Asymmetric Information and Risky Debt Maturity Choice
Author(s): Mark J. Flannery
Source: *The Journal of Finance*, Vol. 41, No. 1 (Mar., 1986), pp. 19-37
Published by: Blackwell Publishing for the American Finance Association
Stable URL: http://www.jstor.org/stable/2328342
Accessed: 26/11/2009 08:18

THE JOURNAL OF FINANCE • VOL. XLI, NO. 1 • MARCH 1986

Asymmetric Information and Risky Debt Maturity Choice

MARK J. FLANNERY*

ABSTRACT

When capital market investors and firm insiders possess the same information about a company's prospects, its liabilities will be priced in a way that makes the firm indifferent to the composition of its financial liabilities (at least under certain, well-known circumstances). However, if firm insiders are systematically better informed than outside investors, they will choose to issue those types of securities that the market appears to overvalue most. Knowing this, rational investors will try to infer the insiders' information from the firm's financial structure. This paper evaluates the extent to which a firm's choice of risky debt maturity can signal insiders' information about firm quality. If financial market transactions are costless, a firm's financial structure cannot provide a valid signal. With positive transaction costs, however, high-quality firms can sometimes effectively signal their true quality to the market. The existence of a signalling equilibrium is shown to depend on the (exogenous) distribution of firms' quality and the magnitude of underwriting costs for corporate debt.

THE CONDITIONS UNDER WHICH financing decisions are irrelevant to a firm's market value and real investment incentives are now well-established. Most of the literature in this area has assumed, *inter alia*, that firm insiders and the market fully share all available information about the distribution of returns accruing to real investment opportunities. In this situation, insiders and outsiders agree about the value of possible financing changes, and equilibrium security prices make the firm indifferent among alternative financing plans. However, if the market's information is less accurate than insiders' information, firms with different "intrinsic" (or insider's) values will be indistinguishable to outsiders. Insiders may then prefer one type of financing plan over another even in equilibrium.

Stiglitz [16] first showed how differences between owners' and potential lenders' bankruptcy assessments will lead to an optimal debt-equity ratio. Subsequently, Leland and Pyle [7] and Ross [14] evaluated the signalling implications of asymmetric information for capital market equilibrium, demonstrating that insiders could—and would—adjust the firm's financial structure to signal their assessment of true firm quality. (Downes and Heinkel [4] have provided empirical evidence supporting Leland and Pyle's main hypothesis about market valuation, although Ritter [13] questions the robustness of their results.) Campbell and Kracaw [3] described how relatively high-quality firms would willingly pay

* Associate Professor of Finance, University of North Carolina at Chapel Hill. I acknowledge with thanks the comments of Christopher James, Jay Ritter, Richard Startz, Edward Kane, and participants at the UNC–Duke and University of Michigan finance seminars. Beyond that, the usual disclaimer applies.

outsiders to evaluate them publicly and derived conditions under which outsider's (costly) evaluations would be credible to other investors in the market. Rendleman [12] demonstrates how asymmetrically informed insiders would prefer some ways of financing new investments to others, and Barnea, Haugen, and Senbet [2] specifically discuss the effect of asymmetric information on optimal debt maturity. However, neither of the latter two papers explores the signalling implications of a firm's financing decisions.

Previous papers have emphasized the fact that imperfect information about firms' quality tends to redistribute market value among existing firms. It follows immediately that such redistributions can have efficiency implications because investment incentives may be distorted if there is no financial signal that perfectly identifies firm quality to outsiders. Stiglitz [16, 17] demonstrated the effect of informational asymmetries on real investment incentives in a single-period context, while Myers [10] argues that outstanding long-term debt can induce a firm's shareholders to pass up investment opportunities that would be taken by an all-equity firm. Similar results have been derived for a firm's need to raise external funds to finance profitable investment projects (Myers and Majluf [11]) and for the dividend decision (Miller and Rock [9]). In each instance, some purely financial decision influences the firm's real value because of asymmetric information in the marketplace.

These papers have generally ignored the impact of asymmetric information on a firm's preferred *maturity* of risky debt (exceptions are Barnea et al. [2] and, to a lesser extent, Myers [10]). Yet when the market's information differs from insiders', firms issuing risky debt will perceive that their bonds are mispriced in a way that varies with maturity. Issuing short debt today implies a need to reissue debt in the future at a price reflecting the firm's (uncertain) condition at that time. By contrast, issuing a long bond today eliminates or substantially postpones the firm's uncertainty about the refinancing rate. With asymmetric information, an insider with a relatively good firm will consider all the market's required default premia to be excessive. But the premium on long debt will appear most unreasonable because the market imputes a higher probability of credit quality deterioration than the insider does. *Ceteris paribus*, relatively bad firms would prefer long debt for the converse reason.[1] It follows that a firm's choice of debt maturity may signal its inside information to the market. The more difficult question is then whether rational market participants can reliably infer a firm's true quality from its debt maturity decisions.

This paper employs a two-period model of debt maturity choice under asymmetric information to investigate the signalling implications of risky debt maturity. The discussion is entirely independent of any changes or uncertainty in the pure (riskless) rate of interest. Section I presents the basic model, then derives equilibrium bond default premia and equity values under alternative borrowing strategies. The signalling implications of private borrowing decisions for debt market equilibrium are presented in Section II. With costless financial transac-

[1] This intuition can be restated using Merton's [8] application of the option pricing model to bond valuation. He shows how a symmetrically informed market will assign default premia according to the debt's term to maturity. In equilibrium, these premia make the borrowing firm indifferent among alternative bond maturities. With asymmetric information (e.g., about the instantaneous variance of firm asset returns), however, insiders will systematically prefer one maturity over the others.

