas because their debt beta is likely high. Control Data's large positive residual is due to its Commercial Credit subsidiary, which borrows heavily to finance its leasing and lending operations.

Table IV-5 presents the equation (3b) estimates obtained by deleting the other firms of Table IV-4 from the sample. The standard errors are lower and the adjusted R-squares higher than those reported in Table IV-3. Qualitatively the results remain the same. The coefficients which have the largest changes between the full-sample and the partial-sample regressions are those with large standard errors. All further tests are run on the full sample.

Debt ratios. Table IV-6 lists the estimates of the coefficients of equation (3b) using the ratio of book long-term debt to asset value as the dependent variable. The denominators of the book debt ratios BBOOKU, BBOOK48, and BBOOKC use the $\tau = 0$, $\tau = .48$, and declining tax shield assumptions, respectively. In most cases corresponding coefficient estimates in book and market regressions are within one standard error of one another. The fits are better and coefficient standard errors lower in the market debt ratio regression. All further

\textsuperscript{23}The adjusted residual is the residual divided by the standard error of the regression.
TABLE IV-4

Large Residuals: Equation (3b)

<table>
<thead>
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<th>Name</th>
<th>U</th>
<th>Adjusted Residual 48</th>
<th>C</th>
</tr>
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<tr>
<td>F. &amp; M. Schaefer</td>
<td>3.27</td>
<td>4.99</td>
<td>3.56</td>
</tr>
<tr>
<td>Publicker Inds.</td>
<td>-3.30</td>
<td>-3.00</td>
<td>-3.48</td>
</tr>
<tr>
<td>Southwest Forest Inds.</td>
<td>2.08</td>
<td>2.85</td>
<td>3.23</td>
</tr>
<tr>
<td>Cyclops</td>
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<td>-1.83</td>
<td>-3.65</td>
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<td>Barnes Group</td>
<td>-2.22</td>
<td>-2.06</td>
<td>-1.02</td>
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<td>Chicago Pneumatic Tool</td>
<td>-2.09</td>
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<td>-2.20</td>
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<td>Control Data Corp.</td>
<td>1.42</td>
<td>1.12</td>
<td>2.22</td>
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<td>White Motor</td>
<td>1.72</td>
<td>2.27</td>
<td>3.91</td>
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### TABLE IV-5

*Equation (3b) Under Three Tax Shield Assumptions, Outliers Deleted*

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<td>(.0123)</td>
<td>(.0151)</td>
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| Adjusted R² | .8172 | .7304 | .7126 |
| Standard error (Y|X) | .0675 | .1131 | .1334 |

*a* Standard errors in parentheses.
TABLE IV-6

Equation (3b) Under Three Tax Shield Assumptions, Book Debt Ratios

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<th>Independent Variables</th>
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<th>BBookC</th>
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<td>(.0155)</td>
<td>(.0196)</td>
<td>(.0202)</td>
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Adjusted $R^2$          | .7185   | .6147   | .6036   |
Standard error (Y|X)   | .0952   | .1600   | .1815   |

*Standard errors in parentheses.*
tests use market debt ratios.

**Nonlinear relationships.** To test for convexity in the relationships between the dependent and independent variables, the residuals from the regressions reported in Table IV-3 are regressed on the square of each independent variable. The regression coefficients obtained are not significantly different from zero at the .05 level for any of the variables except BETA. The t-statistics are 4.2156, 5.3802, and 5.7007 for BETAU, Beta48, and BETAC, respectively. Neither Von Neumann ratio nor Durbin-Watson statistic tests on sorted residuals reveals nonlinearity problems with the other variables. ²⁴

To determine whether a few outliers cause the observed nonlinear relationship, equation (3b) is run on the sample from which they have been purged. Schaefer and Southwest Forest have the highest residuals and lowest betas of the sample. Publicker has the largest negative residual and a moderate beta. With these three firms purged, the adjusted R-squares rise slightly, but the convexity test t-statistics are 2.2160, 2.3741, and 3.9922, indicating remaining nonlinearity.

Equation (3b) is modified to include a new variable equal to beta squared: ²⁵

\[
\frac{B}{V} = a_0 + a_1\mu + a_2\sigma^2 + a_5\beta + a_7\beta^2 + a_5V + a_6 \frac{O1-\Delta R}{V} + a_7 \frac{DT}{V} \\
+ a_8 \frac{ITC}{V} + a_9 \frac{STA}{V} + a_{10} \frac{PVG0}{V} + e. \tag{3c}
\]

²⁴Theil (1971, pp. 222-225) discusses the use of the von Neumann ratio and the Durbin-Watson statistic to test for nonlinearities.

²⁵Like beta, this variable assumes different forms corresponding to the three tax shield corrections.
The regression estimates appear in Table IV-7. The fit of (3c) is an improvement over (3b). The constants rise, while the negative coefficients on BETA rise in absolute value. The coefficients on MU and SIGMA2 move toward their hypothesized signs (especially in the third regression) but remain close to zero. The coefficient on the size variable V moves closer to zero. Finally, except for the constant the coefficient standard errors decrease substantially. Thus the relationship between the debt ratio and beta appears nonlinear. To avoid a specification error the beta-squared variable is included in all subsequent tests.

**Industry effects.** Few of the industry dummy coefficients (not reported in the tables) differ significantly from zero. Only the coefficients for SIC 2400 (forest products) and SIC 3700 (motor vehicles, parts, and accessories) have t-statistics exceeding one in all three regressions of equation (3c). The positive coefficients (.1080 and .0738, respectively) indicate higher debt ratios, for those industries than for SIC 2000 (foods), for which there is no dummy.

The explanatory power of the group of dummies, hence whether they may be omitted without causing a specification error, may be tested by reestimating the equation while restricting the dummy coefficients to zero. The null hypothesis that the coefficients are zero may be tested by creating the statistic

\[
\frac{(RRSS-URSS)/(df_R-df_U)}{URSS/df_U},
\]

where RRSS is the restricted sum of squared residuals, URSS is the unrestricted sum of squared residuals, and df_R and df_U the respective degrees of freedom. Under the null hypothesis the statistic is
TABLE IV-7

Equation (3c) Under Three Tax Shield Assumptions

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<th>Dependent Variables</th>
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<td>(.0152)</td>
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Adjusted R^2          | .8222   | .7368              | .7890    |
Standard error (Y|X) | .0710   | .1253              | .1209    |

^aStandard errors in parentheses.
distributed as \( F_{(df_R-df_U),df_U} \), which has critical values at the .05 and .01 levels of 1.80 and 2.25, respectively, for \( df_R=159 \) and \( df_U=146 \).

The test statistics for the BU, B48, and BC forms of the equation are 1.7403, 1.9277, and 2.2252, respectively. Thus at best only weak support is provided for the hypothesis of industry differences in average debt ratios, controlling for the independent variables. In general the estimated coefficients (not shown) do not change much when the restrictions are imposed. The average change is about ten percent.

