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# Managerial Preference, Asymmetric Information, and Financial Structure

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**ABSTRACT**

If firm performance affects managers' wealth or reputation, preferences of managers dominate firms' financing decisions. When information about real asset investment is symmetric, managers finance exclusively with equity. If managers know more about asset quality than do investors and if managers are sufficiently risk averse, they signal high-quality projects with debt. Increases in collateral value decrease risky debt use. Increases in interest rates that do not change productive opportunities increase debt use. The explanation for these and further results is based on underpricing of equity and overpricing of debt at the margin.

THE LEGACY OF MODIGLIANI and Miller [24, 25] is to begin any study of firms' financing decisions in a perfect market setting. The major features of this setting are frictionless capital markets, homogeneous expectations, individuals who can borrow and lend at a risk-free rate, no bankruptcy costs, and no taxes. An arbitrage argument can be used to show that, given these assumptions, the value of a firm is invariant to the proportion of debt or equity used in its capital structure. To this basic framework, frictions (or advantages or disadvantages of debt use) are typically added to obtain an optimal capital structure. Most advantages or disadvantages of debt take the form of an increase or decrease, associated with debt use, of total present or future cash flows available for distribution to suppliers of capital. The most commonly cited advantage to debt is the corporate tax deductibility of interest payments. (See Modigliani and Miller [25].) The most commonly cited disadvantage of debt is bankruptcy costs. (See Stiglitz [34], Baxter [5], and Kraus and Litzenberger [18].) There is considerable debate over whether these two factors are sufficient to determine an optimal capital structure for individual firms. Warner [36], using data collected from eleven railroad bankruptcies, illustrates that bankruptcy costs are trivial when measured as an expected cost prior to bankruptcy. On the other hand, the empirical finding of Warner [37] that the performance of bonds in the month of a bankruptcy petition is significantly negative indicates nontrivial bankruptcy costs. Further, Altman [2], measuring both direct and indirect costs of bankruptcy

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in a sample of twelve retail and seven industrial bankruptcies, concludes that bankruptcy costs cannot be considered trivial. The methodology used, however, cannot distinguish between reduced cash flows that lead to the possibility of bankruptcy and further reduced cash flows that result because of the possibility of bankruptcy. Haugen and Senbet [12] point out that bankruptcy costs are equal to the minimum of bankruptcy cost proceedings (direct and indirect costs) and informal costs of reorganization through capital markets. Since the latter costs are small, Haugen and Senbet conclude that bankruptcy costs are unlikely to explain cross-sectional regularities. Miller [22] argues that, in an environment of progressive personal taxation, firms, in general, issue bonds until the corporate advantage of debt is offset by the personal tax disadvantage of interest income. This process leads to an optimal capital structure for the economy as a whole but not for an individual firm. DeAngelo and Masulis [8] demonstrate that, even with personal taxes, in equilibrium, the corporate tax advantage of debt for any firm is positive but is offset by bankruptcy costs no matter how small. Kane et al. [17] argue that, if the tax advantage of debt is small, firms' costs of deviating from optimal debt ratios are small and that this result is consistent with a wide range of debt ratios. In Canada, 43.0 percent of corporations rarely pay tax,[1] and 44.9 percent of investment is undertaken by firms that rarely pay tax. These results imply that the tax motivation for debt financing is likely to be overstated.

The ability of the tax-shield and bankruptcy-cost model of capital structure to accurately predict debt ratios is ultimately an empirical question. However, if bankruptcy costs are not great and if the corporate tax advantage of debt is offset by personal tax disadvantages of interest income, or if a large number of firms seldom pay tax, the reasons for commonly observed cross-sectional regularities in debt ratios are not clear. Moreover, many observed regularities in firms' capital-structure decisions do not appear to be explainable in the context of the tax shield-bankruptcy cost methodology. Two of these regularities are the tendency for stock prices to decline substantially after equity financing and the tendency for equity financing to follow stock price increases and strong overall market performance. These and other empirical inconsistencies have led financial economists to view firms' decisions from a broader perspective than has previously been customary. In particular, the assumptions that managers act exclusively in the interests of shareholders and that investors and managers have equivalent information on firms' operations are increasingly being abandoned when interpreting firms' financial behavior.

Much current research on financial structure studies asymmetric information between the firm and investors (and either the moral hazard or signalling generic problems[2]). A firm's capital structure arises to minimize adverse consequences

[1] Rarely taxable firms are defined as firms that have paid tax in fewer than three of the previous six years. The source of these empirical observations is a May 1985 discussion paper by the Honourable Michael H. Wilson, Minister of Finance, entitled "The Corporate Income Tax System: A Direction for Change."

[2] Examples of the moral hazard approach applied to financial structure include Jensen and Meckling [16], Haugen and Senbet [13], Myers [26], and Grossman and Hart [10]. Examples of signalling methodology applied to financial structure include Ross [31], Leland and Pyle [19], and Myers and Majluf [28].

of informational asymmetry. One response a firm might make to asymmetric information associated with its value is financial signalling. Leland and Pyle [19] consider the fractional ownership of a firm retained by an entrepreneur as a signal of firm quality. They are able to show that, as this fraction increases, the value of the firm correspondingly increases. If entrepreneurial ownership is sufficiently great, they show that increases in ownership are associated with increased debt. This result establishes an indirect link between firm value and firm borrowing. In Ross [31], managers have a penalty in their compensation plans that is imposed in bankruptcy. If the firm has a high-quality project, managers can increase their wealth by signalling with debt financing. Investors correctly interpret this action as implying a high-quality project because they realize that managers use debt financing only if the probability of bankruptcy is small. Although this result is intuitively appealing, it rests on the dubious assumption of a managerial penalty for bankruptcy. This feature limits the generation of many interesting propositions.

The intent of the current paper follows that of Ross—to study firms' capital-structure decisions as signalling phenomena. A major difference between this paper and that of Ross is the managerial motivation for signalling. The separation of ownership and control in most modern corporations means that the interests of management and shareholders often diverge. For this reason, managements generally share in firm profitability through compensation plans. This arrangement more closely ties management's interests to those of shareholders. Even in the absence of any transactions costs or taxes, the connection between firm profitability and managerial wealth affects financing decisions. The motivation for managers' capital structure signalling is, therefore, both different from and more appealing than that used by Ross; managers signal with capital structure because the utility of their future wealth is affected by financial decisions.

To be fair to Ross, he does discuss the possibility, in both [31] and [32], that managerial preferences affect capital-structure decisions but abandons this approach because of problems associated with signalling both managerial preference and firm value. One might respond to this view in two ways. First, financial analysts spend considerable time and effort in assessing the quality of firm management when estimating value. In the process of undertaking this evaluation, in addition to assessing the quality of firms' operations, managerial preferences over risk situations are partially revealed. On the other hand, investors may have no knowledge of managerial preference. Through capital-structure decisions of firms over many similar decisions, they are led to expect that certain types or qualities of projects are associated with certain types of financing. Investors need not know managerial motivation to interpret financial signals correctly.

The current paper is also related to that of Myers and Majluf [28]. Both papers use signals that are not fully revealing. In the current paper, firms use debt or equity financing. The decision to use debt or equity establishes regions in which managers prefer either of these securities and in which investors correctly value securities on average. Investors cannot ascertain firm value precisely based on financial signals. The Myers and Majluf paper can best be characterized as a financial-signalling paper where the signal is the decision to either finance a

project with equity or abandon it. They show that, if investors have less information not only on a project to be financed, but also on the value of assets in place, in some circumstances, value-maximizing firms prefer to pass up projects with positive net present value rather than allow new shareholders to participate in capital gains associated with undervaluation of assets in place. Myers and Majluf attempt to extend their analysis to firms' decisions to finance with either risky debt or equity. Unfortunately, they misinterpret the result that capital gains that result from changes in firm value are less for bonds than for newly issued shares to mean that firms always prefer risky debt to equity. In the current paper, it is shown that, if the firm or its managers maximize value, even though capital gains on bonds are less than those on new shares, no rational-expectations equilibria exist. On the other hand, if managers are sufficiently risk averse, they signal high firm value with debt and low firm value with equity.