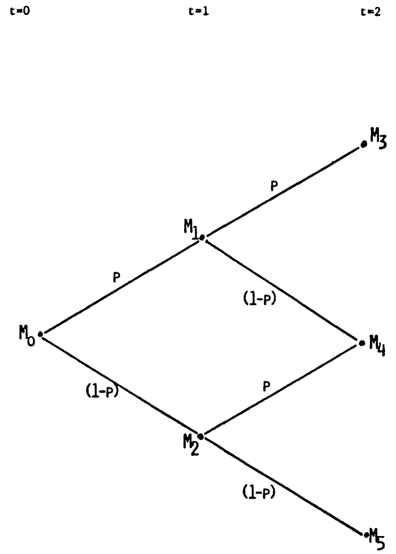

Figure 1. Uncertainty about Changes in Project Value

tions, the debt market will have a (Rothschild and Stiglitz [15]) pooling equilibrium in which different quality firms are indistinguishable to outsiders. If debt issue is costly, however, Section III demonstrates that a (Rothschild-Stiglitz) separating equilibrium may occur. In some circumstances, relatively good firms will be able to choose costly borrowing strategies that cause low-quality firms to select themselves out. Section IV then shows how high-quality firms can increase the number of circumstances in which a separating equilibrium is achieved by partially endogenizing the cost of the short-term debt strategy. (One means of accomplishing this resembles the behavior of many borrowers in the U.S. commercial paper market, where short-term debt is repeatedly rolled over.) The paper's last section summarizes the results and discusses their implications.

I. The Model

The firm's decision about its risky debt's optimal maturity can be evaluated in a two-period model with uncertainty. At time zero, entrepreneurs are endowed with indivisible, nontransferable real investment opportunities. These projects all have positive present values but their required initial capital outlay exceeds the entrepreneur's wealth. In order to undertake an investment project, therefore, the entrepreneur must borrow an (exogenously determined) amount D in the competitive debt market.[2] Investment projects last for two periods. All cash flows occur at the end of period 2, but the project's value follows a binomial process through time that is illustrated in Figure 1.[3] During each (discrete) time period,

[2] The exogeneity of D allows the model to illustrate the information revealed through maturity choice alone, independent of Leland and Pyle's [7] concern about the entrepreneur's choice of how much to invest in the project. Another way to motivate this formulation is suggested by Myers and Majluf [11, p. 208], who describe a situation in which an existing firm always funds a new investment project by issuing debt (rather than equity). The present analysis extends Myers and Majluf's by evaluating the firm's preferred debt maturity.

[3] Rendleman [12] employs a similar framework in the second part of his paper.

there is a probability, p, that the project will increase in value, and a probability $(1 - p)$ that it will decrease in value. This "up" probability, p, is constant over the project's life. At $t = 0$, all investors and entrepreneurs know that the project's liquidating value will be M_3 (with probability p^2), M_4 [with probability $2p(1 - p)$], or M_5 [with probability $(1 - p)^2$]. The project's liquidating value in state M_5 is insufficient to repay D (i.e., $M_5 < D$), although default will not occur in any other state.[4] At $t = 1$ and $t = 2$, the project's fortunes over the preceding period become public information, although the "up" probability remains private information known only to the entrepreneur endowed with the project.

Debt market investors know that there are two types of investment projects that differ only in their "up" probabilities. "Good" projects have $p = p_G$ and "Bad" projects have $p = p_B < p_G$. A project's "up" probability determines its probability of default on debt maturing at $t = 2$, and hence determines the default premium that lenders will demand on that debt. Many entrepreneurs come to the debt market simultaneously to finance their projects, but lenders cannot identify a particular borrower's quality at any cost. Initially, lenders know only the "up" probability values (p_B and p_G) and the fact that θ percent of all projects are Good. At $t = 1$, lenders learn whether or not the project has increased in value during the first period, which provides further (probabilistic) information about its true quality.

All entrepreneurs and lenders are risk-neutral, expected wealth maximizers. Initially, there are no transaction costs, although these will be introduced in Section III. Finally, the riskless interest rate is assumed to be zero with certainty for all time periods. This assumption simplifies notation and emphasizes the effect of default premia on an entrepreneur's welfare.

A. Default Premia with Full Information

The first thing to note is that all debt maturing at $t = 1$ is riskless. The coupon rate on one-period debt issued at $t = 0$ will, therefore, be exactly zero. Debt maturing at $t = 2$, however, may default, and lenders will charge a default premium that reflects the best estimate of their expected loss, conditional on the information available when the debt is issued. With a zero riskless interest rate, risk-neutral lenders would require an interest factor (one plus the coupon rate) that makes the expected payoff on risky debt just equal to the principal amount lent.

First, suppose lenders can (somehow) costlessly identify the quality of individual borrowers. On two-period debt issued at $t = 0$, lenders would require an interest factor (one plus the coupon rate), R_2, such that[5]

$$D = DR_2(p^2 + 2p(1 - p)) + M_5(1 - p)^2 \tag{1}$$

[4] Because it is assumed that all observers agree that $M_2 > D$ (i.e., even the worst projects have a market value that exceeds D at $t = 1$), default can occur only at $t = 2$. The ensuing discussion requires that at least one, but not all, of the final period payoffs be less than the amount borrowed. The particular formulation shown in Figure 1, with only one possible default state, simplifies the exposition without changing the problem's basic characteristics. See also footnote 5.

[5] This calculation assumes that M_3 and M_4 are each larger than the promised bond repayments (principal plus interest), which is a stronger assumption than simply $D > M_5$ and $M_3, M_4 > D$.

or

$$DR_2 = \frac{D - M_5(1 - p)^2}{2p - p^2} \tag{2}$$

where

$P = p_G$ for Good borrowers
$p = p_B$ for Bad borrowers.

The intuition underlying (2) is demonstrated by rewriting it as

$$(2p - p^2)(DR_2 - D) = (D - M_5)(1 - p)^2. \tag{2'}$$

This expression makes it clear that R_2 is set so that the dollar default premium $(DR_2 - D)$, which is paid to lenders (only in nondefault states) with probability $(2p - p^2)$, just compensates for the expected default loss $[(D - M_5)(1 - p)^2]$. Differentiating (2) with respect to p indicates that R_2 is larger for Bad firms than for Good ones.

For short-term debt issued at $t = 1$, the market assigns a zero default premium to all firms known to be in state M_1. For firms in state M_2, the (fully informed) market's one-period interest factor (R_1) is given by

$$DR_1 = \frac{D - M_5(1 - p)}{p} \tag{3}$$

where again p equals the particular project's "up" probability.