The regression equation can be represented by

\[
Y_{ij} = X_{ij} \beta + \mu_{ij} + \varepsilon_{ij} \quad (i=1,2,\ldots,N),(j=1,2,\ldots,T_i)
\]  

(7)

where \( i \) indexes the industry, \( j \) indexes the firm within the industry, and \( T_i \) is the number of firms in industry \( i \). The dummy variable technique is equivalent to assuming each \( \mu_{ij} \) is fixed in repeated samples and running the equation on data which has been transformed by taking deviations from industry means. Thus the variation which the regression seeks to explain through the estimate of the \( \beta \) vector is purely within-industry variation. By using information on \( \sigma^2 \) but ignoring \( \sigma^2_{\varepsilon} \) the dummy variable technique produces inefficient estimates of the \( \beta \) vector if \( \sigma^2 \) is greater than zero, i.e. if there is significant between-industry variation.

Bias caused by errors in variables is exacerbated by the technique. The asymptotic bias is directly related to the size of the variance of the errors in the variables relative to the variance of the true variables. The dummy variable technique, by eliminating the between-industry variation in the variables, raises the asymptotic bias. OLS lumps both within- and between-industry variation together in the
error term. Thus OLS may be more efficient in the case where \( \sigma^2 > 0 \), but the violation of the Gauss-Markov assumption that \( E(\epsilon_i + \epsilon_{ij} | X_{ij}) = 0 \) means that \( \hat{\beta}_{OLS} \) will be biased and inconsistent if \( \sigma^2 > 0 \). The F-test shown above indicates relatively little between-industry variation which could be picked up by the dummies. Thus it is unlikely that any errors in variables bias has been made worse. This is confirmed by the small change in the estimated \( \beta \) vector.

An alternative specification for equation (7) is the variance components, or random effects, model. A column of ones is included in \( X \) to allow for the estimation of a constant for the entire sample. The industry effects are assumed random, rather than fixed as in the dummy variable model, and independently and identically distributed as \( N(0, \sigma^2) \). Further, the \( \mu_i \) are assumed independent of \( x \) and \( \epsilon \). Equation (7) then becomes

\[
Y_{ij} = X_{ij} \beta + \eta_{ij} \quad (i=1,2,\ldots,N),(j=1,2,\ldots,T_i) \tag{8}
\]

where \( \eta_{ij} = \mu_i + \epsilon_{ij} \). The covariance matrix of residuals is

\[
E(\eta\eta') = \sigma^2 \begin{bmatrix}
A_1 & 0 & \cdots & 0 \\
0 & A_2 & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & A_N
\end{bmatrix}
\]

where \( A_i \) is a \( T_i \times T_i \) matrix

\[
\begin{bmatrix}
1 & \rho & \cdots & \rho \\
\rho & 1 & \cdots & \rho \\
\cdots & \cdots & \ddots & \cdots \\
\rho & \rho & \cdots & 1
\end{bmatrix}
\]

\(^{26}E(\mu_i + \epsilon_{ij}|X_{ij}) = 0 \) for \( \mu_i > 0 \) and \( \sigma^2 > 0 \) when \( X_{ij} \) contains a column of ones to allow the estimation of a constant.
$\sigma^2 = \sigma^2 + \sigma^2$, and $\rho = \sigma^2 / \sigma^2$. A generalized least squares (GLS) procedure may be used to combine the information on sample variance and within-industry correlation to obtain an efficient estimate of $\beta$.

Hausman (1978) shows that the GLS estimator $\beta_{GLS} = (X'\Omega X)^{-1}X'\Omega y$ can be obtained by running OLS on the transformed observations $y_{ij} = y_{ij} - \gamma_i \bar{y}_i$ and $x_{ij} = x_{ij} - \gamma_i \bar{x}_i$, where

$$\gamma_i = 1 - \left(\frac{\sigma^2}{\sigma^2 + T_i \sigma^2}\right)^{1/2},$$

and $\bar{y}_i$ and $\bar{x}_i$ are the means of those variables for industry $i$. Consistent estimates $\hat{\sigma}^2$ and $\hat{\sigma}^2$ can be obtained from OLS and dummy-variable regressions.

The random effects model estimated using the GLS procedure produces estimates, shown in Table IV-8, which are very close to the dummy-variable estimates in Table IV-7. The fact that the estimates from the dummy-variable model and those from the random-effects model are nearly the same supports the hypothesis that equation (3c) is correctly specified. Under misspecification the former estimates should be affected more strongly than the latter ones, causing a deviation between the two sets of estimates.

The GLS estimates, themselves, are sensitive to the specification of the industry effect $\mu_i$. Since the $\mu_i$ are treated as part of the residual vector $\eta$, the conditional mean of $\mu_i$ must be independent

---

27 The $\gamma$s are indexed by industry to allow an "unblanced" model in which the number of firms per industry may vary across industries.

### TABLE IV-8

**Equation (3c) Under Three Tax Shield Assumptions, Variance Components Model**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>BU</th>
<th>Dependent Variables</th>
<th>BC</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td>BU</td>
<td>B48</td>
</tr>
<tr>
<td>Constant</td>
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<td>1.7044</td>
<td>1.5104</td>
</tr>
<tr>
<td></td>
<td>(0.0497)</td>
<td>(0.1415)</td>
<td>(0.1052)</td>
</tr>
<tr>
<td>MU</td>
<td>-0.1787</td>
<td>-0.2948</td>
<td>0.0205</td>
</tr>
<tr>
<td></td>
<td>(0.1022)</td>
<td>(0.1793)</td>
<td>(0.1760)</td>
</tr>
<tr>
<td>SIGMA2</td>
<td>0.1850</td>
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<td>-0.0836</td>
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<tr>
<td></td>
<td>(0.1112)</td>
<td>(0.1963)</td>
<td>(0.1903)</td>
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<tr>
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<tr>
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<td>(0.1284)</td>
<td>(0.3149)</td>
<td>(0.2349)</td>
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<tr>
<td>BETA2</td>
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</tr>
<tr>
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<td>(0.0843)</td>
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<td>(0.1332)</td>
</tr>
<tr>
<td>V</td>
<td>-0.1875</td>
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<td>-0.4009</td>
</tr>
<tr>
<td></td>
<td>(0.1479)</td>
<td>(0.2632)</td>
<td>(0.2553)</td>
</tr>
<tr>
<td>NOI</td>
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<td>-0.1976</td>
<td>0.0387</td>
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<tr>
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<td>(0.1058)</td>
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<td>(0.1581)</td>
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<td></td>
<td>(0.5687)</td>
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<td>1.1815</td>
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<td>(1.1041)</td>
<td>(1.5888)</td>
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<tr>
<td></td>
<td>(0.0354)</td>
<td>(0.0506)</td>
<td>(0.0474)</td>
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<tr>
<td>PVGO</td>
<td>-0.0238</td>
<td>-0.0719</td>
<td>-0.1026</td>
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<tr>
<td></td>
<td>(0.0113)</td>
<td>(0.0151)</td>
<td>(0.0143)</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.8187</td>
<td>0.7146</td>
<td>0.7628</td>
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<tr>
<td>Standard error (Y</td>
<td>X)</td>
<td>0.0708</td>
<td>0.1249</td>
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*Standard errors in parentheses.*
of X for consistency to obtain. Hausman (1978) gives a regression test of the hypothesis that $E(\mu_1|X_{ij})=0$. The test amounts to forming a set of independent variables of deviations from industry means $\tilde{X}_{ij}=X_{ij}-\bar{X}_i$ and estimating

$$y = \tilde{X}_B + \tilde{X}_a + \tilde{v}$$

Under the null hypothesis $\alpha=0$. The F-statistics on the sets of coefficients $\alpha$ from the BU, B4B, and BC forms of the equation are .7476, .8060, and 1.2172, respectively. Since the critical point at .05 of the F distribution with 10 and 149 degrees of freedom is about 1.85, the hypothesis that $E(\mu_1|X_{ij})=0$ is accepted. Thus the hypothesis that the GLS estimate is consistent cannot be rejected.