The managerial approach taken in this paper can be justified by the presence of asymmetric information. In a widely held firm, it is managers and insiders, rather than shareholders, who have private information. If managers' reputations or wealth are affected by firm performance, their actions are influenced by attitudes to risk.

The first result in this paper shows that, with symmetric information, managers always use equity. Even in an M-M world where shareholders are indifferent to capital structure, managers prefer equity over debt. The Modigliani-Miller irrelevance proposition remains true, albeit in a restricted form. Shareholders are indifferent to capital structure, but managers prefer equity. Managers' preference for equity means that the economy as a whole prefers equity. This preference is not adverse to owners' interests since they are indifferent to capital structure. Managers' aversion to debt results because debt increases the "total risk" of share ownership. If managers' compensation is in part tied to equity performance and if managers are risk averse, they prefer equity over the financial risk associated with debt.

If a manager of a firm has more information on a project than do investors and if the manager is sufficiently risk averse, then rational-expectations signalling equilibria are shown to exist in which firms with high-quality projects use debt financing. Managers of firms with low-quality projects have no incentive to misrepresent their projects by using debt since misrepresentation creates excessive risk. The rational-expectations equilibria have several surprising properties. If debt is risky, an increase in collateral value reduces debt use. This result obtains because increased fixed assets (collateral value for risky debt) decrease both equity underpricing and bond overpricing at the margin between preference for debt or equity financing. If debt is riskless, if an increase in fixed assets acts like an increase in wealth for managers, and if this increased wealth decreases managerial risk aversion, the use of riskless debt can increase. On the other hand, an increase in fixed assets reduces equity underpricing at the margin, which alternatively can lead to reduced debt use. An increase in interest rates that does not change productive opportunities (i.e., possible cash flows) increases debt use. This result obtains because an increase in interest rates does not alter the mispricing of equity but accentuates overpricing of debt at the margin. Further results establish the effects of managerial risk aversion and scale of

investment. The explanation for all results is based on underpricing of equity and overpricing of debt at the margin between debt and equity use.

The remainder of this paper proceeds as follows. Section I introduces the basic features of the model with which firms' capital-structure decisions are studied and illustrates for comparison the well-known M-M capital-structure irrelevance proposition in an environment in which information between insiders and investors is symmetric and managerial preference has no influence on financial policy. Section II retains the symmetric-information assumption but allows managers' risk preferences to influence capital-structure policy. The major results of the paper are contained in Sections III and IV. In Section III, the assumption of symmetric information is relaxed. Conditions for a rational-expectations signalling equilibrium are established. In Section IV, comparative statics are investigated. Section V discusses empirical implications. Section VI concludes the paper.

## I. Symmetric Information and Value-Maximizing Managers

Insiders and investors have the same information on a project a firm is about to finance. Further, managerial risk preference has no influence on financing decisions. Managers' only motive is to maximize existing shareholders' wealth. The following simple model of a manager's financing decision is considered. The firm has a project that is successful with probability $p$. The total dollar return for the project is $Z$ if it is successful and 0 if it fails. Required investment is $I$, which is financed with either debt or equity. For simplicity, the firm is initially all equity financed, the risk-free interest rate is zero, and the project is zero beta. The project has positive net present value, i.e., $pZ - I \geq 0$. Let $N_0$ be the number of currently outstanding shares and $N_1$ the number of newly issued shares if the firm uses an equity financing. Let $V_0$ be the value of existing operations not associated with the new project. Finally, debt is risky, i.e., $V_0 < I$. The following proposition is a variant of the well-known M-M capital-structure irrelevance proposition.

PROPOSITION 1: *If investors know the values of the project and the firm, existing shareholders' wealth is* $V_0 + pZ - I$, *regardless of the source of financing.*

*Proof*: Price per share is $\dfrac{V_0 + pZ - I}{N_0}$. To maximize shareholders' wealth, this is the price at which the manager should sell new shares to finance the project.[3] The number of newly issued shares is $\dfrac{IN_0}{V_0 + pZ - I}$. After an equity financing, shareholders of record before the financing are entitled to their fraction, $\dfrac{N_0}{N_0 + N_1}$, of everything of value in the firm. This value is comprised of the firm's operations without the project plus the value of cash flows from the project itself.

[3] A general cash offer of new common shares is assumed. For an analysis of rights versus underwritten offerings under asymmetric information, see Heinkel and Schwartz [15].

Shareholders' wealth after equity financing is

$$\frac{N_0}{N_0 + \frac{IN_0}{V_0 + pZ - I}} (V_0 + pZ)$$

$$= \frac{V_0 + pZ - I}{V_0 + pZ} (V_0 + pZ) = V_0 + pZ - I \equiv V_0 + \text{NPV}.$$

This result illustrates that shareholders receive the expected net present value of the project from the financing.

If the manager decides to use debt, the firm receives a cash inflow of $I$ dollars from the sale of bonds, required investment is an outflow of $I$ dollars, and the firm has a present expected value of future interest payments of $I$ dollars. If the project fails, bondholders take over the firm; if the project succeeds, bondholders receive face value $D$, where this amount satisfies

$$I = pD + (1 - p)V_0.$$

The net effect on shareholders' expected wealth is

$$V_0 + pZ - I + I - (pD + (1 - p)V_0) = V_0 + pZ - I \equiv V_0 + \text{NPV}.$$

Since shareholders receive the NPV of the project under either equity or debt financing, they are indifferent to the manager's choice. Q.E.D.

Proposition 1 rests on the assumptions that capital markets are efficient and that the firm's common shares are held in shareholders' well-diversified portfolios so that risk-neutral valuation of the project is appropriate.

## II. Symmetric Information and Managerial Risk Preference

The implication of Proposition 1 is that shareholders are indifferent to a manager's financing decisions. If managers share in firm profitability through a compensation plan, their preferences determine firm capital-structure policy.

Let $U$ ($U' > 0$, $U'' < 0$) be the manager's utility-of-wealth function. Embedded in the definition of the manager's utility function are the details of a compensation plan by which he or she shares in firm profitability.[4] Managers' utility may, therefore, be defined over existing owners' share of firm value.

With symmetric information, there is little motivation for a managerial compensation plan that depends upon firm performance; managers can be paid a fixed wage with no additional direct or indirect costs to shareholders. The importance of the compensation plan arises in following sections on asymmetric information. With asymmetric information, if a manager is paid only a fixed wage and if managers are effort averse, they would undertake no real asset

[4] Managerial compensation takes the form of shares or a percentage of profits. This ties managers' interests to shareholders. A compensation plan with stock options may or may not provide incentives that are consistent with shareholders' interests. Since option values increase with share-price variability, debt might dominate equity.

investment, claiming negative net present values. A compensation plan that depends upon firm performance is required to induce managerial effort.

If the manager uses equity financing, expected utility of final wealth is

$$pU\left[\frac{V_0 + pZ - I}{V_0 + pZ}(V_0 + Z)\right] + (1 - p)U\left[\frac{V_0 + pZ - I}{V_0 + pZ} V_0\right].$$

If the manager uses debt, expected utility of final wealth is

$$pU[(V_0 + Z - D)] + (1 - p)U[0].$$

PROPOSITION 2: *For any probability of project success, equity is preferred by the manager over debt financing.*

*Proof*: The manager's expected final wealth is invariant under either debt or equity financing. However, final wealth is higher under debt financing if the project is successful and lower under debt financing if the project fails. Second-order stochastic dominance ensures that, for any manager with a concave utility function, equity is preferred to debt. Q.E.D.

If the manager's utility function is strictly concave, there is a strict preference for equity, while the manager is indifferent between debt and equity if the utility function is linear.

The intuitive reason for Proposition 2 is that debt financing increases the "total" risk (measured by variance, for example) of equity holding in the firm. If the project succeeds, shareholders do better than if the firm had used equity financing. If the project fails, shareholders do worse than if the firm had used equity financing. Since both methods have the same expected value, the manager chooses to finance with equity. Equity financing results in a lesser variability of return.[5]

## III. Asymmetric Information and Managerial Preference

The firm manager knows that the true probability of project success is $p$. Investors have some information on the unknown probability of success[6] that is fully described by the probability-density function of a random variable $\Phi$, $f(\phi) > 0$, $\underline{p} \leq \phi \leq 1$, $\underline{p} < 1$.[7] All other attributes of the project and the firm are known to

[5] The proposition depends upon the assumed share-ownership form of the managerial-compensation plan. Agrawal and Mandelker [1] find that financial investment of managers in their own firms is dominated by share ownership. For highest ranked officers, share ownership is almost thirty times the value of stock options. Even with compensation plans that include, in part, stock options, managers are likely to prefer variance-reducing financing methods. Human capital investment is also likely to contribute to variance-reducing incentives. Both Treynor and Black [35] and Amihud and Lev [3] argue that managers pursue variance-reducing activities.