B. Default Premia with Asymmetric Information

If lenders cannot distinguish between Good and Bad borrowers, a pooling equilibrium occurs in which bond coupon rates reflect average borrower quality. In pricing two-period debt, lenders again require that their expected return equal zero. The equilibrium interest factor is thus derived from a weighted average of (1) for Good and Bad firms. That is, in a pooling equilibrium

$$D = \theta[DR_2(2p_G - p_G^2) + M_5(1 - p_G)^2] + (1 - \theta)[DR_2(2p_B - p_B^2) + M_5(1 - p_B)^2]$$

or

$$DR_2 = \frac{D - M_5E(1 - p)^2}{2E(p) - E(p^2)} \tag{4}$$

where E denotes the expectations operator conditional on investors' knowledge of the true distribution of firm qualities. (That is, $E(p) = \theta p_G + (1 - \theta)p_B$.) Because the default premium in (4) lies *between* the "fully informed" rates given by (2), there is a redistribution of market value from Good borrowers to Bad in a pooling equilibrium.

For one-period debt issued in a pooling equilibrium at $t = 1$, the story is slightly more complex. Suppose all firms initially issued short debt at $t = 0$. At $t = 1$, some firms will have risen in value from M_0, making their renewed one-period debt riskless. Other firms will have suffered a decline in value (to M_2) by $t = 1$ and will, therefore, have some probability of default on their reissued debt. The market knows that Good and Bad firms differ in their probabilities of reaching

M_2 and will use this information in setting the coupon rate for new debt issued at $t = 1$.[6] With a large number of borrowers, $(1 - p_G)$ of the Good firms and $(1 - p_B)$ of the Bad firms will be at state M_2. This results in the proportions $\left[\frac{\theta(1 - p_G)}{(1 - E(p))}\right]$ of Good firms and $\left[\frac{(1 - \theta)(1 - p_B)}{(1 - E(p))}\right]$ of Bad firms borrowing at $t = 1$. In order for a lender's expected return to be zero, the equilibrium interest factor charged on new one-period debt issued at $t = 1$ must satisfy

$$D = \left[\frac{\theta(1 - p_G)}{(1 - E(p))}\right][p_G DR_1 + (1 - p_G)M_5] + \left[\frac{(1 - \theta)(1 - p_B)}{(1 - E(p))}\right][p_B DR_1 + (1 - p_B)M_5]$$

which can be rewritten

$$DR_1 = \frac{(1 - E(p))D - M_5 E(1 - p)^2}{E(p) - E(p^2)}. \tag{5}$$

This expression for the one-period debt rate at $t = 1$ differs from (3) because investors can no longer identify an individual borrower's credit worthiness, and must, therefore, assume that each borrower's quality is equal to that of the average firm in state M_2. The debt coupon in (5), therefore, lies *between* the rates that fully informed investors would charge to Good and Bad borrowers. It is also important to note that the rate on two-period debt (R_2) at $t = 0$ is less than the one-period rate (R_1) that will be available to risky borrowers at $t = 1$. (The market knows that the average firm at state M_0 is less likely to default than the average firm at M_2.) Good and Bad firms differ in their perceived probabilities of arriving at state M_2, and will, therefore, choose different bond maturities to finance their investment projects.

C. An Entrepreneur's Valuation of the Firm under Alternative Borrowing Plans

An entrepreneur can undertake his or her investment project at $t = 0$ either by borrowing long-term or by issuing short debt and committing himself or herself to rollover debt with an unknown (ex ante) coupon rate at $t = 1$. The insider's evaluation of these alternative strategies depends on his or her assessment of the project's "up" probability and the terms on which different maturity bonds can be sold in the market. Consider first the risk-neutral entrepreneur's valuation of equity when a long borrowing strategy is pursued in a pooling equilibrium:[7]

$$V_L = p^2(M_3 - DR_2) + 2p(1 - p)(M_4 - DR_2) + (1 - p)^2(0). \tag{6}$$

[6] A firm's state at $t = 1$ would also affect the market value of any two-period debt that had been issued at $t = 0$, but this has no significance in itself for firm welfare.

[7] The entrepreneur is assumed to retain the firm's equity in his or her portfolio, which makes his or her wealth depend on his or her debt maturity choice. This is not a very strong additional assumption, however, because investors know the distribution of firms in the market. If entrepreneurs tried to sell their stock, a "lemons" equilibrium would occur in the equity market, with the price reflecting a Bad firm's quality. At this price, only Bad firm owners would sell, thereby identifying themselves.

Substituting (4) into (6) and rearranging yields

$$V_L = [p^2M_3 + 2p(1-p)M_4 + (1-p)^2M_5 - D] + \left[(D - M_5)\,\frac{2(E(p) - p) + (p^2 - E(p^2))}{2E(p) - E(p^2)}\right]. \quad (7)$$

The first bracketed term in (7) is the insider's expected investment payoff less the market value of outstanding debt. Call this the firm's "intrinsic" value, V^i. The second term in (7) measures the firm's "misinformation" value arising from the fact that in a pooling debt market equilibrium insiders and outsiders differ in their assessment of the firm's "up" probability.

It will be useful to rewrite (7) as

$$V_L = V^i + V_L^{mis}. \quad (7')$$

The misinformation value for a long borrowing strategy is denoted $V_L^{mis}(G)$ for a Good firm and $V_L^{mis}(B)$ for a Bad firm. Misinformation values reflect the difference between insiders' and outsiders' assessments of the probability that the default premium implicit in the two-period bond rate will actually be paid. As a result, the numerator of V_L^{mis} in (7) reduces to zero when the market is fully informed about p.[8] It is readily shown that

$$V_L^{mis}(B) > 0$$

$$V_L^{mis}(G) < 0.$$

In other words, Good firms pay an excessive default premium when the market treats them as average, while Bad firms pay too small a premium. Because lenders know the true distribution of borrowing firms and are fully compensated for expected losses, the sum of misinformation costs across all firms in the market is zero. That is, it follows from (7) that

$$\theta V_L^{mis}(G) + (1-\theta)V_L^{mis}(B) = 0. \quad (8)$$

When an entrepreneur follows a short debt (rollover) strategy in a pooling equilibrium, he or she will value his or her equity claim as

$$V_S = p^2(M_3 - D) + p(1-p)(M_4 - D) + p(1-p)(M_4 - DR_1) + (1-p)^2(0).$$

Substituting for DR_1 from (5) and rearranging yields an expression analogous to (7):

$$V_S = V^i + (D - M_5)\,\frac{(1-p)[(E(p) - p) + pE(p) - E(p^2)]}{E(p) - E(p^2)}. \quad (9)$$

The second term in (9) measures the "misinformation" value associated with a short-debt strategy, V_S^{mis}, which has an interpretation similar to that of V_L^{mis}. As before, (9) can usefully be rewritten

$$V_S = V^i + V_S^{mis}. \quad (9')$$

[8] Symmetric information means that outsiders' $E(p) = p$ and $E(p^2) = p^2$ in (7).