The F-test on the set of dummy variables from the OLS regressions provides evidence which at a high significance level rejects the hypothesis that the industry dummies as a group, hence industry average debt ratios, differ significantly when controlling for the independent variables in equation (3a). The variance components model, which provides an efficiency gain if between-industry variations exist, and (2) is less troubled by errors in the variables, produces estimates close to the OLS estimates. This result supports the specification of equation (3a) and the hypothesis of no between-industry variation in the constant. Finally, the specification test on the variance components model does not reject the model's specification.

**Partial adjustment to the target ratio.** The partial hypothesis is tested by including the change in $V$ and the change in unsheltered operating income, both normalized by $V$, in equation (3c). The GLS
regression results for the first variable, ΔV, calculated for 1975-1976 are shown in Table IV-9. The estimated coefficient of ΔV has the correct sign, but is not significantly different from zero at the .10 level. Similar results obtain when ΔV is calculated for the five year period 1971-1976. The results for the 1975-1976 change in unsheltered operating income, ΔNOI, appear in Table IV-10. The positive sign on the ΔNOI coefficients do not support the partial adjustment hypothesis with respect to this variable. Use of ΔNOI for 1971-1976 produces similar results. Since the hypothesis is not supported the ΔV and ΔNOI variables are not retained in subsequent tests.

V. Summary of Results

The regressions lend support to the MH model. They do not reject the hypothesis that as the composition of V changes from short-term assets and assets in place to growth opportunities, the debt ratio falls. While the estimated coefficients of PVGO are small (−.02 to −.11), they are economically significant. With an average debt ratio of about 30 percent and a PVGO ratio below zero, the replacement of a dollar of AIP by a dollar of PVGO reduces the marginal debt ratio to between 20 and 28 percent. This result seems robust with respect to the debt ratio measure.

The coefficient estimates for the asset growth rate and variance do not support the MMTB and MMTBS hypotheses. Part of the explanation may be that these parameters calculated from historical data are not good measures of their future values. They will be affected by changes in plowback rates, earnings fluctuations, the cost of capital, etc. Another part of the explanation may lie in the collinearity between
TABLE IV-9
Equation (3c) Under Three Tax Shield Assumptions, Variance Components Model

<table>
<thead>
<tr>
<th>Independent Variables</th>
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<th>Dependent Variables BU</th>
<th>BC</th>
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<td>(.1348)</td>
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<td>(.0143)</td>
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<td>(.0510)</td>
<td>(.0813)</td>
<td>(.0813)</td>
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Adjusted R²            | .8189      | .7138                   | .7622      |
Standard error (Y|X)  | .0707      | .1250                   | .1212      |

²Standard errors in parentheses.
TABLE IV-10

Equation (3c) Under Three Tax Shield Assumptions.
Variance Components Model With ΔNOI

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<th>Dependent Variables</th>
<th>BC</th>
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<td>.0691</td>
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<td>(.0800)</td>
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<td>(.1339)</td>
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<td>(.0024)</td>
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<td>(.5690)</td>
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<td>(1.5066)</td>
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<td>(.0477)</td>
<td>(.0449)</td>
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<td>(.0135)</td>
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<td>ΔNOI</td>
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<tr>
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<td>(.1253)</td>
<td>(.1825)</td>
<td>(.1848)</td>
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</table>

Adjusted R²       .8398    .7497    .7909
Standard error (Y|X) .0666    .1169    .1136

*Standard errors in parentheses.*
these variables and the asset beta, shown to be a determinant of the
debt ratio. The coefficient of BETA may absorb some of the effect of MU
and SIGMA2. Each has the correct sign (albeit with large standard
errors) in the third regression in Table IV-8. The declining-tax-shield
form of the variables, used in that regression, show the lowest pairwise
correlation with the asset beta.

The tax shelter substitutes variables lend no support to the
MMTBS model. The levels of these substitutes do not appear to be
important determinants of corporate borrowing.
## APPENDIX

### Table IV-A1

**Firms in Sample**

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<thead>
<tr>
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<th></th>
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<tbody>
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<td>Borden</td>
<td>2000</td>
<td>Union Camp</td>
<td>2600</td>
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<tr>
<td>Fairmont Foods</td>
<td>2000</td>
<td>Diamond International</td>
<td>2650</td>
</tr>
<tr>
<td>Kraft</td>
<td>2000</td>
<td>Federal Paperboard</td>
<td>2650</td>
</tr>
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<td>Stone Container</td>
<td>2650</td>
</tr>
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<td>National Distillers and Chemical</td>
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<tr>
<td></td>
<td></td>
<td>Celanese</td>
<td>2800</td>
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<tr>
<td>Publicker Inds.</td>
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<td>Diamond Shamrock</td>
<td>2800</td>
</tr>
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<td>Coca-Cola Bottling (N.Y.)</td>
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<td>Dow Chemical</td>
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<tr>
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<td>Ethyl</td>
<td>2800</td>
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<td>2800</td>
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<td>Liggett Group</td>
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<td>2800</td>
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<td>Philip Morris</td>
<td>2111</td>
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<td>2800</td>
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<tr>
<td>Reynolds (R.J.)</td>
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<td>Pennwalt</td>
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<tr>
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<td>Rohm and Haas</td>
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<td>Graniteville</td>
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<td>2835</td>
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<td>Springs Mills</td>
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<tr>
<td>Jonathan Logan</td>
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<td>2835</td>
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<tr>
<td>Phillips-vanHeusen</td>
<td>2300</td>
<td>Robins (A.H.)</td>
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<td>V.F.</td>
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<td>Warnaco</td>
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<td>Bristol-Myers</td>
<td>2835</td>
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<tr>
<td>Great Northern Nekoosa</td>
<td>2600</td>
<td>Sterling Drug</td>
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<tr>
<td>Hammermill Paper</td>
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CHAPTER V
SIMULTANEOUS EQUATION TESTS AND CONCLUSIONS

This chapter is concerned with bias in the OLS estimates of Chapter IV. The first section focuses on the following causes of bias: (1) measurement errors in PVGO, and (2) simultaneous determination of PVGO and the debt ratio. In the second section a two stage least squares (2SLS) instrumental variables approach is introduced to correct the problem, and a test of the legitimacy of the instruments is performed. The third section describes a test of the hypothesis that the OLS regressions are correctly specified. Under the hypothesis, both OLS and 2SLS estimates are consistent and do not differ significantly. Section IV discusses the OLS and 2SLS results. The implications and conclusions of this study appear in the fifth section.