[6] It is assumed that penalties and probability of detection deter managers from using private information to profit from trades in their firms' securities.

[7] If investors' probability of perceived project quality is defined over a region $[\underline{p}, \bar{p}]$, $\bar{p} < 1$, it is possible for equity to dominate debt. An example is $\underline{p} = \bar{p}$, the case considered in the previous section. Results in this paper hold with a greater investment in mathematical technique if investors' probability distribution of perceived project quality is not absolutely continuous.

investors. If firm management develops through time a sequence of projects of the above form, the density $f$ can be interpreted to be the inherent distribution of quality of these projects. The manager finances the project with risky debt or equity or abandons it. Although it is conceivable that a manager might undertake a negative NPV project (and this possibility is commented on below), it is assumed that, because managers share in firm performance, they undertake only projects with positive expected net present value, i.e., $\underline{p} \geq I/Z$.

The lower bound on investors' perceived probability of project success can be made endogenous to the model. (This extension is given only passing consideration in this paper.) With private information, firm managers undertake negative net present value projects if overvalued securities sold to finance the project offset the effect on existing shareholders of reduced firm value resulting from the project. A signalling equilibrium has the property that projects that are abandoned are revealed to be negative NPV and projects financed with equity are expected by investors to be positive NPV but can be negative NPV, while projects financed with debt are known to be positive NPV. If the lower bound is endogenous to the model, real asset investment and financing decisions are not independent but are jointly determined.

Of course, the manager might sell the project. This option is ignored in this paper because the analysis required to investigate this possibility is sufficiently different from that of the debt/equity choice that it necessitates separate treatment. The decision to sell a project is taken only if the project is of low value. This action introduces another signal that complicates the analysis. Further, the manager might be willing to sell a project with negative NPV, and, still further, if the manager sells the project, the interests of shareholders and managers are not congruent. Management is willing to sell the project for a price less than its true value because the certainty equivalent of the project to managers is less than its expected value.[8]

*Definitions*: Let $S_E$ and $S_B$ be subsets of the interval $[\underline{p}, 1]$, with $S_E \cup S_B = [\underline{p}, 1]$, where investors expect managers to use equity or debt financing, respectively. Let $\Phi_E = \mathrm{E}[\Phi \mid \phi \in S_E]$ and $\Phi_B = \mathrm{E}[\Phi \mid \phi \in S_B]$. These calculations are investors' expected probabilities of project success if managers use equity or debt financing, respectively. Let $\mathrm{E}[U \mid p, \Phi_E]$ be the manager's expected utility if the true probability of success is $p$, the manager finances with equity, and investors value new shares based on an expectation of project success $\Phi_E$. Similarly, let $\mathrm{E}[U \mid p, \Phi_B]$ be the manager's expected utility if the true probability of success is $p$, the manager finances with debt, and investors value this debt based on an expectation of project success $\Phi_B$. Rational-expectations signalling equilibria exist if there are nonempty subsets $S_E$ and $S_B$, of the interval $[\underline{p}, 1]$, in which $p \in S_E \Leftrightarrow \mathrm{E}[U \mid p, \Phi_E] \geq \mathrm{E}[U \mid p, \Phi_B]$ and $p \in S_B \Leftrightarrow \mathrm{E}[U \mid p, \Phi_B] \geq \mathrm{E}[U \mid p, \Phi_E]$.

[8] Myers and Majluf also ignore the possibility that the project might be sold. If it is included in their analysis, loss of firm value associated with abandoning a project with positive NPV disappears. Moreover, adding the possible sale of the project leads to the interesting empirical prediction that, when firms divest assets by sale, stock prices should increase. The intuition for this result is that the sale of assets is a signal that remaining assets are undervalued, and, therefore, the firm wishes to avoid losing part of the capital gain associated with this undervaluation to "new" security holders.

The following proposition establishes several properties of signalling equilibria, should any exist. Specifically, it is shown that the sets $S_E$ and $S_B$ are convex, while their interiors are disjoint. Any element in the interior of $S_E$ is lesser than any element in that of $S_B$. This relationship implies that $\Phi_E < \Phi_B$.

PROPOSITION 3: *If signalling equilibria exist, investors' best estimate of the true probability of project success under equity financing, $\Phi_E$, is lesser than that under debt financing, $\Phi_B$.*

*Proof*: The first part of the proof establishes that the sets $S_E$ and $S_B$ are convex. Next it is shown that, in any rational-expectations equilibrium, if $p_1 \in S_E$ and $p_2 \in S_B$, then $p_1 \leq p_2$. This inequality means that debt signals high project value. The implication of these two results is that $\Phi_E < \Phi_B$.

First note that

$$\mathrm{E}[U \mid p, \Phi_E] = pU[s(V_0 + Z)] + (1 - p)U[sV_0],$$

where $s = \dfrac{V_0 + \Phi_E Z - I}{V_0 + \Phi_E Z}$, and

$$\mathrm{E}[U \mid p, \Phi_B] = pU[V_0 + Z - D] + (1 - p)U[0],$$

where $D = \dfrac{I - (1 - \Phi_B)V_0}{\Phi_B}$. The derivative of the difference between $\mathrm{E}[U \mid p, \Phi_E]$ and $\mathrm{E}[U \mid p, \Phi_B]$ with respect to $p$,

$$\frac{d}{dp}\{\mathrm{E}[U \mid p, \Phi_E] - \mathrm{E}[U \mid p, \Phi_B]\}$$

$$= \{U[s(V_0 + Z)] - U[sV_0]\} - \{U[V_0 + Z - D] - U[0]\},$$

is constant with respect to $p$. Ignoring for the moment the possibility that the derivative is zero, this result means that the sets $S_E$ and $S_B$ are convex. To show that $\Phi_E < \Phi_B$, it must be shown that the above derivative is negative. Suppose that the derivative is not negative (that is, it is either positive or zero); this means that the manager's wealth if debt financing is used and the project is a success is less than wealth if equity financing is used. However, this is not possible since this would imply that expected final wealth (and firm value as well) is greater under equity financing than under debt financing. In this circumstance, equity would always dominate debt.[9] A rational-expectations signalling equilibrium can be characterized as a critical probability of project success, $p^*$, with $\Phi_E \equiv \Phi_E(p^*) = \mathrm{E}[\Phi \mid \phi \leq p^*]$, $\Phi_B \equiv \Phi_B(p^*) = \mathrm{E}[\Phi \mid \phi \geq p^*]$, $S_E = \{\phi \mid \phi \leq p^*\}$, and $S_B = \{\phi \mid \phi \geq p^*\}$. This argument means that, if a rational-expectations equilibrium exists, then $\Phi_E < \Phi_B$. Q.E.D.

The following proposition establishes a sufficient condition for a rational-expectations signalling equilibrium. If no such equilibria exist, any financing

[9] If equity dominates, the manager always uses equity. After a sufficiently long period of time, investors apply expectations based on equity financing for any potential bond financing. Bond financing is then attractive to managers if the probability of success is high. This evolution of expectations means that investors' beliefs that managers always use equity financing are not rational.

decision that investors interpret to imply a poor-quality project induces managers to misrepresent project quality by using alternative financing.