It is readily shown that

$$V_S^{mis} \gtreqless 0 \quad \text{as} \quad p \lesseqgtr E(p)$$

and that lenders are fairly compensated on average:

$$\theta V_S^{mis}(G) + (1 - \theta) V_S^{mis}(B) = 0. \tag{10}$$

This section has derived the market values of Good and Bad firms when the debt markets can (cannot) identify individual firm's project qualities. Previous writers (e.g., Rothschild and Stiglitz [15], Ross [14], and Campbell and Kracaw [3]) have observed that a pooling equilibrium reduces the market value of relatively high-quality firms, to the benefit of poor-quality firms. The next section proves that Good firms can minimize their market value loss in a pooling equilibrium by issuing short-term debt; Bad firms maximize their gain by issuing long debt. Knowing this, rational investors might treat long and short debt issues as if they have different quality, which has important implications for debt market equilibrium.

II. Debt Market Equilibrium with Zero Transaction Costs

Any firm can issue riskless one-period debt at $t = 0$, but some of the firms that do so will have their credit quality deteriorate during the first period. A short (rollover) debt strategy thus exposes the firm to risk about its refunding rate. Issuing long (two-period) debt at $t = 0$ eliminates this uncertainty about future funding costs, while forcing the firm to pay a nonzero default premium for certain. In a symmetrically informed market, firms have no preference between the two debt securities because their (ex ante) expected debt payment at $t = 2$ is the same with either type of issue. When information is asymmetric, lenders use (4) and (5) in a pooling equilibrium to price debt such that the *average* firm is just indifferent between the two strategies. But no firm in this model is "average." Good firms know that they have a greater than average chance of refinancing at the riskless rate at $t = 1$, and therefore view the premium on long debt as excessive. For the converse reason, Bad firms prefer long debt over short if the market treats all firms as having the same "average" credit quality.

This intuition can be formalized by observing that an entrepreneur's perceived misinformation values (V_S^{mis} or V_L^{mis}) vary with the maturity of debt issued. A firm prefers to borrow short if that strategy maximizes its value at $t = 0$; i.e., if

$$V_S > V_L.$$

Substituting from (7′) and (9′), this becomes

$$(V^i + V_S^{mis}) - (V^i + V_L^{mis}) > 0$$

or

$$V_S^{mis} - V_L^{mis} > 0.$$

Substituting from (7) and (9) for these misinformation values and rearranging terms yields the conclusion that a firm will borrow short if (and only if)

$$\frac{D - M_5}{(E(p) - E(p^2))(2E(p) - E(p^2))} [(pE(p) - E(p^2))(pE(1 - p)^2)] > 0. \quad (11)$$

The sign of (11) is the same as the sign of $(pE(p) - E(p^2))$, which is positive for Good firms and negative for Bad firms.[9] In other words, if lenders completely failed to distinguish among firms borrowing in the market, Good firms would prefer to issue short debt and Bad firms would prefer to borrow long.

Clearly, however, lender rationality will make it impossible for both firm types to borrow in their preferred maturities. If some firms borrow short and others long, lenders would assume that Bad firms were issuing the long debt and would assign an appropriate default premium. The value of a Bad firm's equity would then become $V^i < V_S(B)$. When the market acts rationally, therefore, a Bad firm must mimic the (known) borrowing behavior of Good firms in order to gain any positive misinformation value. This is stated more formally as[10]

> Result I: In the absence of transaction costs, the debt market has a pooling equilibrium in short-term debt, and no one will issue long-term debt, despite the fact that assets have a long maturity.

Because Good and Bad firms borrow on the same terms in this equilibrium, a Good firm's value will be lower than it would be in a fully informed equilibrium. As a result, Good firms become willing to bear some additional cost in order to be identified by the market. (Moreover, note that firms will be led to *mismatch* their asset and liability maturities as a result of information asymmetries in the debt market.)

The asymmetric information problem posed here is very similar to Campbell and Kracaw's [3]. Their solution was to posit a costly verification process by which the firm's true quality could be signalled to the market. The best quality firms—which have the most to gain from being identified—then pay to be evaluated. Relative to a full information equilibrium, the best firm's value loss is limited to the cost of being evaluated. Here, I assume that any feasible, cost-effective sorting has been undertaken before arriving at the pooling equilibrium of Result I, with its unavoidable redistribution of market value from Good firms to Bad.[11] The next section demonstrates how capital market transaction costs

[9] Expression (11) corresponds to the difference in default premia the entrepreneur expects (at $t = 0$) to pay on long versus short debt. By substituting the definitions of expected values in terms of p_B, p_G, and θ into (11), it is easy to show that all the terms are positive except $(pE(p) - E(p^2))$. A bit of algebra—or a little thought—makes it clear that this expression has the sign of $(p - E(p))$, which is positive (negative) for Good (Bad) firms.

[10] This proposition is consistent with Ross' comment that "[*i*]*f* the chosen mode of signalling is the financial structure, then *since finance is costless*, the market valuation function. . .will be the same for" both high- and low-quality firms ([14, p. 27; emphasis added]).

[11] Note that no efficiency loss results from these market value redistributions because all possible investment projects are assumed to be have positive intrinsic net present values. Section V briefly indicates how asymmetric information can impose efficiency losses on the economy by distorting investment incentives.

can, in some instances, lead Bad firms to select *themselves* out of the short debt market. The result can be a separating equilibrium in which Good firms borrow short and Bad firms borrow long. Under appropriate conditions, costly self-selection can move the market closer to the full information equilibrium distribution of firm values.

III. Debt Market Equilibrium with Positive Transaction Costs

Suppose now that a firm must pay a fixed transaction cost, C, to issue debt of any maturity.[12] A firm that borrows long to finance its investment project thus pays C over the life of the project, while a firm choosing to rollover successive one-period bonds must pay $2C$. With a fully informed debt market, all firms would economize on transaction costs by issuing only long debt. In this regime, a firm's market value would be $(V^i - C)$. With asymmetric information, however, each type of firm's value-maximizing strategy depends on the behavior of the other type of firm. As noted above, Bad firms can increase their market value above $(V^i - C)$ only if they mimic Good firms' borrowing behavior. Good firms, on the other hand, might be willing to bear the added transaction costs of borrowing short if Bad firms were unwilling or unable to mimic such costly behavior. In short, a separating equilibrium in the debt market may emerge if Good and Bad firms differ in their valuation of alternative borrowing strategies.