I. Bias in OLS Estimates

The estimates of Chapter IV's single-equation model of corporate borrowing may be biased. One source of the bias is the mismeasurement of the independent variables, particularly the PVGO variable. The second source is simultaneity between the dependent and one or more "independent" variables, particularly between borrowing and PVGO.

**Measurement errors in PVGO.** It is difficult to construct an accurate measure of PVGO. Chapter IV describes the estimation technique for PVGO and shows that most of the measurement problems arise from the need to use replacement cost estimates instead of secondary market prices for capital goods. Though not noted in the previous chapter, the measurement errors may vary across firms. Replacement cost is defined
as the minimum cost of replacing the firm's current productive capacity with the most modern available technologies. For expanding firms the replacement cost is likely to provide a fairly good estimate of the physical assets' market value. Firms not investing in new equipment find that the present value of the cash flows generated by their old equipment (and its potential replacement) does not exceed the cost of replacement. Thus the replacement cost is greater than the old equipment's market value; estimated PVGO may be negative, even though actual PVGO is zero or slightly positive. This helps explain several firms' very large negative estimated PVGO levels in the sample. Most of those firms (e.g. Schaefer and White Motor) actually began liquidating assets, rather than growing. Lindenberg and Ross (1981) also encounter this "dying firm" problem when they attempt to estimate Tobin's q (the ratio of market value to replacement cost) for each of the firms in their sample. To correct for the effect, for each firm they regress the time series of q estimates on a constant and a variable measuring net new investment normalized by firm size. They find the effect negligible. My study cannot employ their technique because a time series of PVGO estimates is not available.

Lindenberg and Ross point out another problem with replacement cost numbers. Capital goods price indices are not as volatile as the highly cyclical spot prices. Thus the replacement cost estimates which are based on these indices overstate underlying spot prices during a period of slack demand, such as 1975–1976.¹ The overstatement biases

¹From year-end 1975 to 1976 unfilled capital goods orders rose only 1.4 percent. From 1976 to 1977 the rate of increase was 66.7 percent. (See Survey of Current Business, various issues.)
downward the PVGO estimates for firms using the indices to estimate replacement costs. This helps to explain the negative average measured PVGO for the 1976 sample.

To determine whether the 1976 regression results are affected by the low PVGO (and q) estimates of that year, Williamson (1979) employs a regression equation to explain 1976 cross-sectional debt ratios. Many of the independent variables in the 1979 study are similar to those used in the previous chapter. Williamson first uses book data instead of replacement cost data to estimate PVGO and reruns the 1976 regression. The coefficients of the book regression, like the replacement cost regression, do not reject the MH hypothesis. The estimate of borrowing against tangible assets changes little. For each firm he estimates 1974 and 1966 PVGO using book data. Average PVGO estimates should be lower and higher than the 1976 estimates, respectively, since the 1974 q ratio was smaller and the 1966 ratio greater than the 1976 ratio. Like the 1976 results, the 1974 and 1966 regressions cannot reject the MH hypothesis, suggesting that the result is not due only to the low 1976 PVGO estimates.

If, in spite of the evidence to the contrary, measurement errors in the PVGO variable exist, they may lead to biased and inconsistent OLS estimates. For a given firm, a deviation of the measured value of PVGO from its actual level may not induce a corresponding change in the debt ratio; the ratio is a function of the actual level of PVGO. The mismeasurement produces a residual which is positively correlated with the measured PVGO, violating one of the assumptions necessary for

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least-squares consistency. This is the classic errors in variables problem illustrated below. A standard remedy is the instrumental variables technique. This entails selecting variables, or "instruments," which are highly correlated with the actual PVGO but uncorrelated with the measurement errors.

Simultaneity of borrowing and PVGO. A second factor may bias the OLS estimates. The appendix to Chapter III shows the debt ratio in the NH model is determined by the interaction of bond- and stockholder reaction functions. In an effort to protect themselves against wealth expropriation from firm underinvestment, the bondholders demand higher promised returns at higher firm debt ratios. Since underinvestment opportunities depend on firm growth options, for a given debt ratio the bondholders' required promised return is positively related to the level of growth options. Stockholders select the debt ratio, a negative function of firm growth options, which maximizes the equity's net present value. The stockholders balance the large interest tax shields of a high debt level with the low promised bondholder returns they pay at a low debt level. The simultaneity problem arises because the value of the growth opportunities is affected by the debt ratio selected. The underinvestment incentive of a high debt ratio reduces the expected present value of the opportunities, PVGO.

The simultaneity of the debt ratio and \( \frac{PVGO}{V} \) is, then, the second source of possible bias in the single-equation coefficient estimates. Imagine that for a given observation there is a rise in the

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4See Malinvaud (1970), Chapter 10.
debt ratio unrelated to the independent variables. This causes a rise in the observation's residual. The high debt ratio simultaneously causes a reduction in the value of the firm's growth opportunities. Thus the residual is negatively related to the measured PVGO, again violating a condition for consistency of the least-squares estimators.

**Errors-in-variables bias.** Consider the regression model

\[ y = X\beta + u \]  \[ (5.1) \]

representing equation (3c), estimated in the last chapter. The ordinary least squares (OLS) estimator \( \hat{\beta} \) used in that chapter is given by

\[ \hat{\beta} = (X'X)^{-1}X'y = \beta + (X'X)^{-1}X'u, \]  \[ (5.2) \]

where \( \beta \) is the true parameter vector, \( y \) the dependent variable, and \( u \) the error term. The OLS assumption is that in the limit the independent variables \( X \) are uncorrelated with the residuals. This is a necessary condition for consistency of the OLS estimator, i.e. for plim \( \hat{\beta} = \beta \).

