Screening, Market Signalling, and Capital Structure Theory

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ABSTRACT

This paper develops an equilibrium model in which informational asymmetries about the qualities of products offered for sale are resolved through a mechanism which combines the signalling and costly screening approaches. The model is developed in the context of a capital market setting in which bondholders produce costly information about a firm's a priori imperfectly known earnings distribution and use this information in specifying a bond valuation schedule to the firm. Given this schedule, the firm's optimal choices of debt-equity ratio and debt maturity structure subsequently signal to prospective shareholders the relevant parameters of the firm's earnings distribution.

OUR OBJECTIVES IN this paper are threefold. First, we discuss an alternative equilibrium mechanism for resolving the informational asymmetry problem in a "lemons" type market in which some agents are a priori better informed than others. This mechanism, recently proposed by Thakor [19], is *distinct* from and yet integrates the salient features of the screening (see Stiglitz [17] and Viscusi [21]) and signalling (Bhattacharya [41]) paradigms. Second, we demonstrate that the equilibrium notion developed is relevant to the determination of an interior optimal capital structure for a firm in a world of imperfect information. This application of our model involves firms with intertemporally distributed cash-flows which vary cross-sectionally and are *not* necessarily independent and identically distributed (i.i.d.) through time. We use this multiperiod setting to address our third objective, which is to explain a firm's debt maturity decision. Essentially, our argument is that when both the size and timing of a firm's future earnings are indistinguishable ex ante from other firms in the economy, the firm's capital structure *and* debt maturity choices could simultaneously function as signals of these a priori unknown parameters of its earnings.

The market structure we consider is similar to that in Thakor [19].[1] There are sellers, each of whom offers a variety of products with qualities dependent upon a *common* set of exogenous attributes unique to the seller, and buyers who are unaware of these attributes. Buyers interested in *one* of the products offered

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[1] A feature that distinguishes our model from Thakor's [19] is that we consider vector-valued signals, whereas Thakor [19] looks at scalar signalling. Like the signalling model of Spence [14, 15, 16] and the screening model of Stiglitz [17], our model primarily examines a feasible mechanism that can be deployed to resolve informational asymmetry problems that could otherwise lead to market failure (Akerlof [1]).

generate costly information about the attributes of the seller and use this information to determine the price they should pay. The price is set in a manner that permits buyers to recoup their investment in information production. The seller's choice of the quantity of that product to offer for sale then *signals*, to the buyers of *other* products, the common set of underlying factors that affect the qualities of the products *they* buy. In equilibrium, therefore, even though the buyers of only one product expend resources to discover the seller's attributes, all buyers deduce this information *without* any explicit collusion among buyers. We develop this model in detail, within the context of a firm's optimal capital structure choice, and examine the conditions under which it may lead to an ex ante more efficient competitive equilibrium than that attainable either with *direct* Spencian signalling by sellers or costly quality certification by outside agencies.

The rest of the paper is organized in four sections. Section I contains a development of the general model, with specifics devoted to the capital structure model described in the preceding paragraph. Necessary and sufficient conditions for the existence of both separating and pooling equilibria are derived in Section II for the continuum of firm-types case. In Section III, an illustration is given to aid an intuitive understanding of the model. The illustration shows that only separating equilibria (but not pooling) equilibria are generally feasible. Finally, concluding remarks are presented in Section IV.

I. The Model Formulation

A common feature of the signalling and screening approaches is that the under-valued entity is singularly responsible for eliminating the informational asymmetry pertaining to its value. Consequently, there is no incentive for outside investors (or buyers) to engage in costly information production, unless there is a *partial* revelation equilibrium in which a subset of firms *choose* to remain unidentified ex post. The uniqueness of our approach is that the onus for making the decision to generate the necessary information shifts from the firm to initially uninformed outsiders. Thus, although costly information production is allowed, our model differs from the screening literature. However, some resemblance to the signalling models is preserved because, in choosing *how* to transact with outsiders who have produced information, the firm still controls the *actual* transmittal of information to the rest of the market. What makes this possible is that the firm's transactions with information producers operate as signals.

Consider a multiperiod economy in a discrete time framework. Each firm in the economy has access to a possibly unique, *exogenously* determined investment opportunity.[2] Every opportunity requires a real, incremental investment of I. The necessary funds for making this incremental investment must be raised by selling either stocks or bonds, or some combination, to outside investors.