PROPOSITION 4: *A sufficient condition for the existence of a rational-expectations signalling equilibrium is that managers be sufficiently risk averse.*

*Proof*: A signalling equilibrium exists if there exists a probability $p^* \in (\underline{p}, 1)$ such that $E[U \mid p^*, \Phi_E(p^*)] = E[U \mid p^*, \Phi_B(p^*)]$. Because $\underline{p} < 1$, note that $E[U \mid 1, \Phi_E(1)] < E[U \mid 1, \Phi_B(1)] = E[U \mid 1, 1]$. Since $E[U \mid p, \Phi_E(p)]$ and $E[U \mid p, \Phi_B(p)]$ are continuous, a sufficient condition for a signalling equilibrium to exist is that, for $p = \underline{p}$,

$$E[U \mid \underline{p}, \Phi_E(\underline{p})] = E[U \mid \underline{p}, \underline{p}] > E[U \mid \underline{p}, \Phi_B(\underline{p})]. \tag{1}$$

The inequality does not hold for utility functions with Arrow-Pratt indices of absolute risk aversion (over the range of this calculation) in a neighborhood of zero. The inequality is satisfied, and, therefore, the sufficient condition for signalling equilibria is satisfied if the utility function is "sufficiently" risk averse. The utility function $U$ can be made more risk averse with an increasing concave transformation (i.e., $G' > 0$, $G'' < 0$; for details see Pratt [29]). Define $G(\cdot) = \log(\cdot - \varepsilon)$. As $\varepsilon$ approaches $U[0]$ from the left, the inequality in (1) holds with the utility function $U$ replaced by the utility function $G(U)$. If the manager is sufficiently risk averse (as reflected in the above utility transformation), then the condition for signalling equilibria, equation (1), is satisfied. Q.E.D.

The intuition behind Proposition 4 begins with Proposition 2. Other things being equal (in particular, symmetric information), managers prefer equity to debt financing. For any equilibrium, if $p \in (\Phi_E(p^*), p^*]$, then the manager sells undervalued equity. The manager accepts this underpricing because of equity preference. However, if equity is overly underpriced, i.e., $p \in (p^*, 1]$, the manager signals this underpricing by using debt. Investors correctly interpret debt to imply a high-value project because they know of managers' equity preference and would use debt only if the probability of project success were high. A high success probability promises a higher return when the project succeeds if debt rather than equity is used. Debt is a credible signal only if manager risk aversion is great and, correspondingly, equity preference is strong. If risk aversion is not great and if investors interpret debt to mean high quality, managers use debt even if quality is low because aversion to financial risk is low and, as a result, there are no inhibitions against falsely signalling as a high-quality project with overvalued bonds.[10]

Proposition 4 does not guarantee a unique signalling equilibrium.[11] However, of all equilibria, the one that uses the greatest amount of equity dominates all

[10] The model in this paper is similar to that of Leland and Pyle [19] in that an insider signals firm value by bearing risk.

[11] The following example illustrates the possibility of multiple signalling equilibria. Let $U(\cdot) = \log(\cdot)$, $V_0 = 27$, $I = 100$, $Z = 100$, and let the manager have initial wealth at 20. If $\Phi$ is uniformly distributed over [.25, 1], there are two rational-expectations equilibria with $p^*$ at 0.39 and 0.55.

others[12] in the sense that managers' expected utility is greatest (for any probability of project success) in the equilibrium with the greatest equity use. To see this, note that $\frac{d\Phi_E(p^*)}{dp^*} > 0$, $\frac{d\Phi_B(p^*)}{dp^*} > 0$,

$$\frac{\partial}{\partial \Phi_E}\{pU[s(V_0 + Z)] + (1 - p)U[sV_0]\}$$

$$= \{pU'[s(V_0 + Z)](V_0 + Z) + (1 - p)U'[sV_0]V_0\}\frac{\partial s}{\partial \Phi_E} \geq 0 \ \forall\, p \in [\underline{p}, 1],$$

and

$$\frac{\partial}{\partial \Phi_B}\{pU[V_0 + Z - D] + (1 - p)U[0]\}$$

$$= -\{pU'[V_0 + Z - D]\}\frac{\partial D}{\partial \Phi_B} \geq 0 \ \forall\, p \in [\underline{p}, 1].$$

The result that managers' utility is greatest in the equilibrium with the greatest equity illustrates managers' inherent equity preference.

Signalling equilibria exist if the function $\mathrm{E}[U \mid p, \Phi_E(p)] - \mathrm{E}[U \mid p, \Phi_B(p)]$ has a zero for some $p \in (\underline{p}, 1)$. The sufficient condition, equation (1), establishes the positivity of this function at $\underline{p}$. As discussed previously, $\mathrm{E}[U \mid 1, \Phi_E(1)] - \mathrm{E}[U \mid 1, \Phi_B(1)] = \mathrm{E}[U \mid 1, \Phi_E(1)] - \mathrm{E}[U \mid 1, 1] < 0$. These two results and continuity of the function ensure that, at the dominating equilibrium (i.e., that with the greatest $p^*$),

$$\frac{d}{dp}\{\mathrm{E}[U \mid p, \Phi_E(p)] - \mathrm{E}[U \mid p, \Phi_B(p)]\} \leq 0$$

at $p = p^*$. Equality in this expression is possible in the presence of multiple equilibria. In this case, comparative statics do not exist because the equilibrium disappears for small perturbations. Comparative statics in the following section are therefore restricted to the case where strict inequality applies.

As a corollary to Proposition 4, it can be shown that no signalling equilibrium exists if the manager is risk neutral. Assume the contrary, i.e., that there exists a $p^* \in (\underline{p}, 1)$ such that $p < p^* \Leftrightarrow s(V_0 + pZ) > p(V_0 + Z - D)$ and $p > p^* \Leftrightarrow s(V_0 + pZ) < p(V_0 + Z - D)$. However, if $p = \Phi_E$ (and since $\Phi_E < p^*$), the first inequality does not hold, and, therefore, a signalling equilibrium does not exist.[13]

[12] The notion of a signalling equilibrium that dominates all others is also used by Leland and Pyle [19] and Riley [30].

[13] This result does not imply that debt always dominates equity if the manager is risk neutral. The reason that this implication cannot be drawn is that, if debt dominates equity, and as a result debt is always used in preference to equity, then there is no basis for the expectation that the probability of project success is lesser under equity than debt financing (i.e., $\Phi_E < \Phi_B$). On the other hand, assuming that the expectation of the probability of project success under equity financing is equal to or greater than the expectation of the probability of project success under debt financing also leads to managerial behavior that is inconsistent with the expectations of investors.

If manager risk aversion is low, the incentive to misrepresent low-quality projects is not abated by aversion to financial risk.

The nonexistence of a signalling equilibrium, when managers are risk neutral, is true even though capital gains (that result when investors learn of the true project-success probability) are lesser on bonds than on newly issued shares.[14] This relationship between capital gains on bonds and equity is misinterpreted by Myers and Majluf [28] to mean that risky debt is always preferred to equity.[15] What can be concluded from this relationship is that no rational-expectations equilibrium is possible with debt or equity financing if the firm's operational objective is to maximize value. This conclusion is consistent with Heinkel [14], who establishes necessary and sufficient conditions for costless[16] capital-structure signalling models. Assuming value-maximizing behavior, Heinkel shows that one condition for costless capital-structure signalling is that capital gains (associated with revelation of unknown firm quality) on debt are positive while capital gains on equity are negative. This condition is restrictive,[17] and, since capital gains on both equity and debt are positive in both this paper and Myers and Majluf, in neither case does a signalling equilibrium exist (assuming a risk-neutral manager or a value-maximizing firm).

A costless signalling equilibrium exists in the model if "double-liability" common stocks are issued. Double-liability common stocks have the property that, if the firm goes bankrupt, common shareholders are bonded to make an additional contribution of funds to creditors. If the sum of fixed assets in the firm and the bonded additional contribution is greater than the original issue value of bonds, then a costless signalling equilibrium exists. Since, in this case, capital gains and losses with respect to changes in the unobserved component of firm value are opposite in direction for common shareholders and bondholders, the results of Heinkel [14] can be invoked to guarantee a signalling equilibrium. A firm with a low-quality project does not attempt to misrepresent itself as a high-quality firm by using debt financing because, if it does and the project fails (which is more likely with the low-quality firm), shareholders are forced to make the bonded additional payment. Only firms that are most certain that they will not incur this penalty use double-liability securities.

[14] Showing that capital gains on bonds are less than those on newly issued shares is the same as showing that, after financing, the true value of the firm (i.e., assuming that the probability of project success is revealed) increases faster for a change in the probability of project success if debt is used rather than equity. In other words,

$$\frac{\partial}{\partial p}\, s(V_0 + pZ) \leq \frac{\partial}{\partial p}\, p(V_0 + Z - D).$$

It is easy to show that this inequality holds.