The assumption that \( \frac{1}{n} X'u = 0 \) in the limit (as the sample size \( n \) goes to infinity) is violated when one of the variables in \( X \), PVGO, is measured with error so that the measured values \( X \) are equal to the sum of the true values \( X^* \) plus the measurement errors \( v \):

\[ X = X^* + v \]  \[ (5.3) \]

Running OLS on the measured \( X \) is then equivalent to running

\[ y = X\beta + u - v\beta \]  \[ (5.4) \]

The OLS estimator becomes

\[ \hat{\beta} = \beta + (X'X)^{-1}X'(u-v\beta) \]  \[ (5.5) \]
This is an inconsistent estimator for \( \beta \) since, taking probability limits,

\[
\text{plim} \hat{\beta} = \beta + \text{plim}(\frac{1}{n}X'X)^{-1}\cdot\text{plim}(\frac{1}{n}X'u) - \text{plim}(\frac{1}{n}X'X)^{-1}\cdot\text{plim}(\frac{1}{n}X'v)\beta. \tag{5.6}
\]

Assume for the moment that neither \( X^* \) nor \( v \) is correlated with \( u \) and that the errors \( v \) are uncorrelated with the true \( X^* \). Then the difference \( \text{plim} \hat{\beta} - \beta \) is just \( -\text{plim}(\frac{1}{n}X'X)^{-1}\cdot\text{plim}(\frac{1}{n}v'v)\beta \). Without loss of generality let the vector of observations on PVGO correspond to the first column of \( X \). If no other variables are measured with error, then \( v \) consists of the vector of errors in PVGO as the first column and zeroes everywhere else. \( v v' \) converges to a matrix \( m_{vv} \) containing the asymptotic variance of the errors in PVGO as \( m_{vv}^{1,1} \), and zeroes elsewhere. Let \( m_{xx}^{-1} = \text{plim}(\frac{1}{n}X'X)^{-1} \), the inverse of the asymptotic variance-covariance matrix of the observed independent variables. The asymptotic bias in \( \hat{\beta}_1 \) is negative one times \( m_{vv}^{1,1} \) times \( m_{xx}^{-1,1} \cdot m_{vv}^{1,1} \), and \( m_{xx}^{-1} \) are both nonnegative. Thus, under the MH hypothesis where \( \hat{\beta}_1 < 0 \), \( \hat{\beta}_1 \) is biased upward (toward zero), even in large samples. The errors-in-variables inconsistency raises the probability of rejecting the MH hypothesis. The asymptotic bias in each of the remaining coefficient estimates, \( \hat{\beta}_i \), is given by negative one times the product of \( m_{vv} \), \( \hat{\beta}_i \), and the \( i \)-th element of the first column of \( m_{xx}^{-1} \). Since the sign of each of these latter elements is a function of the variances and covariances of a given set of the independent variables, \( \hat{\beta}_i \) may over- or underestimate \( \beta_i \) in the limit. If, however, the assumption that

\[
\text{plim}(\frac{1}{n}X'u) = \text{plim}(\frac{1}{n}X^*v) = 0
\]

is violated, it is impossible to predict the direction in which any of the coefficients are biased.
Simultaneous equation bias. Contrary to the assumption just made, the residual \( u \) is likely to be correlated with the true and measured values of \( X \). The simultaneity between \( B \) and PVGO produces a negative correlation between the residual and PVGO (the observations on which are assumed to form the first column of \( X \)). Thus \( \hat{\beta} - \beta \) is equal to the errors-in-variables inconsistency plus \( \text{plim} (\frac{1}{n}XX'X)^{-1} \cdot \text{plim} (\frac{1}{n}X'u) \), the latter being, in general, nonnegative. Imagine that in the limit \( u \) is correlated only with PVGO. Then, if \( m_{XX}^{-1} = \text{plim} (\frac{1}{n}XX'X)^{-1} \) and \( m_{Xu} = \text{plim} (\frac{1}{n}X'u) \), the first element of \( m_{Xu} \) is negative, while the rest of the elements are identically zero. The asymptotic bias introduced in \( \hat{\beta} \) is negative, being the product of \( m_{XX}^{-1} \) (positive) and \( m_{Xu} \) (negative). Under the hypothesis that \( \beta_1 < 0 \), this works in the opposite direction from the errors-in-variables effect and raises the probability of accepting the NH hypothesis. Each of the remaining elements of the vector \( \beta \), \( \beta_i \), is under- or overestimated by an amount equal to \( m_{XX, i}^{-1} \) times \( m_{Xu} \). The sign of the asymptotic bias of \( \beta_i \) due to the simultaneity effect is opposite to that of \( m_{XX, i}^{-1} \), hence opposite to that resulting from the measurement errors in PVGO. Although the two sources of inconsistency in the coefficient estimates work in opposite directions, there is, of course, no assurance that the effects will exactly cancel out. As a result, a method other than OLS is required to provide consistent estimates.

II. A Simultaneous Equations Approach

An instrument for PVGO. An instrument which is highly correlated with actual PVGO and uncorrelated with the structural error term \( e \) is
required to remove the sources of inconsistency in the regression equation

\[
\frac{B}{V} = a_0 + a_1 \mu + a_2 \sigma^2 + a_3 \beta + a_4 \beta^2 + a_5 V + a_6 \frac{O-I-A_R}{V} + a_7 \frac{D T}{V} + a_8 \frac{ITC}{V} \\
+ a_9 \frac{STA}{V} + a_{10} \frac{PVGO}{V} + e. \tag{5.7}
\]

B and PVGO are both endogenous variables, while the others are predetermined. ⁵

An equation determining PVGO completes the two-equation system. The second equation is not intended to provide a test of the determinants of PVGO. Rather it is a means of constructing an instrument for PVGO. ⁶

\[
\frac{PVGO}{V} = b_0 + b_1 \frac{B}{V} + b_2 \text{ALPHA} + b_3 \text{ROI} + b_4 \frac{E}{P} + b_5 \frac{RD}{V} + b_6 \frac{BV}{V} + b_7 \text{LI} \\
+ b_8 \text{CR} + v. \tag{5.8}
\]

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⁵In many economic systems most variables are truly endogenous if the relationships between the variables are pursued to a basic enough level. In this system of two equations B is a function of PVGO and several exogenous variables, and PVGO is a function of B plus a different set of exogenous variables. BETA is considered exogenous to this system. Going one step deeper, PVGO is probably one of the many determinants of BETA. Thus there is really a three-equation system, and BETA is endogenous. BETA may be linked to errors in the first (B) equation through the second (PVGO). I have chosen not to treat BETA (or any additional variables) as endogenous for two reasons. First, the cost involved in enlarging the system is too large to be justified by the small expected improvement in consistency. Second, the theory of asset beta determination is not sufficiently developed to be able to specify a third equation and expect a significant improvement in the estimates of equation (5.6). (See Foster (1978), Chapter 9 for a discussion of the difficulties of identifying the determinants of betas.)

⁶In the limit two-stage least squares is equivalent to an instrumental variables method where the instrument is the fitted left hand side variable from the first stage and the equations are linear. (See Johnston (1972), pp. 380-387.)
Now consider the right-hand side variables, first the endogenous $\frac{B}{V}$, then the exogenous variables. The latter were selected for their expected high correlation with actual $\frac{PVGO}{V}$ and lack of correlation with the errors in measured $\frac{PVGO}{V}$.

1. In the MH model a high value of the endogenous debt ratio, $\frac{B}{V}$, leads to the rejection of investment opportunities with positive net present values but which reduce the equity net present value. Since these options would be exercised at a lower debt ratio, the expected net present value of the options, PVGO, is negatively related to firm borrowing.