The probabilistic realization of the periodic cash flows each investment can

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[2] Thus, each firm's feasible investment opportunity set is a singleton. This assumption obviates the need to consider possible interactions between a firm's investment policy and the manner in which informational asymmetries are resolved in the capital market.

potentially generate varies intertemporally as well as across firms. In particular, over its life of t years,[3] a firm's investment yields a vector of risky cash flows, $X \in \mathbb{R}_+^t$, where $\mathbb{R}_+ \equiv [0, \infty)$. The probability measure, $Q(X)$, is defined over a sigma-algebra of subsets of $\mathbb{R}_+^t$. Firms are indexed by these probability measures, and the domain of the cross-sectional distribution of these measures is some (compact) set $\mathbb{T}(X)$. Although investors may know $\mathbb{T}(X)$, they are initially unaware of the *specific* $Q(X)$ associated with a given firm. Each firm, however, possesses (private) knowledge about its own $Q(X)$.

Any investor, or group of investors, can obtain perfect information about a firm by investing an amount, $K(Q(X))$, in information production. We assume that bondholders form a coalition and incur the cost $K(Q(X))$ to become informed. They will then use this information to specify a debt valuation schedule to the firm. The information production cost, $K(\cdot)$, may be viewed as being similar to the testing costs in Guasch and Weiss [6].

Taking the debt valuation schedule into account, and in conjunction with the perceived impact of the firm's debt policy on the price of *new* shares, current stockholders in turn determine the optimal mix of debt and equity and the maturity of debt for financing the incremental investment. The firm's (marginal) debt policy is described by the *ordered* vector, $F \equiv\ <F_1, \cdots, F_t>\ \in \mathbb{R}_+^t$, which denotes the promised payment to bondholders in each future time period.

It is assumed that the debt valuation schedule bondholders announce to the firm *cannot* be made public until the firm has declared an *irrevocable* capital structure and debt maturity policy. This assumption is crucial because without it investors with *no* investment in information production could deduce the necessary information about the firm by simply studying the schedule, and the firm could then conveniently retract from its initial selection of debt policy. The net result would be an inability on the part of bondholders to recover their information production cost. Our assumption precludes this bothersome possibility.

Finally, the market clearing prices of all securities are assumed to be determined by an open *tatonnement* process, and the financial markets are perfect and competitive with no transactions costs or taxes. Consequently, no individual investor or firm exercises monopoly power in the financial markets and each participant acts as if demand were infinitely elastic at the quoted prices.

Equilibrium is reached in this market setting when the conditions stated below are satisfied.

Definition of Equilibrium: In equilibrium,

   (i) each firm has chosen a debt-equity mix and debt maturity structure which maximizes the difference between the proceeds from the sale of claims to

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[3] Although every firm is assumed to have the same t, it does not mean that all investments have equal "lives." That is, for some firm, there may exist an $m < t$, such that

$$\text{Prob}[X_j > 0 \mid X_1 = \bar{X}_1, \cdots, X_{j-1} = \bar{X}_{j-1}] = 0, \qquad \forall\, j > m,$$

and $\forall\ \langle \bar{X}_1, \cdots, \bar{X}_{j-1} \rangle \in \mathbb{R}_+^{j-1}$, where $X \equiv \langle X_1, \cdots, X_t \rangle$. Thus if i refers to the "life" of an investment project, then for the cross-section of firms in the economy $(\exists t)(i)(i \le t)$.

outside investors and the initial outlay, I, required by the investment opportunity (value-maximization);

(ii) given each firm's optimally chosen debt policy, the prices of bonds of all maturities are set such that bondholders are exactly compensated for the risk borne, in a manner consistent with the economy's equilibrium valuation mechanism (competitive bond pricing); and

(iii) the prices of all stocks, predicated only upon the associated observable choices of debt policy, are "correct" in the sense that they are determined as if stockholders had complete information in a perfectly competitive market (ex ante rational expectations).