Table I shows the relation between borrowing strategies and market value for each type of firm. Each entry in the table describes the increase in market value above $(V^i - C)$ for the indicated combination of Good and Bad behaviors. (Negative numbers in the table thus denote value *reductions* relative to a costly, fully informed equilibrium.) For example, in the table's upper right-hand cell, Good firms borrow short while Bad ones borrow long. If this occurred, lenders would treat all long borrowers as Bad and all short borrowers as Good, and each firm's quality would be correctly identified. A Bad firm's resulting increase in market value above $(V^i - C)$ is thus zero: the firm is properly identified as Bad and pays only one transaction cost (C). In the same cell, a Good firm's market value will be given by

$$V^i(G) - 2C$$

which is an increase of $(-C)$ over the full information equilibrium value. The other cells in Table I describe market values similarly, taking account of both misinformation values and the transaction costs associated with each type of borrowing strategy. The sign of each market value increment is noted below the amount.

The optimal response of Bad firms to Good firms' debt strategy is easily seen from Table I. Consider first the bottom section of Table I, where Good firms borrow long. Bad firms can then choose between a market value increment of

[12] Alternatively, C can be viewed as the extra transaction cost of financing the firm's investment with short rather than long debt. Assume for simplicity that entrepreneurs pay this transaction cost out of their personal wealth.

Table I

Net Benefits from Alternative Combinations of Borrowing Strategies

Good Firm \ Bad Firm	Short Debt	Long Debt
Short Debt	Good: $V_S^{mis}(G) - C$ (−) Bad: $V_S^{mis}(B) - C$ (?)	Good: $-C$ (−) Bad: zero
Long Debt	Good: zero Bad: $-C$ (−)	Good: $V_L^{mis}(G)$ (−) Bad: $V_L^{mis}(B)$ (+)

Note: $V_L^{mis}(G) < V_S^{mis}(G) < 0$
$V_L^{mis}(B) > V_S^{mis}(B) > 0.$

$(-C)$ or $V_L^{mis}(B)$. Since the latter is unambiguously positive, a Bad firm will always borrow long if Good firms do.[13]

> Result II: If positive transaction costs cause Good firms to borrow long, there will be a pooling equilibrium in the long debt market. The short debt market will cease to operate.

Now consider the more complicated situation, in which Good firms choose to issue short debt. The top section of Table I indicates that the Bad firms' reaction depends on whether

$$V_S^{mis}(B) - C \gtreqless 0. \tag{12}$$

If $V_S^{mis}(B) \leq C$, Bad firms cannot afford to pay the extra cost, C, to misrepresent themselves and will optimally issue long debt even when Good firms borrow short. This self-selection by Bad firms produces a separating equilibrium in which Good firms pay an additional transaction cost to have their quality properly identified. On the other hand, if Bad firms can afford to mimic the Good ones' short borrowing strategy [i.e., if $V_S^{mis}(B) > C$], the market will have a pooling equilibrium. Good firms will, therefore, choose their preferred debt maturity knowing that Bad ones will follow suit.

Given these reactions of Bad firms to Good firms' alternative borrowing strategies, what combination of borrowing strategies will emerge in equilibrium? If $V_S^{mis}(B) > C$, the Good firms can only have a pooling equilibrium, although they can choose whether it entails short or long debt. (That is, Good firms can select either the upper left-hand or lower right-hand cell of Table I.) The short pooling equilibrium will occur if the Good firms' net cost of a rollover strategy is

[13] Another way to state this conclusion is that the lower left-hand cell of Table I is irrelevant: Bad firms will never pay additional transaction costs to identify *themselves* as bad.

less than the misinformation cost of the long strategy, i.e., if

$$V_S^{mis}(G) - C > V_L^{mis}(G)$$

or

$$V_S^{mis}(G) - V_L^{mis}(G) > C. \tag{13}$$

In words, a Good firm will choose the short pooling equilibrium over the long one only if its (negative) misinformation value is reduced sufficiently to cover the added transaction cost associated with borrowing short. If (13) fails to hold, Good firms will issue long debt at $t = 0$, and Bad firms will (happily) follow suit to yield a long pooling equilibrium.

If $V_S^{mis}(B) \leq C$, Bad firms will always borrow long. The Good firms' relevant choice, therefore, comes down to a separating equilibrium (the upper right-hand cell of Table I) versus a less costly, long pooling equilibrium (the lower right-hand cell). Good firms choose the separating equilibrium only if the added cost of a rollover strategy is smaller than their (negative) misinformation value in the pooling equilibrium. That is, when

$$-C > V_L^{mis}(G). \tag{14}$$

To summarize, the addition of transaction costs allows three possible types of equilibrium: a short pooling equilibrium (similar to Section II), a long pooling equilibrium, or a separating equilibrium. The latter occurs only when $V_S^{mis}(B) \leq C$ and (14) hold simultaneously.

This description of alternative debt market equilibria can be restated graphically. Recall that the misinformation values in a pooling equilibrium sum to zero across all firms:

$$\theta V_j^{mis}(G) + (1 - \theta) V_j^{mis}(B) = 0 \quad \text{for} \quad j = S, L. \tag{15}$$

The inequalities [(12) through (14)] that determine cell selection in Table I can thus be expressed in terms of a Bad firm's (positive) misinformation values. Figure 2 summarizes the way a Bad firm's misinformation values determine the type of debt market equilibrium that will prevail.

First, recall that $V_L^{mis}(B) > V_S^{mis}(B)$ by (11). This implies that only points above the 45° line in Figure 2 are relevant to the analysis. Consider the region to the left of the vertical line $V_S^{mis}(B) = C$, where Bad firms cannot profitably mimic Good firms' short borrowing behavior. In this region, Good firms will use (14) to determine if a separating equilibrium is in their interest. Substituting (15) into (14), the separating equilibrium will be chosen if

$$V_L^{mis}(B) > \left(\frac{\theta}{1 - \theta}\right) C. \tag{14'}$$

This is denoted Region I in Figure 2. When (14′) fails to hold, Good firms are unwilling to pay the premium of C to borrow short, and a long pooling equilibrium occurs in Region IV.