[15] The conclusion of Myers and Majluf that risky debt financing is preferred to equity financing is independent of their assumption that insiders have more information on both the returns to assets in place and a project to be financed.

[16] In the current paper, it is easy to show that shareholders' expected wealth is the same in the signalling equilibrium as with exclusive debt or equity use. The equilibrium is, therefore, costless.

[17] A similar condition is obtained by Brennan and Kraus [6], who show that, if a firm signals its earnings distribution from among a set of earnings distributions that are ranked by first-order stochastic dominance with a single security and if a costless signalling equilibrium exists, the value of the security cannot be monotone in the true earnings of the firm.

A fundamental feature of Proposition 4 is that the signalling equilibrium is less than fully revealing. That is, investors cannot ascertain with certainty firm value. This feature results because managers in the firm finance the project entirely with equity or entirely with debt. One might wonder whether this assumption is restrictive. It is relatively easy to show that the combination of pure debt and pure equity financing always dominates a mixture of debt and equity financing as a signal of firm value. Only an outline of the proof is given here. Because the manager's utility (and firm value as well) increases most rapidly for an increase in the true probability of project success for debt financing, less rapidly for a mixed financing, and least rapidly for an equity financing, any signalling equilibrium has the property that investors' best estimate of the true probability of project success is least under equity financing, greater under a mixed financing, and greatest under a debt financing. At the same time, at the probability of project success for which the manager's expected utilities under pure debt and pure equity financing are equal (given investors' expectations), the manager's expected utility under a mixed financing is lesser. This is true even if there is no probability of default on debt associated with the mixed financing. This result, combined with the sensitivities of the manager's expected utility with respect to the true probability of project success under the three financing options, ensures that, for any probability of project success (given investors' expectations under the three financing methods), the manager's utility under one of either pure debt or pure equity financing is always greater than the manager's utility under a mixed financing. In other words, a mixed financing is a "lemon" with respect to a strategy of either pure debt or pure equity financing. This argument means that an equilibrium with debt, equity, and mixed debt and equity financing does not exist.

## IV. Comparative Statics

The relationship between financing and various firm characteristics is studied in this section. None of the comparative-static changes affect investors' probability density of perceived project quality[18] $f(\phi) > 0$, $\underline{p} \leq \phi \leq 1$, $\underline{p} < 1$. The critical probability of project success, $p^*$, that establishes the regions in which the firm uses equity or debt financing represents the firm's relative use of debt. Over a sequence of similar projects, the critical probability represents the propensity of an individual firm to use debt or equity.

### *A. Collateral Value Decreases Debt Use*

The value of the firm's operations not associated with the project, $V_0$, is the collateral value of risky debt.

PROPOSITION 5: *Firms' debt use decreases with the collateral value of risky debt.*

[18] Other than their effects on investor expectations, $\Phi_E$ and $\Phi_B$, perturbations in investors' probability density of perceived project quality have no effect on managers. Changes that affect the mean or mean-preserving spreads in this distribution can either increase or decrease either $\Phi_E$ or $\Phi_B$. Such changes, therefore, have differing effects on financial structure. A mean-preserving spread where probability is massed at the extremities of the distribution's support, $\underline{p}$ and 1, decreases $\Phi_E$ and increases $\Phi_B$ and, therefore, increases debt use.

*Proof*: Define

$$F(p) = \{\mathrm{E}[U \mid p, \Phi_E(p)] - \mathrm{E}[U \mid p, \Phi_B(p)]\}.$$

The effect of collateral value on financing is then determined by

$$\frac{dp^*}{dV_0} = -\frac{\partial F(p)/\partial V_0 \mid_{p=p^*}}{\partial F(p)/\partial p \mid_{p=p^*}}.$$

In Section III, it was established that $\partial F(p)/\partial p \mid_{p=p^*} < 0$ and, therefore, that $\text{sign}(dp^*/dV_0) = \text{sign}(\partial F(p)/\partial V_0 \mid_{p=p^*})$. Note that

$$\partial F(p)/\partial V_0 \mid_{p=p^*} = p^* U'[s(V_0 + Z)] \frac{\partial\{s(V_0 + Z)\}}{\partial V_0} + (1 - p^*)U'[sV_0] \frac{\partial sV_0}{\partial V_0} - p^* U'[V_0 + Z - D]\left\{1 - \frac{\partial D}{\partial V_0}\right\}. \quad (2)$$

The terms $\frac{\partial\{s(V_0 + Z)\}}{\partial V_0}$, $\frac{\partial\{sV_0\}}{\partial V_0}$, and $1 - \frac{\partial D}{\partial V_0}$ are positive; the managerial utility function is concave; and, because both $s(V_0 + Z)$ and $sV_0$ are less than $V_0 + Z - D$, equation (2) is positive if

$$p^* \frac{\partial\{s(V_0 + Z)\}}{\partial V_0} + (1 - p^*) \frac{\partial sV_0}{\partial V_0} \geq p^*/\Phi_B.$$

More explicitly,

$$\frac{IV_0}{(V_0 + \Phi_E Z)^2} + \frac{V_0 + \Phi_E Z - I}{V_0 + \Phi_E Z} + \frac{IZp^*}{(V_0 + \Phi_E Z)^2} \geq p^*/\Phi_B.$$

Simplifying,

$$1 + \frac{(p^* - \Phi_E)IZ}{(V_0 + \Phi_E Z)^2} \geq p^*/\Phi_B.$$

Since $\Phi_E \leq p^* \leq \Phi_B$, this inequality holds. Q.E.D.

The intuition behind Proposition 5 rests on changes in underpricing of equity and overpricing of debt at the margin between the firm's use of debt and equity. The true value of newly issued shares, given that investors have valued equity based on their expectation, $\Phi_E$, is

$$(1 - s)(V_0 + pZ) = \frac{I(V_0 + pZ)}{V_0 + \Phi_E Z} \quad \forall\ p \in [\underline{p}, p^*],$$

while the price that was paid for these shares is $I$. Equity underpricing is, therefore,

$$\frac{IZ(p - \Phi_E)}{V_0 + \Phi_E Z} \geq 0 \quad \forall\ p \in [\Phi_E, p^*]. \quad (3)$$

For $p \in [\Phi_E, p^*]$, shares have been underpriced, and, for $p \in [\underline{p}, \Phi_E]$, shares have been overpriced. In the area of marginal equity use (i.e., underpricing), an

increase in the value of assets in place $V_0$ reduces equity underpricing. Since managers have a natural preference for equity (Proposition 2) and only switch to debt if there is serious underpricing of equity, a reduction in equity underpricing induces increased equity use. The intuitive reason for reduced underpricing is, in part, that new shareholders are purchasing claims on the firm's fixed assets, the value of which is known. Underpricing of securities used to finance a project that makes up a small portion of the total value of the firm is not a serious error for the firm.

If the manager uses debt and if $p \in [p^*, \Phi_B]$, debt is overpriced, while, if $p \in [\Phi_B, 1]$, debt is underpriced. Given that the manager finances with debt, the overpricing of bonds is

$$p \frac{I - (1 - \Phi_B)V_0}{\Phi_B} + (1 - p)V_0 - I \leq 0 \ \forall \ p \in [p^*, \Phi_B]. \tag{4}$$

The derivative of this expression with respect to $V_0$ is

$$\frac{\Phi_B - p}{\Phi_B} \geq 0 \ \forall \ p \in [p^*, \Phi_B].$$

If $p \in [p^*, \Phi_B]$, increased collateral value decreases the overpricing of debt. At the margin, decreased overpricing of debt reduces the attractiveness of bonds to managers.

The intuition for reduced bond overpricing is that, in the region of bond overpricing, investors have overestimated the probability of project success. This error is less serious (reduced bond overpricing) if collateral value of debt is higher. In other words, even if the firm goes bankrupt, the bondholders take over a firm with substantial value, and, therefore, misestimation of the probability of project success is a less serious problem. As the collateral value of debt approaches the required investment on the project, misestimation of the probability of bankruptcy does not affect shareholders at all.