2. The acquisition of a valuable growth opportunity by a firm leads to an upward revaluation of the firm's assets in the market. The firm's equity should display abnormal risk-adjusted price performance when the market recognizes the acquisition of a growth opportunity. A firm with a high level of PVGO at time $t$ should therefore show positive equity alphas (in the context of the Sharpe-Lintner capital asset pricing model) during a period prior to $t$. ALPHA is the equity alpha during the five-year period from year-end 1971 through year-end 1976. Under this hypothesis $b_2 > 0$.

3. Firms which have been successful in the past at identifying projects which produce high rates of return may be more successful than others in the future, thus have higher levels of PVGO. ROI measures the average of the annual rates of return on the firm's tangible assets during the 1971-1976 period. The numerator of ROI is constructed by subtracting taxes paid (the book amount corrected for reported investment credits and deferred taxes) from operating income net of depreciation and adding back the estimated tax shield on interest
expense. Thus, $b_3$ should be positive.

4. $E_P$ is the five-year average of the year-end earnings-price ratio for the firm's stock. An earnings-price ratio less than the firm's cost of capital reflects the valuation of assets which are not currently contributing to the earnings stream, i.e. growth opportunities. Thus $b_4$ should be negative.

5. One way to discover and develop growth opportunities is through research. Firms spending heavily for R&D are more likely to have high levels of PVGO. $\frac{RD}{V}$ is the average ratio of research and development expense to beginning-of-period firm value for the 1971-1975 period. Thus $b_5$ should be positive.

6. $\frac{B}{V}$ is the 1976 ratio of book to market value of the firm's physical and financial assets. Errors are induced in $\frac{PVGO}{V} = \frac{V-AIP}{V}$ by the use of replacement cost estimates for the market value of the tangible assets, AIP. The book value of those assets, BV, is correlated with their market value, but not necessarily related to the errors in estimated AIP. Thus $\frac{V-BV}{V}$ is a proxy for the PVGO variable, and $\frac{BV}{V}$ is is negatively related to $\frac{PVGO}{V}$.

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7 Ideally, I would use the true, economic return during the year on the tangible assets the firm owned at the beginning of that year then divide by the beginning-of-year level of assets. Unfortunately, the data do not permit this calculation. The market value of the firm's securities overstates the denominator due to the inclusion of intangibles in the market value. Subtracting the estimated PVGO causes this exogenous variable to be correlated with the residuals in this second equation due to measurement errors in the estimated PVGO.

8 This measure does not capture all R&D expenditures since firms have some latitude in the decision to capitalize these expenditures, rather than to expense them.

9 It is possible that some of the errors in the replacement cost estimate of AIP are also found in the BV estimate. For example, misstatement of actual economic depreciation will affect both. The legitimacy of $\frac{BV}{V}$ as an instrument is tested later in this chapter.
7. LI is an estimate of the Lerner index, and CR the four-firm concentration ratio for the firm's industry shown in the Commerce Department's Census of Manufactures (1972). Both are commonly used measures of market power. A determinant of the value of a new product to its producer is the ability to establish a price which exceeds production and capital costs. The threat of entry in competitive industries may force producers to set prices near the levels at which the project's net present values are zero, LI = \( \frac{P-MC}{P} \). Lacking marginal cost data LI is approximately (sales-operating expenses)/sales. Thus, \( b_7 \) and \( b_8 \) should be positive.

The estimates. The two-stage least-squares (2SLS) method is used to estimate equation (5.7). The method and properties of the estimator are well known. In the first stage PVGO is regressed on the predetermined variables of the equation system (5.7)-(5.8). The fitted values \( \hat{PVGO} \) are used in place of the actual values, PVGO, when (5.7) is estimated in the second stage. By construction \( \hat{PVGO} \) is orthogonal to the residuals, \( e \), of (5.7) so that the inconsistency from the simultaneity of \( B \) and PVGO is purged. \( \hat{PVGO} \) is in effect an instrument for PVGO with the predetermined variables weighted to maximize the correlation between the two. If the predetermined variables are uncorrelated with the

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10A problem with these measures is that they are backward-rather than forward-looking. They measure the conditions in the industry in which most of the firm's current products are classified, rather than the one in which its growth opportunities exist. The presumption is that most firms' growth opportunities are in the industries in which they currently operate.

11See Lindenberg and Ross (1981), p. 27.

measurement errors in PVGO, the errors-in-variables inconsistency is also eliminated.

The results of the 2SLS regressions appear in Table V-1. The left-hand variables BU, B48, and BC are uncorrected for interest tax shields, corrected at \( \tau = .48 \), and corrected assuming declining tax shields, respectively. The coefficient estimates of some variables change little from the corresponding OLS regression reported in Table IV-7. These variables, Constant, BETA, BETA2, and PVGO, have small standard errors in both OLS and 2SLS regressions. The estimated coefficients of many of the remaining variables change considerably, particularly in the 348 and BC regressions. The wrong signs on the MU and SIGMA2 coefficients in two of the 2SLS regressions and the large standard errors in the third reject the NMTB hypothesis. Wrong signs and large standard errors on the tax shelter substitutes variables reject the NMTBS hypothesis. The negative sign and generally low standard error on the PVGO coefficient does not reject the MH hypothesis.

**BV**
A test of \( V \) as an instrument. Hausman and Taylor (1980a) derive a test of the null hypothesis that a variable assumed predetermined is indeed uncorrelated with the structural disturbance term. The test determines whether \( \frac{BV}{V} \) is uncorrelated with the disturbance term in equation (5.7). If it is correlated, the estimates in Table V-1 are inconsistent. If it is uncorrelated but omitted from the first stage, the second stage estimates are inefficient. \( q = \hat{\beta} - \beta \) is equal to the difference between the vectors of estimated structural coefficients when \( \frac{BV}{V} \) is included in the first stage and when it is excluded. Under \( H_0 \), \( q \) converges to a variable with mean zero. Let \( X_1 \) be the RHS variables in
TABLE V-1

2SLS Estimates of Equation (5.7),
Three Tax Shield Assumptions

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<td>MU</td>
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<td>(.0475)</td>
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<td>(.0176)</td>
<td>(.0156)</td>
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<td>Resid. Variance</td>
<td>.0054</td>
<td>.0171</td>
<td>.0167</td>
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</table>

*a Asymptotic standard errors in parentheses.
(5.8), \( W \) the matrix of all predetermined variables except \( \frac{BV}{V} \), and \( W_1 \) the same matrix including \( \frac{BV}{V} \). The test statistic \( m \) equals

\[
\frac{1}{2} \sum_{e} \left( [\left( X_1' P_W X_1 \right)^{-1} - \left( X_1' P_{W_1} X_1 \right)^{-1}] \right) q'.
\]

\( P_W \) and \( P_{W_1} \) are the orthogonal projection operators on the column spaces of \( W \) and \( W_1 \). The generalized inverse is denoted by \( (\dagger) \). Under \( H_0 \), \( m \) is asymptotically distributed as chi-square with one degree of freedom.

The test statistic \( m \) is 0.0061, 0.2300, and 2.2503 for the BU, B48, and BC regressions, respectively. With the 90th and 95th percentiles of the chi-square at 2.71 and 3.84, the hypothesis that \( \frac{BV}{V} \) is uncorrelated with \( e \) cannot be rejected at the .10 or .05 level in any of the three regressions. Thus \( \frac{BV}{V} \) is retained.