Consider now the area to the right of $V_S^{mis}(B) = C$ where a Bad firm can

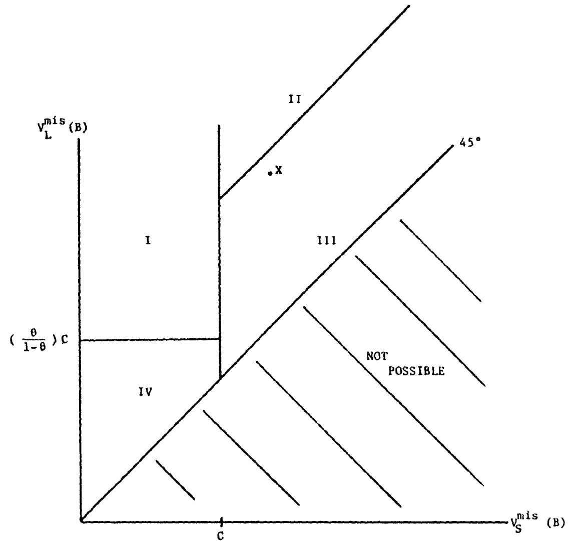

Figure 2. Bond Market Equilibria. Region I: separating equilibrium (upper right cell of Table I). Region II: short pooling equilibrium (upper left cell of Table I). Regions III and IV: long pooling equilibrium (lower right cell of Table I).

profitably mimic any borrowing behavior chosen by the Good ones. In this situation, a Good firm will borrow short if (13) holds. Substituting (15) into (13) yields

$$V_L^{mis}(B) - V_S^{mis}(B) > \left(\frac{\theta}{1-\theta}\right) C. \tag{13'}$$

In words, the debt market will have a short pooling equilibrium if the combination of short and long strategy misinformation values lies above the 45° line in Figure 2 that intersects the vertical axis at $\left(\frac{\theta}{1-\theta}\right) C$. This area is denoted Region II. When (13′) does not hold, the market will have a long pooling equilibrium in Region III.

Note that the analysis here is consistent with Result I. When transaction costs (C) approach zero, Region II expands to fill the entire positive quadrant about the 45° line, meaning that a short pooling equilibrium occurs for any values of $V_S^{mis}(B)$ and $V_L^{mis}(B)$.

To summarize this section, Good firms can actually *benefit* from debt market transaction costs, which may give them an opportunity—albeit at some cost—to separate themselves from Bad borrowers in the market. In particular, transaction costs can allow a separating equilibrium if Bad firms' misinformation value is low for the short strategy relative to *both* C and V_L^{mis}.

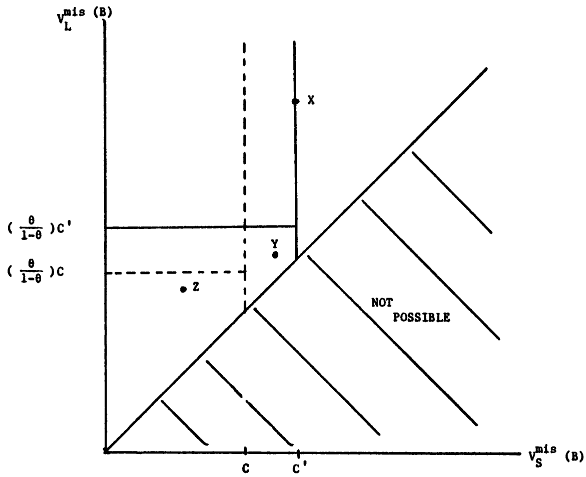

Figure 3. Effect of Higher Transaction Costs on Equilibrium Regions

IV. Partially Endogenous Transaction Costs

Transaction costs in economic and financial models are usually viewed as technologically determined. In the present context, however, only the *minimum* level of transaction costs is exogenous. Good firms may have a strong incentive to devise borrowing methods that are excessively costly if those methods serve to redistribute market value in their favor. For example, the preceding analysis has assumed that firms borrow either one-period or two-period funds, but there is nothing in the problem's structure to prevent a rollover strategy with successive bonds whose maturity is less than one period. With two-period investment projects, a rollover strategy will cost $(2/n)C$ to implement, where n is the maturity of each successive bond. If a firm wishes to undertake such a borrowing strategy, its cost can be made arbitrarily large by the choice of bond maturity. Alternatively, one can imagine a variety of institutional arrangements for distributing bonds to individual investors. A good firm might employ a relatively high-priced investment banker as a way of raising the market borrowing cost, C, to a level where Bad firms would be unwilling to mimic the Good ones' behavior.[14] Finally, a market for debt (firm) rating services might evolve, in which the information produced by the rating agency is, per se, worthless but a firm's payment to the agency is publicly observable. Each of these devices allows Good firms to manage the terms of their debt issue in a way that raises the cost of pursuing a short versus long borrowing strategy. The transaction cost differential between long and short debt strategies can then be altered by a firm's choice of bond maturities

[14] The market would know that only Good firms would be willing to bear the additional expense of employing the unnecessarily expensive investment banker. This observation has interesting implications for equilibrium in the investment banking industry. Good firms would tend to prefer (at least in some circumstances) investment bankers which had (somehow) acquired a reputation for charging hefty fees. The implied excess profits in investment banking would then generate an unusual form of competition for membership in that industry. On this sort of reputation equilibrium, see Klein and Leffler [6] or Allen [1].

or distribution methods. This possibility gives Good firms a greater opportunity to generate a separating equilibrium. (For expositional ease, the Good firms' optimal strategy is discussed here in terms of bond maturity choice; the argument's essential feature is that the Good firm somehow raises the differential cost of borrowing short versus long.)