Formally, the above can be expressed as

$$F^* \in \text{argmax}_{F \in \;\{} [S(F) + D(F, Q(X)) - I], \tag{1}$$

subject to

$$D(F^*, Q(X)) = \sum_{m=1}^{t} L(B_m \mid F^*, Q(X)) - K(Q(X)), \tag{2}$$

and

$$S(F^*) = L(Q(X)) - \sum_{m-1}^{t} L(B_m \mid F^*, Q(X)), \tag{3}$$

where variables with asterisks denote equilibrium values. Note that $D(F^*, Q(X))$ is the total market value of all bonds issued, and $S(F^*)$, the market value of equity, is based *only* upon the observed debt policy. B_m is the *actual* (random) payoff on bonds of maturity m, and $L(\cdot)$ is the economy's (positive) valuation operator for risky payoffs.

Two points deserve mention. First, our assumption of perfect and competitive financial markets with a "no arbitrage" constraint implies that the valuation operator, $L(\cdot)$, is a linear functional. This fact has been used in both (2) and (3). Second, we assume that information is produced with *no* duplication. This requires all creditors to collaborate in information production, a condition stated earlier, and reflected in (2).

The important differences between Ross's [12] model and ours are now self-evident. We employ a *vector* of signals, as opposed to the "scalar" signalling in Ross [12] and other signalling papers. Although multivariate models have been studied in the general rational expectations literature (e.g., Allen [2] and Kraus and Sick [9]), our model is, to the best of our knowledge, the only multivariate signalling application other than the papers of Engers [5] and Talmor [18]. Further, unlike Ross [12], we explain the debt maturity decision as well. This is made possible by explicitly considering an intertemporal structure *without* the simplifying assumption that successive single period flows are i.i.d., as for example, in Bhattacharya [3]. Finally, Ross's model precludes costly information production. Apart from the novelty afforded by combining the information production feature with signalling, the advantage of our approach is that it is *endogenously* insulated against the "side payments" possibility that is an inherent problem in the Ross model. Because the determination of the bond valuation schedule is endogenized and is constrained by the competitive consistency con-

dition which must hold in equilibrium, bondholders cannot privately gain by accepting any "secret" payments from the entrepreneur (or current shareholders) to go along with a deception of prospective shareholders. Note, however, that since the cost of implicit quality certification simply represents a transfer payment from the current shareholders to the bondholders, there is no deadweight loss in welfare, and thus our model has a nondissipative signalling cost structure like Ross's [12].

A significant aspect of our model is that all market participants need not produce information. Some can learn by observing the actions of informed participants. While this feature has an intuitive appeal, it also raises the "free rider" problem analyzed by Grossman [7] and Grossman and Stiglitz [8], who essentially argue that if market prices are efficient signals of "superior" information, there may be no incentives for costly information production. Fortunately, this problem does not arise in our framework. As long as the bond valuation schedule is not revealed to prospective shareholders prior to the announcement of an irreversible capital structure policy by the firm, bondholders *will* be compensated for their investment in information production.

II. Existence and Properties of Equilibrium

To examine the existence and properties of equilibrium in our model, we will assume that all functions are at least twice continuously differentiable in their arguments. Scalar partial derivatives will be denoted by subscripts, and vector partial derivatives by gradients with subscripts. The argument of $Q(\cdot)$ is dropped throughout, and the notation $\underline{0}$ represents an appropriate dimensioned column vector of zeros. Further, if A and B are vectors, then $A < B$ implies that every element of A is strictly less than the corresponding element of B, and $A \cdot B$ denotes the inner product of A and B. In the case of matrix multiplication, $[C]D$ indicates that matrix C premultiplies matrix D.

From (1), the first-order condition is

$$\nabla_F S(F^*) + \nabla_F D(F^*, Q) = \underline{0}. \tag{4}$$

Adding the competitive consistency conditions (2) and (3) yields the condition

$$S(F^*) + D(F^*, Q) = L(Q) - K(Q). \tag{5}$$

And, taking the total derivative of (5), we have

$$(\nabla_F S(F^*) + \nabla_F D(F^*, Q)) \cdot \nabla_F F^*(Q) + D_Q(F^*, Q) = L_Q(Q) - K_Q(Q). \tag{6}$$

Now substituting the first-order condition (4) in (6) results in

$$D_Q(F^*, Q) = L_Q(Q) - K_Q(Q), \tag{7}$$

which must hold, along $F^*(Q)$, for *every* Q.