III. A Test of Inconsistency of the OLS Estimates

The OLS and 2SLS can be used to test the null hypothesis that the OLS regressions are correctly specified, i.e. that the errors in variables problem does not exist. Under \( H_0 \) the 2SLS estimator is consistent but not asymptotically efficient. OLS is both consistent and asymptotically efficient. Under the alternative hypothesis of misspecification the OLS estimator is inconsistent, while the 2SLS estimator is not. Thus only under the alternative hypothesis is it desirable to retain the 2SLS estimates.

Following the procedure given by Hausman (1978), let \( X_2 \) denote the matrix of known predetermined variables (excluding \( \frac{PVGO}{V} \)) in the structural equation (5.7) and \( Z \) denote the same matrix with an additional column corresponding to observations on the instrument \( \frac{PVGO}{V} \).

\[
\hat{X}_1 = Z(Z'Z)^{-1}Z' \frac{PVGO}{V},
\]

the orthogonal projection \( \frac{PVGO}{V} \) onto the column
space of Z. A test of $H_0$ is $\alpha = 0$ in the regression

$$\frac{B}{V} = \beta_0 \frac{PVGO}{V} + \beta_1 x_2 + \alpha \hat{X}_1 + e. \quad (5.9)$$

The test results appear in Table V-2. The critical $t$ value at the .05 level is 1.65. Thus the null hypothesis of the orthogonality of $\frac{PVGO}{V}$ and $e$ is rejected only for the BC regression. The greatest change in estimated coefficients between OLS and 2SLS also occurs for the BC regression.

**TABLE V-2**

<table>
<thead>
<tr>
<th>Regression</th>
<th>BU</th>
<th>B48</th>
<th>BC</th>
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<tbody>
<tr>
<td>$\alpha$</td>
<td>0.0105</td>
<td>-0.0386</td>
<td>-0.0883</td>
</tr>
<tr>
<td>S.E.($\alpha$)</td>
<td>0.0201</td>
<td>0.0266</td>
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<tr>
<td>t-statistic</td>
<td>5.20</td>
<td>1.450</td>
<td>-3.511</td>
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**IV. Discussion of Results**

The 2SLS technique attempts to purge the coefficients of inconsistency which may arise from measurement errors in the PVGO variable and from the simultaneous determination of B and PVGO. The 2SLS estimates show little qualitative difference from the OLS estimates; MMTB and MMTBS can be rejected, while MH cannot. The specification test of the 2SLS models indicates that the efficiency of the OLS estimates can be exploited in the BU and B48 regressions because it detects no misspecification of those single-equation models. The 2SLS estimates
can be exploited in the 8U and B48 regressions because it detects no 
misspecification of those single-equation models. The 2SLS estimates of 
the BC model should be used because the test cannot reject the hypo-
thesis of misspecification of the BC equation OLS estimates, indicating 
that they may be inconsistent.

In the 2SLS regressions the $\mu$ and $\sigma^2$ variables again give 
ambiguous results. They cannot be construed as supporting MMTB and 
MMTBS. There may be several causes for these 2SLS (and OLS) results. 
In Chapter III's two-period model the firm sets borrowing at a level 
which equates the present values of the expected bankruptcy cost and the 
expected tax shield on a marginal dollar of borrowing. These quantities 
are functions of the one-period asset growth rate. In reality, of 
course, portions of the firm's debt mature at different times. Thus the 
probability distributions of the ex ante compound growth factors to 
several time points are important. Furthermore, since $\mu$ and $\sigma^2$ are dis-
tributional parameters of a future growth rate, they cannot be measured 
directly. Unless the distribution of one-period rates is stationary 
through time, the historical estimates may contain errors. The $\sigma^2$ 
estimate probably contains errors due to the small number of observa-
tions for each firm, even if the distribution is stationary.

The variable $\mu$ is intended to proxy for the firm's reinvest-
ment rate by picking up the firm's growth rate. The growth rate is 
likely to be related to other variables appearing in the tests, e.g. the 
asset beta and the level of growth opportunities. This may explain the 
positive sample correlation between asset beta and asset growth rate 
noted in Chapter IV. The asset growth rate also shows high sample 
correlation with the PVGO variables; firms which have grown rapidly also
have high current levels of growth opportunities. If μ picks up some of the PVGO effect on borrowing, under MH μ may have a negative coefficient in the regressions.

The 2SLS and OLS coefficient estimates for the tax shelter substitutes lead to the rejection of MMTBS. The lumpiness of a firm's investment credits may explain why the current level of ITC does not affect borrowing if there are costs of adjustment to the target debt ratio. It is more surprising, though, that income net of depreciation is not positively related to the debt ratio. Perhaps managers consider it easy to "sell" unused interest and depreciation x shields through mergers and acquisitions. Furthermore, managers may to some extent follow a financing path of least resistance. That means using retained earnings when available, instead of issuing debt or equity. High-income firms will have lower, not higher, debt ratios due to their use of retained earnings for financing.

The 2SLS PVGO coefficient estimates differ from the corresponding OLS estimates by up to approximately 30 percent. Only the 2SLS estimate from the BU equation is not less than zero at the .05 level.\(^1^3\) We cannot reject the MH hypothesis in light of this evidence that firm borrowing against PVGO is less than against AIP. For a ten percent increase in \(\frac{PVGO}{V}\), the debt ratio BU (assuming firm value does not reflect any interest tax shields) falls by about 0.3 percent. For the same increase in \(\frac{PVGO}{V}\), the debt ratio BC (assuming firm value reflects

\(^{13}\) The specification test above suggests that the OLS estimates of the BU and B48 equations are consistent and more efficient than the corresponding 2SLS estimates.
declining tax shields on currently held assets) falls by about 1.3 percent.

The estimates of the systematic risk coefficients are consistently significantly negative in the OLS and 2SLS runs. There is very little difference between the two sets of estimates. The asset systematic risk's impact on the debt ratio is very strong. A ten percent rise in beta reduces the BU ratio by more than 12 percent and reduces B48 by more than 26 percent. If V reflects no interest tax shields (the BU regression), a rise in asset beta to .8184 from its sample mean of .7440 causes the debt ratio to drop to .2425 from .2756. Similarly, if V reflects perpetual 48 percent tax shields (the second regression), the debt ratio drops to .2491 from .3400 if the asset beta rises to .9451 from its .8592 sample mean.

The 2SLS estimates of the firm size effects on borrowing differ by more than 50 percent from the OLS estimates. In all cases the sign is "wrong," suggesting that the debt ratio falls with increasing firm size. In none of the regressions, however, do the estimates differ significantly from zero.