Consider the case in which a Bad firm's short and long misinformation costs are given by the point X in Figure 2 (which corresponds to X in Figure 3). If a "short" strategy is confined to issuing two successive one-period bonds, the market will have a long pooling equilibrium. As a result, Good firms lose $V_L^{mis}(G)$ relative to their full information market value. Rather than tolerate this loss in market value, Good firms would find it profitable to redefine the "short" strategy in way that raises its relative cost. Suppose each Good firm announces a policy of funding its two-period investment by rolling over successive n-period bonds, where n satisfies: $C' = \{(2/n) - 1\}C$.[15] Now Region I in Figure 3—the separating equilibrium—is no longer bounded by the dotted lines (as in Figure 2), but rather by the solid lines. Whereas a long pooling equilibrium would occur if Good firms were limited to one-period short debt, when they rollover shorter term debt, they can achieve a separating equilibrium in which lenders correctly identify each borrower's credit quality. This occurs because Good firms have raised the relative cost of a "short" borrowing strategy to the point where Bad firms self-select out of the short market. In the process, Good firms raise their own transaction costs and consequently lose $V_S^{mis}(B)$ relative to their full information value. This additional transaction cost will sometimes be smaller than a Good firm's misinformation value in the long pooling equilibrium.

Under some circumstances, it may be impossible for Good firms to force Bad ones to self-select. If misinformation costs are given by points like Y or Z in Figure 3, for example, the market will produce a long pooling equilibrium with any transaction cost at or above C. Good firms would then have no incentive to raise the relative cost of a short-term borrowing strategy above its exogenous level C. What relation between $V_L^{mis}(B)$ and $V_S^{mis}(B)$ allows the Good firms to

[15] Note that this discussion ignores the integer constraint on the number of debt rollovers in a two-period horizon. It must also be shown that an announced policy of this sort is credible in the present framework. Suppose a firm announces that it will borrow n times during the two-period investment horizon. Default can occur only at $t = 2$, and new information about the probability of default becomes available only at $t = 1$. Any debt maturing before $t = 2$ will, therefore, bear the riskless rate while bonds maturing at (or after) $t = 2$ will bear a risk premium sufficient to compensate borrowers for the perceived chance of losing $(D - M_5)$ if the firm defaults. Suppose Good firms announce a policy of rolling over four successive half-period bonds. Can a Bad firm profit by mimicking this strategy at the start, then reneging part way through? (For example, could a Bad firm profitably plan to issue half-period bonds at $t = 0$ and $t = 1/2$, then borrow for a full period at $t = 1$?) The answer is no. Such a violation of the announced policy would identify the firm as Bad, and its debt would become appropriately priced at $t = 1$. Yet, any debt maturing before $t = 2$ would have been riskless. So by reneging on its announced policy, the Bad firm raised its transaction costs (by rolling over the initial half-period bonds), but failed to save any interest expenses. It follows that an announced rollover policy will actually be fulfilled. The essential point that makes such a rollover policy credible is that bond prices reflect all available information. When information is released at discrete intervals, the market's required default premium does not change between information release dates, and there is nothing to gain (in terms of default premia) by misrepresenting one's credit quality within a period.

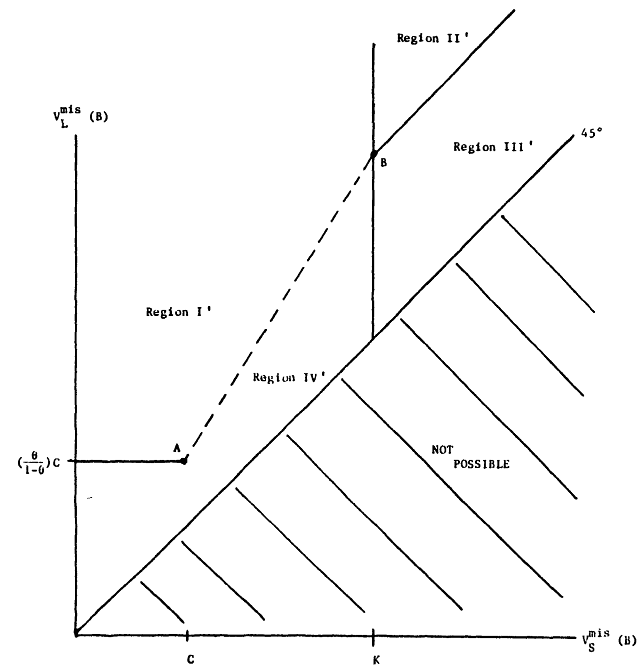

Figure 4. Equilibrium Regions with Endogenous Transaction Costs

achieve a (costly) separating equilibrium? Figure 3 is redrawn as Figure 4, which shows the alternative equilibrium regions when $V_S^{mis}(B) = K$, and Good firms endogenously choose the relative cost of a short borrowing strategy. An increase in the differential cost of the short strategy moves the point that separates the four regions from one another in the northeastward direction along a line through the origin with slope $(\theta/(1 - \theta)$. This is the dotted line in Figure 4. Any combination of short and long misinformation costs in the trapezoid above AB, therefore, allows Good firms to manipulate the short rollover strategy in a way that yields a separating equilibrium. The (augmented) Region I′ which supports the separating equilibrium is considerably larger than the case first described in Figure 2.[16]

In general, the type of bond market equilibrium depends on the number of Good versus Bad firms and the difference in their "up" probabilities. However, there is one condition under which it is *always* possible for the Good firms to generate a separating equilibrium: when Good firms are in the minority ($\theta \leq 1/2$). Because all misinformation costs in a rational bond market must sum to zero [see Equations (8) and (10)], when $\theta \leq 1/2$, a representative Good firm loses more from a pooling equilibrium than a representative Bad firm gains. Therefore,

[16] *A priori*, therefore, Good firms have the greatest chance of forcing a separating equilibrium (i.e., maximize the area of Region I′) if exogenous transaction costs are small but positive. Good firms and their investment bankers consequently have an incentive to devise new institutional arrangements with lower C. Kane [5] describes more generally how institutional arrangements evolve as regulated firms seek to circumvent existing institutional restrictions.

Good firms can always raise the level of debt transaction costs to a point where Bad firms find it uneconomic to pass for average. Only when the majority of borrowing firms in the market are Good ($\theta > \frac{1}{2}$) might the debt market produce some sort of pooling equilibrium.

V. Summary and Discussion

Previous discussions of a firm's optimal risky debt maturity have generally focused on considerations like asset maturity, anticipated versus unanticipated term structure movements, or "liquidity." This paper has presented an uncertainty model in which the maturity of a firm's risky debt sometimes serves as a signal about its credit quality. If bond market investors cannot distinguish between Good and Bad firms, Good ones will consider their long-term debt to be relatively underpriced and will, therefore, issue short debt. Conversely, in the same circumstances, Bad firms will sell overpriced long debt. Rational investors naturally take these incentives into account when pricing risky corporate debt. The interaction of borrowers' incentives and investors' inferences determines the type of equilibrium that prevails in the debt market. Alternative equilibria have been characterized as "pooling" or "separating."