The above two results, that, at the margin between equity and debt use, both equity underpricing (undesirable for managers) and bond overpricing (desirable for managers) are reduced with increases in assets in place, mean that there is an incentive for managers to use increased equity and, correspondingly, decreased debt. Increased collateral value of debt reduces the mispricing of all securities. This reduction moves the asymmetric-information problem toward the symmetric-information problem of Section III, where managers' equity preference dominates. Reduction in the significance of security mispricing leads managers to use more of their preferred security equity and, correspondingly, lesser debt.

Early in Section III, it was mentioned that it is possible to make the lower bound on investors' perceived probability of project success, $\underline{p}$, endogenous to the model. However, this lower bound represents a negative NPV. Managers undertake projects with low probabilities of success regardless of negative NPV because the benefit of overvalued equity sold to finance the project offsets for existing shareholders the effect of reduced firm value from the project itself. As fixed assets in the firm increase, investors' estimate of the minimum possible probability of success for a project to be financed increases. The intuition for

this result follows from equation (3). If $p \in [\underline{p}, \Phi_E]$, the firm has sold overvalued equity. A sale of overvalued equity is attractive to managers and encourages its use in this region. However, as fixed assets increase, overvaluation of equity decreases and discourages its use.

Notice that, even if the firm can issue default-free debt, the firm finances with equity if the true probability of project success is sufficiently low. In other words, there remain regions in which the firm uses debt or equity financing. Even though bonds are always correctly priced, managers use equity because of their inherent preference for this type of financing. Managers switch to riskless debt financing only if the underpricing of equity is sufficiently severe. This result is in contrast to Myers and Majluf, who claim that firms always use default-free financing before risky financing. The reason for the difference in these two results is the effect of managerial preference on financing activities in the current paper.

If an increase in fixed assets affects managerial risk aversion with respect to decisions made for the firm in the same way an increase in personal wealth affects personal risk aversion and if increased fixed assets decrease managerial risk aversion, it is possible for increased use of *default-free* debt to result from increased fixed assets. The reason for this possibility is that managers become less averse to the more risky security. On the other hand, if the effect of fixed assets on managerial risk aversion is not great, the effect of decreased equity underpricing (at the margin) dominates and the use of equity increases; correspondingly, the use of default-free debt decreases. In the case of *risky* debt, mispricing of securities always dominates the effect of fixed assets on managerial risk aversion.

Notice that the expression for the underpricing of equity, equation (3), is convex, while the expression for the overpricing of bonds, equation (4), is linear in the value of fixed assets. The strength of the effect of mispriced equity decreases with fixed assets, while the strength of the effect of mispriced bonds is unaltered. These factors imply that the relationship between the value of fixed assets and the critical probability of project success, $p^*$, tends to be increasing concave. These relationships can be interpreted to mean that a firm's ability to finance with equity is enhanced to the greatest extent, for an increase in fixed-asset value, for smaller rather than larger firms. This result can be interpreted to mean that the ability of a private firm to "go public" is affected by the size of fixed assets. The greatest hindrance to small firms "going public" is informational asymmetries. Without these asymmetries, there would be no difference between the abilities of small and large companies to finance with equity. The problems of asymmetric information are alleviated by fixed assets.

In Proposition 5, no firm value was lost because of the manager's financing decision. This assumption means that financing choice is dominated by managerial preference. However, if firm value is lost through bankruptcy, there is an aversion to debt that decreases its use.[19]

[19] All simplified models of reality have bounds on their area of applicability. The following corollary treads close to these bounds since the signalling equilibrium is no longer costless. The region over which shareholders would like to signal (credibly) high firm value is not the same as the region in which managers would like to signal. Because of managers' preference for equity, shareholders would view managers as using too little debt. The interests of managers and shareholders are not congruent.

COROLLARY TO PROPOSITION 5: *A decrease in asset (in place) value that results from bankruptcy reduces debt use.*

*Proof*: Let $V_0 - C_0$ ($C_0 < V_0$) be the loss of assets in place that is caused by bankruptcy. Collateral value of debt is $C_0$, and face value is

$$D = \frac{I - (1 - \Phi_B)C_0}{\Phi_B}.$$

Since $\operatorname{sign}\left(\frac{dp^*}{dC_0}\right) = \operatorname{sign}(\partial F(p)/\partial C_0 \mid_{p=p^*})$ and

$$\partial F(p)/\partial C_0 \mid_{p=p^*} = p^* U'[V_0 + Z - D] \frac{\partial D}{\partial C_0}$$

$$= -p^* U'[V_0 + Z - D](1 - \Phi_B)/\Phi_B < 0,$$

bankruptcy costs reduce debt use. Q.E.D.

*B. Risk Aversion*

Although not surprising, the following proposition is included for completeness.

PROPOSITION 6: *An increase in managerial risk aversion increases equity use.*

*Proof*: Define $X_1 = U[s(V_0 + Z)]$, $X_2 = U[sV_0]$, $Y_1 = U[V_0 + Z - D]$, and $Y_2 = U[0]$. The marginal probability between equity and debt use, $p^*$, satisfies

$$p^* X_1 + (1 - p^*)X_2 = p^* Y_1 + (1 - p^*)Y_2. \tag{5}$$

Consider a more risk-averse manager with utility function $G[U]$ ($G' > 0$, $G'' < 0$). Because of equation (5) and the relations $Y_2 \leq X_2 \leq X_1 \leq Y_1$, second-order stochastic dominance ensures that

$$p^* G[X_1] + (1 - p^*)G[X_2] - \{p^* G[Y_1] + (1 - p^*)G[Y_2]\} > 0.$$

This expression is decreased by increasing $p^*$, and, therefore, equity use increases. Q.E.D.

*C. Higher Interest Rates Increase Debt Use*

If the one-period cash flows from existing assets and the project are $V_0$ and $Z$, respectively, and if $R$ is one plus the one-period riskless interest rate, then the capitalized values[20] of existing assets and project return (if the project succeeds) are $V_0/R$ and $Z/R$. Since share price before an equity financing is $[(V_0 + \Phi_E Z)/R - I]/N_0$, existing owners' share of the firm is

$$s = \frac{V_0 + \Phi_E Z - RI}{V_0 + \Phi_E Z}.$$

The present value of total dollar returns is $s(V_0 + Z)/R$ if the project succeeds

[20] Alternatively, $V_0$ and $Z$ can be interpreted as perpetual cash flow earnings from existing assets and from the project (if it is successful). The amounts $V_0/R$ and $Z/R$ are the corresponding capitalized values, where $R$ is reinterpreted to be the interest rate rather than one plus the interest rate.

and $sV_0/R$ if the project fails. The face value of debt is $D = \dfrac{RI - (1 - \Phi_B)V_0}{\Phi_B}$. The present value of bond payments is $D/R$ if the project succeeds and $V_0/R$ if the project fails. The marginal probability of project success, $p^*$, satisfies

$$p^*U\left[\frac{s(V_0 + Z)}{R}\right] + (1 - p^*)U\left[\frac{sV_0}{R}\right] = p^*U\left[\frac{V_0 + Z - D}{R}\right] + (1 - p^*)U[0]. \quad (6)$$

PROPOSITION 7: *Increased interest rates increase firms' debt use.*

*Proof*: Since

$$\frac{\partial}{\partial R}\left[\frac{s(V_0 + Z)}{R}\right] = -\frac{V_0 + Z}{R^2},$$

$$\frac{\partial}{\partial R}\left[\frac{sV_0}{R}\right] = -\frac{V_0}{R^2},$$

and

$$\frac{\partial}{\partial R}\left[\frac{V_0 + Z - D}{R}\right] = -\frac{V_0 + \Phi_B Z}{\Phi_B R^2}$$

and since $\text{sign}(dp^*/dR) = \text{sign}(\partial F(p)/\partial R\,|_{p=p^*})$, the sign of

$$-p^*U'[E_1]\frac{V_0 + Z}{R^2} - (1 - p^*)U'[E_2]\frac{V_0}{R^2} + p^*U'[D_1]\frac{V_0 + \Phi_B Z}{\Phi_B R^2}, \quad (7)$$

where $E_1 = \dfrac{s(V_0 + Z)}{R}$, $E_2 = \dfrac{sV_0}{R}$, and $D_1 = \dfrac{V_0 + Z - D}{R}$, must be determined. Multiplying by $\Phi_B R^2$, equation (7) reduces to

$$-p^*U'[E_1]\Phi_B(V_0 + Z) - (1 - p^*)U'[E_2]\Phi_B V_0 + p^*U'[D_1](V_0 + \Phi_B Z). \quad (8)$$