Finally, while the results are not shown, the hypothesis of partial adjustment of the actual ratio to target was tested in the 2SLS model. The test is made by including ΔV, the change in firm value and ΔNOI, the change in operating income, as predetermined variables. As described in Chapter IV, these variables were constructed for periods of several lengths, all ending in 1976. In both OLS and 2SLS regressions, ΔV's estimated coefficient was not significantly different from zero, while ΔNOI's estimate was of the "wrong" sign. The inclusion of ΔV and ΔNOI resulted in negligible changes in the other coefficient estimates.
These tests indicate that firms' partial adjustment to target debt ratios is unlikely to significantly affect the reported results.

**Direct effects on borrowing.** Chapter IV shows that the direct effect of the level of AIP on borrowing is given by the partial derivative \( \frac{\partial B}{\partial AIP} = a_0 + 2Va_5 \), where \( a_0 \) is the regression constant and \( a_5 \) the coefficient on \( V \). Table V-3 gives the values of this derivative at the sample mean firm value, \( V \). The estimates for the 3U and 348 forms of the regression are derived from the efficient and consistent GLS coefficients, while the estimate for the BC form uses the 2SLS coefficients. Under the MM hypotheses \( \frac{\partial B}{\partial AIP} = 1 \). The table displays the t-statistics for the difference \( 1 - \frac{\partial B}{\partial AIP} \).\(^{14}\) A one-tailed test rejects the MM hypotheses at the .05 level for the 348 and BC estimates. This may indicate that the full 48 percent perpetual tax shield correction to firm value is much too high.

The direct effect of PVGO on borrowing is given by

\[
\frac{\partial B}{\partial PVGO} = \frac{\partial B}{\partial AIP} - a_{10},
\]

where \( a_{10} \) is the coefficient on \( \frac{PVGO}{V} \). Table V-3 shows that, while firms borrow significantly less against PVGO than against AIP, they do borrow quite heavily against PVGO. Since growth options are probably often riskier than tangible assets, the beta coefficient's magnitude suggests that risk may be a larger deterrent to borrowing against PVGO than is the moral hazard problem.

It may be possible to structure tests differently to derive more efficient estimates of the direct effects on borrowing. The estimates presented above are derived from equations which are

\(^{14}\)The standard error is given by \[
\left[ \sigma^2 + (2V)^2 \sigma^2 + 2(2V) \sigma_{a_0} \sigma_{a_5} \right]^{1/2}.
\]
structured to provide power to distinguish between several capital structure hypotheses. Given that one hypothesis is accepted, new tests may be devised to provide more efficient, unbiased estimates.

TABLE V-3

Direct Effects on Borrowing

<table>
<thead>
<tr>
<th></th>
<th>BU (GLS)</th>
<th>B48 (GLS)</th>
<th>BC (2SLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{\partial B}{\partial AIP} )</td>
<td>0.9232</td>
<td>1.6989</td>
<td>1.3171</td>
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<tr>
<td></td>
<td>(1.5454)</td>
<td>(-4.7465)</td>
<td>(-2.7522)</td>
</tr>
<tr>
<td>( \frac{\partial B}{\partial PVGO} )</td>
<td>0.8994</td>
<td>1.1270</td>
<td>1.1860</td>
</tr>
</tbody>
</table>

*at-statistics of 1 minus \( \frac{\partial B}{\partial AIP} \) in parentheses.*

V. Conclusions

Implications of this study. Two simple hypotheses receive strong support from all of the tests. First, the firm debt ratio is negatively related to the proportion of the firm's value comprised of growth opportunities, ceteris paribus. The negative coefficients on the PVGO variable in every regression in this study support the hypothesis. Although the change in the debt ratio relative to a change in \( \frac{PVGO}{V} \) is economically small, the negative coefficient estimates always have very small standard errors, suggesting that the estimates are precise. This piece of direct evidence adds to Smith and Warner's (1979) in showing that agency costs affect corporate debt policy. They suggest that the MMIB and MMIBS models are incomplete. Similarly, in predicting random cross-sectional debt ratios the Miller model (1977) is inconsistent with this study's results.
The second hypothesis receiving support from every regression in this work is that the debt ratio is negatively related to the systematic risk of the firm's assets. These results are consistent with the MMTB model derived in Chapter III, which shows that the optimal debt ratio is negatively related to the asset systematic risk through the bankruptcy cost effect. Since the bankruptcy cost effect is consistent with the MMTB, MMTB3, and MH models, this result cannot be used to reject any of the three. It does suggest that Miller (1977), Warner (1977b), and Haugen and Senbet (1978) ignore important factors when they argue that bankruptcy costs are either too small or can be avoided too easily to affect debt ratios.

The erratic signs of the estimated coefficients of the asset growth rate and variance lead to rejecting the MMTB and MMTB3 hypotheses that these variables have positive and negative effects on the debt ratio respectively. This is further support for the MH model, since asset growth is a function of future (discretionary) investment. Current borrowing against expected investment creates a moral hazard and may lead to "suboptimal" investment. Furthermore, the asset growth rate is highly correlated with the growth opportunities variable. The correlation could obscure the positive growth effect on the debt ratio.

This study provides no support for the hypothesis that tax shelter substitutes reduce firm debt ratios. The signs on the tax shelter variables fluctuate across regressions, are frequently inconsistent with the hypothesis, and have large standard errors.

Finally, the hypothesis of scale and industry effects on the debt ratio can be rejected. The sign on the firm size variable rejects the scale hypothesis in every regression. This result conflicts with
those of several studies reviewed in Chapter II. The industry effect result agrees with the Ferri-Jones (1979) result and suggests that industry may proxy for the asset risk and growth opportunities variables.

**Areas needing further investigation.** The support for the MH hypothesis is strong. Econometric techniques have been carefully employed to test for and reduce the effects of specification and measurement errors. Yet several problems remain. The theory suggests that borrowing is related to the expected asset level when the debt matures. First, using the past asset growth rate to proxy for the expected future rate may introduce errors. Second, the fact that portions of the firm's debt mature at different times means that no single ex ante growth rate is sufficient information.

A second problem lies in the measurement of the present value of growth opportunities. The number of firms having negative estimated PVGOs is evidence, in spite of PVGO's theoretical zero lower bound. The replacement cost numbers used to estimate PVGO likely contain noise and may systematically mis-estimate the physical asset's market value. If \( VIT > 0 \) (due, for example, to monopoly rents) for a given firm, the measured PVGO incorrectly contains the value of those intangibles. While this chapter employs an instrumental variables technique to purge errors from the PVGO estimates, it would be preferable to develop better estimates to begin with.

We still don't know much about estimating the present value of expected bankruptcy costs. As a result it is difficult to state the direct effect of the costs on the debt ratio. While the value is probably related to the asset risk, and the risk was found to affect
borrowing, the link between the costs and borrowing is still practically unexplored.

Finally, it is clear that the value of interest tax shields must play an important role in any study of this type. Yet we know little about estimating that value. Without perpetual debt the MM estimate is probably too large, but we have no idea how large that value is and how much it varies cross-sectionally.

In spite of its shortcomings this study sheds some supporting light on a new theory of capital structure, which has received scant empirical attention.
REFERENCES


Survey of Current Business, various issues.