To interpret (7), *suppose* we can rank order firms in the economy so that $Q_i(X) < Q_{i+1}(X) \ \forall \ i, X$. Then, for any monotone increasing utility function defined over consumption, the distribution of cash flows for type i firms must be valued more highly than type $i + 1$ firms. That is, the valuation operator must be such

that $L_Q < 0$. Hence, if the cost of information production is inversely related to quality ($K_Q \geq 0$), in equilibrium higher quality firms will utilize more debt.[4] However, if higher quality firms require a greater expenditure of resources in information production, the cross-sectionally positive equilibrium relationship between quality and leverage may be violated. Thus, since we explain the use of debt as a function of both the costs of information acquisition and the underlying attributes of firms, unlike Ross [12], we can make no assertions about empirically verifiable associations between leverage and value.

Condition (7) is necessary for all equilibria. It is sufficient however, only for pooling equilibria in which firms with differing cash flow profiles are not distinguishable on the basis of their observable, optimally chosen debt policies. For separating equilibria, we need additional conditions. These are derived below.

The second-order sufficiency condition for the existence of a (globally) unique value maximizing debt policy is that the Hessian

$$H_{FF}(F^*, Q) = [S_{F_iF_j}(F^*) + D_{F_iF_j}(F^*, Q)], \tag{8}$$

be negative definite.

Totally differentiating the first-order condition (1) yields

$$[H_{FF}(F^*, Q)]\nabla_Q F^*(Q) + \nabla_F D_Q(F^*, Q) = \underline{0}. \tag{9}$$

In a similar fashion, taking the total derivative of the equilibrium condition (7) gives us

$$(\nabla_F D_Q(F^*, Q)) \cdot (\nabla_Q F^*(Q)) = L_{QQ}(Q) - K_{QQ}(Q) - D_{QQ}(F^*, Q). \tag{10}$$

Finally, noting that the Hessian $H_{FF}(F^*, Q)$ is nonsingular, and using (9) and (10), we obtain that, along $F^*(Q)$

$$(\nabla_F D_Q(F^*, Q)) \cdot \{[H_{FF}^{-1}(F^*, Q)]\nabla_F D_Q(F^*, Q)\}$$
$$= -\{L_{QQ}(Q) - K_{QQ}(Q) - D_{QQ}(F^*, Q)\}. \tag{11}$$

Defining $\Sigma_{FF} \equiv \text{adj } H_{FF}(F^*, Q)$, and rearranging terms, we have

$$\{(\nabla_F D_Q(F^*, Q)) \cdot \{[\Sigma_{FF}]\nabla_F D_Q(F^*, Q)\}\}\{L_{QQ}(Q) - K_{QQ}(Q)$$
$$- D_{QQ}(F^*, Q)\}^{-1} = -|H_{FF}(F^*, Q)| \tag{12}$$

along the equilibrium schedule $F^*(Q)$.

To satisfy (8), the matrix $H_{FF}^{-1}(F^*, Q)$ must be negative definite. By definition, $H_{FF}^{-1}(F^*, Q) \equiv [|H_{FF}(F^*, Q)|^{-1}]\Sigma_{FF}$. So if $H_{FF}^{-1}(F^*, Q)$ has odd (even) rank, to ensure its negative definiteness, Σ_{FF} must be positive (negative) definite. That is, the determinant $|H_{FF}(F^*, Q)|$ and the quadratic form which constitutes the numerator on the left-hand side of (12) must assume *opposite* signs. Thus, if $L_{QQ}(Q) - K_{QQ}(Q) - D_{QQ}(F^*, Q) > 0$ *and* $\nabla_F D_Q(F^*, Q)$ contains at least one nonzero element, we can satisfy (8).

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[4] In spite of the similarity between this observation and Ross's [12] main result, the two models are separated by a fundamental difference. In the usual signalling paradigms, including Ross's [12], the inverse cross-sectional relationship between signalling cost and quality is ordinarily a must in an informationally consistent equilibrium. However, in our model *no* systematic relationship between the information production cost function and quality is required.