Because of the concavity of the utility function, equation (8) is lesser than

$$-U'[E_1]\Phi_B(V_0 + p^*Z) + U'[D_1]p^*(V_0 + \Phi_B Z).$$

This expression is lesser than

$$U'[D_1]\{(p^* - \Phi_B)V_0\} < 0. \quad \text{Q.E.D.}$$

Following the intuition developed in Subsection *A*, debt usage increases if, for $p \in [\Phi_E, p^*]$, the underpricing of equity increases and if, for $p \in [p^*, \Phi_B]$, the overpricing of debt increases. The underpricing of equity is

$$p(1 - s)\frac{V_0 + Z}{R} + (1 - p)(1 - s)\frac{V_0}{R} - I \;\forall\; p \in [\Phi_E, p^*].$$

Since $1 - s = \dfrac{RI}{V_0 + \Phi_E Z}$, this expression reduces to

$$\frac{[p - \Phi_E]IZ}{V_0 + \Phi_E Z} \geq 0 \ \forall \ p \in [\Phi_E, p^*].$$

Because this expression is independent of $R$, interest rates have no effect on equity mispricing. Increased interest rates mean that new shares must be sold at a lesser price and that new shareholders receive an increased share of the firm. The benefit to new shareholders of increased interest rates is exactly offset by reduced present value of assets in place and project returns.

The overpricing of bonds is

$$p\,\frac{RI - (1 - \Phi_B)V_0}{\Phi_B R} + (1 - p)\,\frac{V_0}{R} - I \leq 0 \ \forall \ p \in [p^*, \Phi_B].$$

The derivative of this expression with respect to $R$ is

$$\frac{(p - \Phi_B)}{\Phi_B R^2}\,V_0 \leq 0 \ \forall \ p \in [p^*, \Phi_B].$$

Increased interest rates intensify bond overpricing. In the region of bond overpricing (i.e., $p \in [p^*, \Phi_B]$), investors overestimate the probability of project success. With increased interest rates and increased magnitude of financial loss if the project fails, overpricing of bonds is more pronounced.

Since increased interest rates increase the overpricing of bonds and have no effect on equity mispricing, there is an incentive for managers to increase debt use.

### *D. Capital Intensity*

The effect of the magnitude of the capital investment $I$, $(I/Z < \underline{p})$, on financial structure is considered.

PROPOSITION 8: *An increase in project capital investment increases debt use.*

*Proof*: The effect of capital intensity on financial structure is determined by the sign of

$$\begin{aligned}\partial F(p)/\partial I\,|_{p=p^*} &= -p^* U'[E_1]\,\frac{V_0 + Z}{V_0 + \Phi_E Z} \\ &\quad - (1 - p^*)U'[E_2]\,\frac{V_0}{V_0 + \Phi_E Z} + U'[D_1]p^*/\Phi_B, \\ &\leq -U'[E_1]\left\{\frac{V_0 + p^* Z}{V_0 + \Phi_E Z} - p^*/\Phi_B\right\} < 0. \quad \text{Q.E.D.}\end{aligned}$$

Underpricing of equity, given by equation (3), increases with investment, while the overpricing of debt, given by equation (4), increases with investment, and, therefore, an increase in the scale of the capital investment increases debt use.

Large investments require that new shareholders receive a larger percentage of the firm and, therefore, that they are entitled to a larger percentage of equity underpricing. On the other hand, increased face value of debt associated with the scale of investment accentuates bond overpricing. Both effects contribute to increased debt use.

## V. Empirical Implications

Asquith and Mullins [4], Dann and Mikkleson [7], and Mikkleson and Partch [21] have found significantly negative share-price movements on the announcement of common stock financings. This result is consistent with the signalling equilibrium in this paper that predicts that equity financing is a signal of "bad news". Dann and Mikkleson [7], Eckbo [9], and Mikkleson and Partch [21] also find a smaller, but not statistically significant (at the five percent level), fall in share price associated with the announcement of straight debt financing. The fall in share price is inconsistent, while the result that debt financing is more favorably received by investors is consistent, with the signalling equilibrium in this paper. These less than conclusive results indicate the need for a more comprehensive study of share-price effects of bond financing. Attention should be paid to the types of firms included in such a study. The above papers are indiscriminate in their choice of firms. If one were to use only firms with large research and development expenditures (i.e., firms where information asymmetry is undoubtedly more important), the positive bond-financing signal predicted in this paper might be revealed. Dann and Mikkleson also show a significantly negative share-price effect of convertible bond issues. Since convertible debt is a hybrid security with some of the characteristics of both debt and equity, the price effects of announcement and issue are affected by conversion restrictions. If these restrictions are severe, a convertible bond is essentially straight debt, and results in this paper predict a positive price effect. If conversion restrictions are mild, the convertible bond is more like equity than debt, and price decreases should be prominent. More exacting hypotheses are required before the results of Dann and Mikkleson can be used as a basis for understanding firms' financing.

To ascertain the relative predictive ability of the current paper against the paper of Myers and Majluf, one might consider the different implications they have for riskless debt financing. Myers and Majluf would predict that there is no share-price effect of riskless debt financing because, if the firm can finance risklessly, it always does so and, as a result, there is no information content to this financing. In the current paper, firms that can finance risklessly do not always do so, and, when they finance with equity, there are negative effects on share price. On the other hand, if the firm finances with riskless debt, there are positive share-price effects.

The importance of the current paper for empirical research is that it provides more precise predictions on debt/equity signalling than previously available. On the one hand, these hypotheses help explain firms' financing decisions, and, on a broader level, they provide opportunity for evaluating signalling methodology in financial economics.

Proposition 5 in this paper predicts that collateral value decreases debt use. This proposition is difficult to test directly because large fixed assets are likely to be associated with both symmetry of information between managers and investors and lesser bankruptcy costs and, as a result, increased debt use. This view is consistent with Marsh [20], who finds that larger firms tend to use proportionally more debt. However, if Proposition 5 is combined with Proposition 8, a testable prediction is obtained. Proposition 8 predicts that the larger the investment, the more likely is debt use. Together, Propositions 4 and 8 predict that the higher the ratio of investment to fixed assets, $I/V_0$, the greater the likelihood of debt use. At the same time, the larger the investment/fixed asset ratio, the less likely the possibility that the financing is required to cover a firm's (possibly temporary) inability to pay target dividends from cash savings. This inability is a negative signal of firm value. (See Miller and Rock [23].)

Marsh [20] and others have documented a tendency for firms to use equity financing after an increase in share price and strong overall market performance. Most authors attribute this association to firms' attempts to time financing decisions with favorable market conditions. There is no evidence that these attempts are successful. Timing is inconsistent with capital market efficiency. However, Proposition 7 in this paper can be interpreted to be consistent with apparent market timing without resorting to explanations related to delusions of financial managers. If increased share prices and strong market performance are the result of decreased interest rates, Proposition 7 is directly applicable and predicts a relative increase in equity financing. This prediction results from decreased bond overpricing and is not the result of irrational financial behavior. With this interpretation of market timing, an indirect test of Proposition 7 is to compare capital-structure changes between firms with and firms without large research and development expenditures. There is little value to market-timing adjustments in capital structure if information is largely symmetric between managers and investors. On the other hand, other things equal, capital-structure changes should be most sensitive to market conditions for firms with large R & D expenditures. For these firms, mispricing of securities is most pronounced.

Proposition 7 can also be given empirical content if it is interpreted in terms of the maturity of bonds a firm might use. For example, if a firm uses original-issue discount bonds, an increase in the riskless rate of interest in Proposition 7 reflects a longer maturity bond. Since the riskless interest rate and the critical probability are negatively related, this can be interpreted to mean that only very high-quality firms finance with short-term debt. The empirical implication is that short-term debt financing is a relatively more encouraging signal of firm quality than is long-term debt financing.