If debt issue is costless, only a pooling equilibrium is possible because there is no costly signal available to Good firms. The market undervalues Good firms and overvalues Bad ones. When debt issue is costly, however, Bad firms can sometimes be induced to self-select into the long debt market. If the distribution of Good and Bad firms in the market is appropriate, Good firms can engineer a short debt borrowing strategy that generates a separating equilibrium. In other circumstances, however, a financial signalling equilibrium cannot be attained.

The model could easily be extended to recognize the allocational effects of alternative debt market equilibria. In the discussion above, it was assumed that the type of bond market equilibrium does not influence the number of investment projects undertaken. An alternative assumption would be that Bad projects have negative intrinsic NPV's and would be undertaken only if they could pass for "average" quality—i.e., only in a pooling equilibrium. The Good firms' ability to attain a separating equilibrium would then have allocational as well as distributional effects.

This model complements earlier asymmetric information models in the literature. Leland and Pyle [7], for example, show how an entrepreneur with a new investment project can signal its quality to potential equity-holders by retaining a large part of the equity in his or her own portfolio. Because the entrepreneur thereby reduces personal diversification, such an investment is a costly signal of project quality. Suppose the entrepreneur in Leland and Pyle's model could also choose between short and long debt as a way of raising capital. With two costly signals rather than one, it seems likely that the entrepreneur's total cost of signalling project quality would be reduced.[17]

The model was exposited here in terms of an entrepreneur with a single investment project. Another interpretation is an existing firm seeking funds for

[17] Talmor [18, pp. 420–21] discusses a firm's simultaneous use of several signals.

a new (marginal) project. Myers and Majluf [11] have argued that when the market is asymmetrically informed about firm asset values, signalling considerations make the firm prefer to fund new projects with debt rather than equity. Given a decision to fund entirely with debt at the margin, the present model applies directly to the choice between short and long debt. In an earlier paper, Myers [10] describes the effect of outstanding risky debt on a firm's marginal investment incentive when debtholders are less well informed than shareholders. Myers concludes that a firm's value will be maximized by issuing debt whose maturity corresponds to the life of the investment projects being undertaken. The present analysis, however, offers a reason why some firms would prefer to issue short debt to finance longer maturity investment projects: such behavior credibly signals insiders' optimistic evaluation of the firm's prospects.

It is clear that asymmetric information can create a complex, multidimensional relation between financial structure and market value. The present model has several empirical implications that could be tested to determine its relevance to real-world financial decisions. First, because the model predicts a correlation between debt maturity and underlying asset risk, its conclusions will affect the term structure of risky debt. The premium on private debt over similar Treasury debt should increase with time to maturity by more than the usual option pricing model would imply. Second, asymmetric information should make the response of stock prices to a new debt issue depend on the debt's maturity. In particular, a firm's equity market value should rise if it shortens its outstanding debt's average maturity. Finally, the model has a cross-sectional implication: industries characterized by greater information asymmetries (e.g., financial institutions whose portfolios are not well documented externally) should tend to issue shorter debt *ceteris paribus* as a signal of high current—and anticipated—portfolio credit quality. Industries less likely to have substantial asymmetric information (public utilities come to mind here) would generally issue debt whose maturity corresponds more closely to that of the underlying assets.

REFERENCES

1. Franklin Allen. "Reputation and Product Quality." *The Rand Journal of Economics* 15 (Autumn 1984), 311–27.
2. Amir Barnea, Robert A. Haugen, and Lemma W. Senbet. "A Rationale for Debt Maturity Structure and Call Provisions in the Agency Theoretic Framework." *Journal of Finance* 35 (December 1980), 1223–34.
3. Tim S. Campbell and William A. Kracaw. "Information Production, Market Signalling and the Theory of Financial Intermediation." *Journal of Finance* 35 (September 1980), 863–82.
4. David Downes and Robert Heinkel. "Signaling and the Evaluation of Unseasoned New Issues." *Journal of Finance* 37 (March 1982), 1–10.
5. Edward J. Kane. "Accelerating Inflation, Technological Innovation, and the Decreasing Effectiveness of Banking Regulation." *Journal of Finance* 36 (May 1981), 355–67.
6. Benjamin Klein and Keith B. Leffler. "The Role of Market Forces in Assuring Contractual Performance." *Journal of Political Economy* (August 1981), 615–41.
7. Hayne Leland and David Pyle. "Information Asymmetries, Financial Structure, and Financial Intermediaries." *Journal of Finance* 32 (May 1977), 371–87.
8. Robert C. Merton. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance* 29 (May 1974), 449–70.

9. Merton C. Miller and Kevin Rock. "Dividend Policies and Asymmetric Information." *Journal of Finance* 40 (September 1985), 1031–52.
10. Stewart C. Myers. "Determinants of Corporate Borrowing." *Journal of Financial Economics* 5 (November 1977), 147–75.
11. ——— and Nicholas S. Majluf. "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have." *Journal of Financial Economics* 13 (June 1984), 187–221.
12. Richard J. Rendleman. "Information Asymmetries and Optimal Project Financing." Mimeo, University of North Carolina, 1980.
13. Jay R. Ritter. "Signaling and the Valuation of Unseasoned New Issues: Comment." *Journal of Finance* 39 (September 1984), 1231–37.
14. Stephen A. Ross. "The Determination of Financial Structure: The Incentive-Signalling Approach." *Bell Journal of Economics* 8 (Spring 1977), 23–40.
15. Michael Rothschild and Joseph E. Stiglitz. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information." *Quarterly Journal of Economics* 91 (November 1976), 629–49.
16. Joseph E. Stiglitz. "Some Aspects of the Pure Theory of Corporate Finance: Bankruptcies and Takeovers." *The Bell Journal of Economics and Management Science* 3 (Autumn 1972), 458–82.
17. ———. "Reply." *The Bell Journal of Economics* 6 (Autumn 1975), 711–14.
18. Eli Talmor. "Asymmetric Information, Signaling, and Optimal Corporate Financial Decisions." *Journal of Financial and Quantitative Analysis* (November 1981), 413–35.