To recapitulate, the conditions sufficient for the existence of a separating equilibrium are that there must exist a vector-valued function $F^*(Q)$ such that, given the function $D(F^*, Q)$, $\nabla_F D_Q(F^*, Q)$ is not a zero vector, and for each $\hat{Q}$ in the applicable (cross-sectional) domain of probability measures, the value of equity, $\{L(Q) - K(Q) - D(F^*, Q)\}$, attains its unique global minimum with respect to the measure Q at $\hat{Q}$. These existence conditions are analogous to their scalar counterparts in Bhattacharya [4] and Thakor [19], and are different from those required for separating equilibria with dissipative (exogenously costly) signalling cost structures.[5]

It is transparent from the above discussion that the equilibrium vector $F^*(Q)$ is unique in a separating equilibrium, *given* the valuation schedules $S(F)$ and $D(F, Q)$. However, unless there are ex ante exogenously specified financial market constraints which bind the functional forms of $S(F)$ and $D(F, Q)$, neither these schedules nor the separating equilibrium they induce are unique. This point will become clearer in the next section, which illustrates the model by utilizing alternative feasible stock and bond pricing schedules.

III. Illustrations of Equilibria

For a simple illustration of our model, assume that all investors are risk neutral, or equivalently, that all risks are purely idiosyncratic and hence diversifiable. Further, suppose the economy lasts for two periods and consists of two types of firms. Type A firms expect to realize, at the end of the first period, a cash flow of \$$X$ with probability n and nothing with probability $(1 - n)$; at the end of the second period, these firms realize a zero cash flow with probability one. The converse is true for type B firms. Their first period cash flow is (almost surely) zero, and their second period cash flow is \$$X$ with probability n, and nothing with probability $(1 - n)$. The payoff \$$X$ is the *same* for both types of firms and for each firm within each type. However, each type has firms which are distinguished by their "success" probabilities, n, which lie cross-sectionally in the open set $(0, 1)$. Hence, if two firms in different groups have the same n, the type A firm is of higher quality in the first-degree stochastic dominance sense.

With $F \equiv \langle F_1, F_2 \rangle$ we will denote $T (\in \{A, B\})$ as the firm type, and R as (one plus) the riskless rate of interest. It is assumed that the (default free) term structure is flat and nonstochastic. We shall now illustrate a separating equilibrium for this simple model.

Suppose the stock and bond valuation schedules are given respectively by

$$S(F_1, F_2) = 2R^{-1}F_1 - 2(RX)^{-1}F_1^2 + 2R^{-2}F_2 - 2(R^{-1}X)^{-1}F_2^2, \qquad (13)$$

and

$$D(F_1, F_2, n, T) = \begin{cases} \begin{aligned} &-2R^{-1}F_1 + 2R^{-1}nF_1 + R^{-1}nX - (2R)^{-1}n^2X \\ &\quad - 2R^{-2}F_2 - K(n, A) \quad \text{for} \quad T = A \\ &-2R^{-2}F_2 + 2R^{-2}nF_2 + R^{-2}nX - (2R^{-1})^{-1}n^2X \\ &\quad - 2R^{-1}F_1 - K(n, B) \quad \text{for} \quad T = B \end{aligned} \end{cases} \qquad (14)$$

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[5] See Bhattacharya's [4] comparison of the existence conditions in his model with those in Spence's [15].

Then, the following is an informationally consistent equilibrium

$$F^*(n, A) = \langle 2^{-1}nX, 0 \rangle \quad \text{and} \quad F^*(n, B) = \langle 0, 2^{-1}nX \rangle \tag{15}$$

and satisfies the competitive consistency conditions

$$S(F_1^*, F_2^*) = \begin{cases} R^{-1}n(X - F_1^*) & \text{for} \quad T = A \\ R^{-2}n(X - F_2^*) & \text{for} \quad T = B \end{cases} \tag{16}$$

$$D(F_1^*, F_2^*, n, T) = \begin{cases} R^{-1}nF_1^* - K(n, A) & \text{for} \quad T = A \\ R^{-2}nF_2^* - K(n, B) & \text{for} \quad T = B \end{cases} \tag{17}$$

It can be readily seen that this solution satisfies the necessary and sufficient conditions for a separating equilibrium.

As we mentioned previously, a characteristic of this model is that the separating equilibrium is not unique if the stock and bond valuation functions can be chosen freely. What is interesting, though, is that all feasible separating equilibria entail the *same* welfare for all participants. Thus, there is no a priori reason for one equilibrium to be preferred over another. This can be easily verified by experimenting with alternative valuation schedules.