## VI. Conclusion

It might appear that the assumption in this paper that there are only two states of nature for the real asset project is restrictive. However, project returns could also be used as the source of uncertainty with similar results. Moreover, the assumption that there is only one source of project uncertainty is not restrictive.

As Sick [33] points out, it is ultimately the value of the firm (which is a scalar random variable) that is the object of signalling. Only the compound effect of uncertainty on market values is important for signalling.

If assets in place (not associated with the project) are random and cannot be spun off from the project itself, the results of Myers and Majluf [28] become relevant. In some states of nature, the project may be abandoned even though it has a positive net present value.

The central assumption that generates the major results in both this paper and Myers and Majluf [28] is that financial signalling is less than fully revealing. On the one hand, this is restrictive; in some instances, managers sell undervalued securities. These occasions create managerial incentives to search for more complex or additional methods of signalling. If firms maximize value, it is unlikely that such search leads to full revelation of firm value. Heinkel [14] shows that fully revealing and costless signalling equilibria exist under restrictive assumptions. On the other hand, if managers maximize utility, a fully revealing signalling equilibrium implies that investors can ascertain with perfect certainty either managerial risk preferences or the implications of financial signals for firm value. These requirements are stringent. At the same time, to abandon the view that managerial risk preferences affect financial decisions is too strong a reaction; managers have risk preferences, they affect managerial decisions, and investors are undoubtedly aware of this. A less than fully revealing signalling equilibrium is a compromise between the restrictive information-processing requirements of a fully revealing signalling equilibrium and the extreme view that investors ignore their understanding of the implications of managerial preferences for security valuation. This compromise illustrates a general methodological problem in economic analysis. As observed by Haltiwanger and Waldman [11], "A recurring controversy in economic thought concerns the conflict between the assumption of rationality and the view that economic agents have limited capacities to process information." Any method of signalling is unlikely to be sufficiently precise to reveal firm value exactly. Less than perfect signalling can be interpreted to be the result of bounds on investors' ability to correctly interpret financial signals. In this sense, a less than perfectly revealing rather than a perfectly revealing signalling equilibrium is likely to have close correspondence with empirical results. To the extent that fully revealing signalling is not possible, the implications of this paper for financial structure are relevant.

## REFERENCES

1. Anup Agrawal and Gershon Mandelker. "Managerial Incentives and Corporate Investment and Financial Activities." Paper presented at the 1986 Western Finance Association Annual Meeting, 1986.
2. Edward Altman. "A Further Investigation of the Bankruptcy Cost Question." *Journal of Finance* 39 (September 1984), 1067–89.
3. Yakov Amihud and Baruch Lev. "Risk Reduction as a Managerial Motive for Conglomerate Mergers." *Bell Journal of Economics* 12 (Autumn 1981), 605–17.
4. Paul Asquith and David Mullins. "Equity Losses and Offering Price Dilution." *Journal of Financial Economics* 15 (January/February 1986), 61–89.

5. Nevins Baxter. "Leverage, Risk of Ruin and the Cost of Capital." *Journal of Finance* 22 (September 1967), 395–403.
6. Michael Brennan and Alan Kraus. "Notes on Costless Financial Signalling." In G. Bamber and K. Spreemen (eds.), *Risk and Capital.* Berlin: Springer-Verlag, 1984, 33–51.
7. Larry Dann and Wayne Mikkleson. "Convertible Debt Issuance, Capital Structure Change and Financing-Related Information." *Journal of Financial Economics* 13 (June 1984), 157–86.
8. Harry DeAngelo and Ron Masulis. "Optimal Capital Structure Under Corporate and Personal Taxation." *Journal of Financial Economics* 8 (March 1980), 3–29.
9. B. Espen Eckbo. "Valuation Effects of Corporate Debt Offering." *Journal of Financial Economics* 15 (January/February 1986), 119–51.
10. Sanford Grossman and Oliver Hart. "Corporate Financial Structure and Managerial Incentives." In J. McCall (ed.), *The Economics of Information and Uncertainty.* Chicago: The University of Chicago Press, 1982, 102–33.
11. John Haltiwanger and Michael Waldman. "Rational Expectations and the Limits of Rationality." *American Economic Review* 75 (June 1985), 326–40.
12. Robert Haugen and Lemma Senbet. "The Insignificance of Bankruptcy Costs to the Theory of Optimal Capital Structure." *Journal of Finance* 33 (May 1978), 383–93.
13. ———. "Resolving Agency Problems of External Capital Through Options." *Journal of Finance* 36 (May 1981), 629–47.
14. Robert Heinkel. "A Theory of Capital Structure Relevance under Imperfect Information." *Journal of Finance* 37 (December 1982), 1141–50.
15. ——— and Eduardo Schwartz. "Rights versus Underwritten Offerings: An Asymmetric Information Approach." *Journal of Finance* 41 (March 1986), 1–18.
16. Michael Jensen and William Meckling. "Theory of the Firm: Managerial Behavior, Agency Costs and Capital Structure." *Journal of Financial Economics* 3 (October 1976), 11–25.
17. Alex Kane, Alan Marcus, and Robert McDonald. "How Big is the Tax Advantage of Debt?" *Journal of Finance* 39 (July 1984), 841–53.
18. Alan Kraus and Robert Litzenberger. "A State Preference Model of Optimal Financial Leverage." *Journal of Finance* 28 (September 1973), 911–21.
19. Hayne Leland and David Pyle. "Information Asymmetries, Financial Structure, and Financial Intermediation." *Journal of Finance* 32 (May 1977), 371–87.
20. Paul Marsh. "The Choice Between Equity and Debt: An Empirical Study." *Journal of Finance* 37 (March 1982), 121–44.
21. Wayne Mikkleson and Megan Partch. "Valuation Effects of Security Offerings." *Journal of Financial Economics* 15 (January/February 1986), 31–60.
22. Merton Miller. "Debt and Taxes." *Journal of Finance* 32 (May 1977), 261–75.
23. ——— and Kevin Rock. "Dividend Policy under Asymmetric Information." *Journal of Finance* 40 (September 1985), 1031–51.
24. Franco Modigliani and Merton Miller. "The Cost of Capital, Corporation Finance, and the Theory of Investment." *American Economic Review* 48 (June 1958), 261–97.
25. ———. "Corporate Income Taxes and the Cost of Capital." *American Economic Review* 53 (June 1963), 433–43.
26. Stewart Myers. "Determinants of Corporate Borrowing." *Journal of Financial Economics* 5 (November 1977), 147–76.
27. ———. "The Capital Structure Puzzle." *Journal of Finance* 39 (July 1984), 575–92.
28. ——— and Nicholas Majluf. "Corporate Financing and Investment Decisions When Firms Have Information Investors Do Not Have." *Journal of Financial Economics* 13 (June 1984), 187–221.
29. John Pratt. "Risk Aversion in the Small and in the Large." *Econometrica* 32 (January 1964), 122–36.
30. John Riley. "Competitive Signaling." *Journal of Economic Theory* 10 (April 1975), 174–86.
31. Stephen Ross. "The Determination of Capital Structure: The Incentive Signalling Approach." *Bell Journal of Economics* 8 (Spring 1977), 23–40.
32. ———. "Some Notes on Financial-Incentive Signalling Models, Activity Choice and Risk Preferences." *Journal of Finance* 33 (June 1978), 777–92.

33. Gordon Sick. "Discussion: Asymmetric Information, Signalling, and Optimal Corporate Financing Decisions." *Journal of Financial and Quantitative Analysis* 16 (November 1981), 437–38.
34. Joseph Stiglitz. "Some Aspects of the Pure Theory of Corporate Finance: Bankruptices and Takeovers." *Bell Journal of Economics and Management Science* 3 (Autumn 1972), 458–82.
35. Jack Treynor and Fischer Black. "Corporate Investment Decisions." In S. Myers (ed.), *Modern Developments in Financial Management.* New York: Praeger, 1976, 236–57.
36. Jerold Warner. "Bankruptcy Costs: Some Evidence." *Journal of Finance* 32 (May 1977), 337–48.
37. ———. "Bankruptcy, Absolute Priority, and the Pricing of Risky Debt Claims." *Journal of Financial Economics* 4 (May 1979), 239–76.