To some it may seem strange that the debt valuation schedule $D(\cdot, \cdot)$ can be chosen freely and endogenously without its form being dictated by any form of exogenous constraints. In a sense, this concern is not relevant because regardless of which $D(\cdot, \cdot)$ schedule is chosen from the feasible set of such schedules, the same welfare results. But one may still ask: of the large number of attainable capital structure equilibria, in practice should we expect a *particular* equilibrium to be the sole surviving one? On a priori grounds, the answer is *no*. However, to interpret this to mean that the model does not assert the existence of a unique optimal capital structure is to miss the essence of the (nondissipative) signalling argument. Note that when the firm in our model chooses its optimal capital structure, it *need not think of itself as signalling*. Given the market's stock and bond valuation schedules, it simply responds by choosing its capital and debt maturity structure to maximize its market value. If, for the moment, we take the stock schedule as exogenously given, then competition among those who have produced information (and are prospective bondholders) will ensure that the debt valuation schedule is the *unique* solution to the problem of finding a schedule that is simultaneously informationally consistent and maximizes the firm's welfare. That is, the debt valuation schedule evolves in response to the manner in which prospective shareholders interpret the firm's choice of debt levels for varying maturities and use their interpretation in pricing the firm's stock. These remarks are in the spirit of Spence's explanation of his signalling model. In his introductory paper, Spence [14] states,

> Notice that the individual, in acquiring an education, need not think of himself as signalling. He will invest in education if there is sufficient return as defined by the offered wage schedule, (p. 286)

And, in a later paper, Spence [15] emphasizes,

> The signal emitted (by the seller) depends in part on the buyer's response to signals. This response is either known or anticipated by sellers. (p. 297)

Thus, in our context, both the debt valuation schedule and the firm's choice of capital structure can be viewed as optimal responses (perhaps through experimenation over time) of firms and information producers (bondholders) to the way in which uninformed investors (prospective shareholders) try to infer the firm's earnings distribution from these activities. Given a particular stock valuation schedule, $S(\cdot, \cdot)$, there is a unique $D(\cdot, \cdot)$ and a unique pair (F_1^*, F_2^*). In turn, $S(\cdot, \cdot)$ itself may be the outcome of intertemporally self-confirming "rules of the game" followed by investors, linking observed debt levels and maturity choices to consensus market forecasts of future corporate earnings. How the $S(\cdot, \cdot)$ function is *actually* determined is perhaps less important than the fact that *given* a response function $S(\cdot, \cdot)$, one can construct an equilibrium that is informationally consistent and yields a unique capital structure.

The above result is reminiscent of the Modigliani and Miller [10] leverage indifference theorem—a firm's total value is determined solely by its investments in real assets and not by how the financial claims to these assets are packaged. However, our model demonstrates that when the amount and maturity of a firm's debt convey information, such a conclusion is not inconsistent with the existence of an interior optimal capital structure.

This simple illustration is rather exceptional in that a perfect dichotomy between signals is achieved. Each firm signals its type through the maturity of its debt, and distinguishes itself from other firms of the same type through the size of its promised debt payment. In this regard, the result exemplifies the "maturity matching" debt policy strategy prescribed in most basic corporate finance textbooks.[6] Apart from risk-avoidance arguments to justify maturity matching, such as those found in Neihans and Hewson [11][7], such a policy appears to have little theoretical support in the existing literature.[8] The insight our example provides is that even ignoring stochastic term structure considerations, the debt maturity decision may be of importance because it conveys information about some aspect of the firm's future earnings. Moreover, this decision is an intrinsic part of the firm's overall capital structure policy.

Generally speaking, a pooling equilibrium is not possible in this model. The only way to obtain such an equilibrium is to impose the ad hoc constraint that the bond contract includes a costlessly enforceable identure provision that the firm cannot pay any dividends at the end of the first period, and must escrow its first period cash flow in a noninterest bearing sinking fund to meet possible debt obligations at the end of the second period. Since this is not a particularly appealing restriction—and because it leads to an equilibrium that is Pareto dominated by the separating equilibrium—we shall not present details of the

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[6] For example, see Weston and Brigham [22] and Van Horne [20].

[7] Actually, the Neihans and Hewson [11] analysis is in the context of financial intermediaries choosing asset and liability maturities to seek an optimal tradeoff between term structure risk and the gains from exploiting possibly "lopsided" relationships between yields on bonds of varying maturities.

[8] In a perfect capital market framework, it is difficult to create a plausible scenario in which debt maturity structure matters. If the firm's debt matures in a period in which cash flows are insufficient to meet the contractual payments, the shareholders should be able to raise the necessary funds by issuing additional financial claims against *future* cash flows. Alternatively, if the current market value of the firm's existing and potential assets is less than the firm's obligations to the bondholders, shareholders can simply opt to default and transfer ownership to the bondholders.

pooling equilibrium. Noteworthy, however, is the fact that in the "scalar signall-ing" version of this model studied by Thakor [19], separating and pooling equilibria with risk neutral agents have *identical* welfare connotations. This difference between the two models arises because our model is multiperiod while Thakor's is single period, and because the identities of those with a priori unknown attributes are *time-related* in our model. This means that a pooling equilibrium within the structure adopted here necessitates welfare-reducing tem-poral reallocations of wealth by firms. The single period, "one unknown attribute" framework in Thakor [19] allows one to avoid this. For instance, suppose Thakor's model were embellished to admit two types of firms with varying, ex ante unknown default probabilities within each type, such that one type has only a first period (stochastic) cash flow and the other type has only a second period (stochastic) cash flow. Also assume that the market is a priori unaware of which firm belongs to which type, and hence both default probabilities and types must be signalled. Then, if all bonds are issued at the same time and the *timing* of insurance premium payments (but not the actual amount) is observable to all, an informational pooling equilibrium there will also be Pareto dominated by separating equilibria unless one imposes an "unnatural" constraint on firms like the one here. In general, we suspect that pooling equilibria in nondissipative signalling models are unlikely to be feasible (from a welfare point of view) when vector signalling is involved, particularly with intertemporal structures.

IV. Concluding Remarks

In this section, we discuss some issues that we hope will sharpen both the focus and the clarity of the ideas presented thus far.

First, we wish to explain our choice of bondholders as information producers. Clearly, an information producer has at least three other alternatives. It can be a portfolio manager, a direct seller of information, or a shareholder. We cannot claim to have eliminated the first two possibilities, but they do raise some questions connected with moral hazard in information-related transactions. For instance, portfolio managers, operating presumably on an effort-contingent fee basis, will generally have insufficient incentives to make decisions which maxi-mize the welfare of those whose wealth is being invested in assets with a priori unknown true values. A similarly difficulty also exists with information producers acting as direct sellers of information. In this case, however, the issue is further clouded by the fact that information is like a "public good" which can generally be resold without diminishing its value. Therefore, without a fairly restrictive set of assumptions, it will not be possible to ensure that inducements for generating costly information are not completely diluted. As to whether information pro-ducers choose to become bondholders or stockholders, it should be kept in mind that this choice is not critical. The efficacy of the mechanism we have proposed for resolving informational asymmetries does *not* depend crucially upon which group of investors—bondholders or stockholders—bears the cost of information production. In equilibrium, competition will force information to be produced by those who incur the lowest cost.

Second, one may ask whether in fact there is a "need" for multivariate signals. After all, since investors are ultimately interested in knowing the firm's market value, why should the firm simply not signal value directly? It is easy to think of market situations in which investors are either unconcerned about the specific determinants of value, or can unambiguously infer the relevant determinants from the value itself.[9] In these cases, a scalar signal of value would accomplish the same result as an indirect vector signal of the components of value.

It is, however, easy to visualize an economy in which firms would need to signal all the a priori unknown parameters of the probability distributions of their earnings rather than just market values. This would be an economy in which a firm's equilibrium market value determination requires knowledge of the market distribution (as in the single factor CAPM) of earnings and this distribution becomes known only when signalling by *all* firms is complete. Any attempt by firms to directly communicate values will involve communicating possibly erroneous estimates of the market earnings distribution and could lead to loss in welfare. With a few minor adjustments, such an altered structure can be conveniently imposed on our model.

As a final note, an issue of some importance for future research is extending the Spencian (dissipative) signalling model to the multivariate (unknown) attributes case, particularly because it involves difficult questions regarding appropriate boundary conditions (see Engers [5]).

[9] This is the main thrust of Sick's [13] criticism of Talmor [18].

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